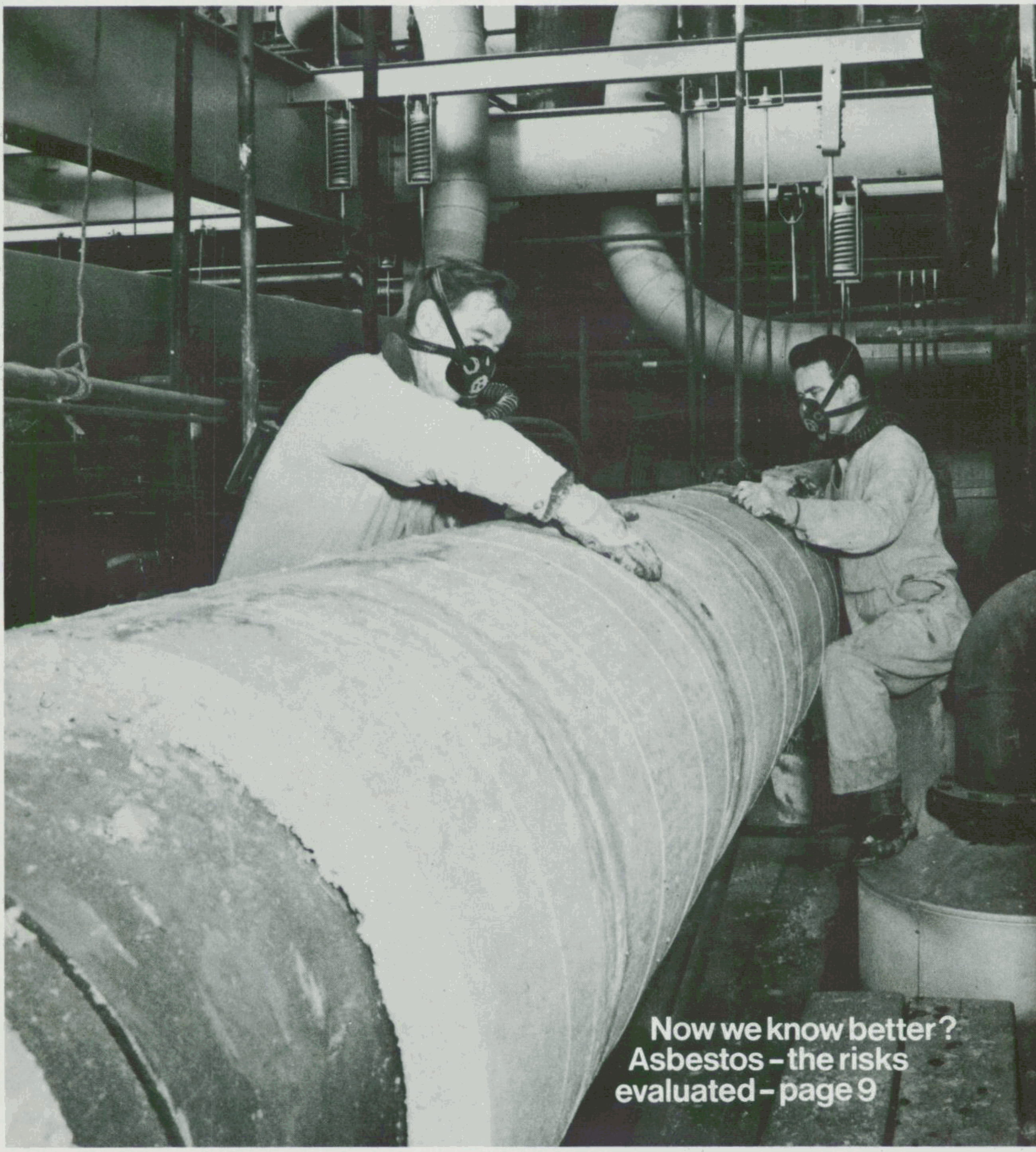
The Journal of the Institute of Hospital Engineering October 1983

HOSPITAL ENGINEERING



- Microprocessor-based event recording
- Britain's first all-electric hospital

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HOSPITAL ENGINEERING

The Journal of the Institute of Hospital Engineering

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Volume 37 No 8 **October 1983**

Front cover: Lagging in the mid-1960's before Asbestos Regulations 1969. An evaluation of the risks on page 9.

INSTITUTE NEWS

FORTHCOMING BRANCH MEETINGS

Midlands Branch: *Hon Sec. W. Turnbull TN Birmingham (021) 378 2211 ext 3590*

18th October	Health and Safety Executive and Its Involvement in Steam Plant Incidents	Seminar Room 2 Post Graduate Medical Centre, Queen Elizabeth Hospital, Edgbaston, Birmingham.
23rd November	Water Supplies and Contingency Planning.	as above

Southern Branch: *Hon Sec. R. P. Boyce TN Chichester (0243) 781411*

8th November	Visit to Eli Lilley Basingstoke with tour, film and buffet	Park Prewitt Hospital (6 pm)

North Western Branch: *Hon Sec. E. A. Hateley TN Manchester (061) 236 9456 ext 452*

20th October	Visit to Stott Benham Limited, Oldham Subject – 'Catering Equipment'
21st November	Visit to Dinorwic Power Station

New publishers for HOSPITAL ENGINEERING

It is something of a challenge and certainly a responsibility, to become the new publishers of such an authoritative and respected journal as Hospital Engineering. Tully Goad Vinall have worked for many years in publishing and have won several awards for excellence of design. We put our experience at the service of the Institute.

One of the first things we have learned is that this is a time of change and rapid development for hospital engineering. It is clear that the role of the hospital engineer, and the work he does, is becoming specialised and complex and intermeshes more and more with other experts' fields in hospital design, construction and equipment.

The implications for the Institute's membership are discussed in this month's Opinion column. But whatever the eventual outcome of the debate, we are convinced that these changes and developments should be reflected in the Journal. We therefore plan a relaunch for Hospital Engineering in February 1984. It will be brighter and better-looking in order to keep pace with all that is new and lively and to become a real and valued forum for news, views and information.

We hope too that it will come to be regarded as required reading for those professional men and women who work side by side with Institute members and whose work is closely related. But be assured, the heart of the editorial content will remain the publishing of learned and technical papers.

Looking ahead to further opportunities for communication among hospital engineers, we are organising, together with T. Jarvis (Exhibitions) Limited, a two-day exhibition to be held in conjunction with and as a complement to the Annual Conference. The exhibition dates are 16-17 May 1984; the venue, The Dragonara Hotel, Bristol.

Our role as publishers is not to make news or form opinion. We will use our best abilities to provide you, the Institute members, with a medium for *your* contributions. We want your letters, your opinions (as controversial as you like), ideas and experience. Direct them to the Editor, Hospital Engineering, Tully Goad Vinall, St. Agnes House, Cresswell Park, Blackheath, LONDON SE3 9RJ. Telephone: 01-852 9448.

Welcome . . .

On behalf of the Council and all members of the Institute, I would like to welcome our new publishers – Tully Goad Vinall. The Journal is one of our principle means of communication between the Council, officers and members at large. It also provides a vital link between members themselves.

We all attach great importance to the Journal and the role it has to play. As such it is up to us all equally to support the Journal by seeing that it is kept an informative and lively publication, worthy of the high standards of the Institute. We must, together, work towards this.

The Institute has arranged an interesting and, I hope, informative programme of seminars for the rest of the year. I am sure members will respond by giving such functions their ready support.

The Annual Conference is to be held on 16-18 May 1984, this time at the Dragonara Hotel, Bristol. For the first time our new publishers will be introducing an exhibition, whose theme will complement that of the Conference. We all look forward to that participation with much interest and enthusiasm.

Do please make sure you book the date in your diaries.

L G HADLEY CEng FIMechE FInstE FCIBS MConsE FIHospE
President of The Institute of Hospital Engineering

OPINION

Wider membership – the way ahead?

Has the time come for the Institute to admit non-engineers to its ranks? S. Ratcliffe, C Eng MICE MIMechE FIHospE, member of Council and Chairman of Council's Membership Committee, discusses the issue.

The Elders of the Kirk responsible for guiding the affairs of the Institute repeatedly show themselves to be extremely acute in furthering its interests.

One particular example of their acumen is that the incorporation of the Institute of Hospital Engineering as a company (under the Companies Act 1948) on the first day of January 1967. This move had very many advantages. The first being that the affairs of the Institute, like any other company, are regulated by the definitions in the Memorandum and Articles of Association.

The Memorandum of Association very clearly states that the objects for which the Institute is established are 'to promote the science of hospital engineering, which science involves the design, construction, employment and maintenance of plant equipment machinery and apparatus used in the engineering and associated services of hospitals, clinic and laboratories'. This definition is the one which is used when applications for Membership are considered.

Much of what has happened in the health care business in this country since those words were written, makes this yardstick less easy to use than was originally the case. For example, although tele-communications, ambulance, and bio-medical engineering could reasonably be seen to fall within the scope of this definition, what of the Structural side? And if Structural Engineers are considered eligible are Building Surveyors? If Building Surveyors are admissible what about Architects? If Architects are admitted, should Quantity Surveyors and perhaps even Administrators? These may seem to be academic points, but the Institute is often under pressure to admit representatives of these professions to its ranks.

The Elders many years ago also recognised that, as an engineering Institute, our future lay within the Council of Engineering Institutions. This meant that all Corporate members of this Institute would need to be registrable with the Engineers Registration Board either as Chartered Engineer, Technician Engineer or Engineering Technician. This in turn means that before any candidate can be considered for Corporate membership of this Institute he or she must satisfy the requirements of the Engineers Registration Board for Registration in one of the three categories. This particular policy has been followed very strictly by the Institute, and by the Membership Committee. Non-registrable candidates may, of course, be elected to the Associate Grade which enjoys all the advantages of Corporate Membership *except* voting rights.

It is also worthy of note that the present regulations of the Council of Engineering Institutions allow for a body such as ours to have a nominal percentage of the Corporate membership as non-registrable persons. The CEI and the Engineers Registration Board is currently being wound up and the responsibility transferred to the new Engineering Council. In my own dealings with the new Engineering Council I sense a very strong movement towards much stricter control over qualifications and Corporate membership requirements of the constituent bodies. To me this means, amongst other things, that the present rule allowing a percentage of non-engineers to be Corporate members of an engineering council body may well vanish.

If all these threads are drawn together the picture becomes a little clearer. Do we want to be a body of engineers or do we wish to take on a learned society role which would allow the entry of 'non-engineer' corporate members? Doing this, of course, would mean our withdrawing from the Engineering Council and thereby losing the means of registering our suitably qualified members.

If for any reason it should be desired to broaden the Corporate membership beyond the bounds already set or, in effect, to give the Associates voting rights, then the full implications spelt out above should be borne in mind.

INSTITUTE NEWS

New member of Council

Mr Mike Smith, currently chairman of the North Eastern Branch of the Institute, and member of the Publications Committee, has been elected to Council for the North East and Yorkshire Area. He holds the post of District Works Officer with the Gateshead Health Authority, with whom he has worked since his original appointment as Area Works Officer in 1974.

Mr Smith's career in engineering began when he served an apprenticeship with C A Parsons & Co Ltd, the turbo alternator manufacturers. He gained further experience as an engineer in the Merchant Navy and as a Works Engineer in industry.

In 1962 he joined the Health Service as a hospital engineer, and worked in both mental and acute teaching hospitals. In 1965 he was appointed to the post of Group Engineer for the City and County of Perth General Hospitals, and in 1968 became Group Engineer to the Newcastle H M C.

Mr Smith has taken part in a number of working parties including the Operation and Management of Electronics and Medical Engineering Maintenance sponsored by the Group Engineers Association and the first Works Computer Management System – EMIS. He is a member of the Advisory Group on Estate Management, and was a member of Working Group No 1 on Strategic Planning. He was a member of the Enquiry into Underused and Surplus Property which reported to the Minister of Health last year, and is current Chairman of Working Group No 6 on the structure of Estate Management Information.

His main interests outside the Health Service include cricket, golf and photography.

Successful Institute sponsorship

We are delighted to announce that our sponsorship of Mr A C Hartley as Chartered Engineer has been successful. Mr Hartley is a member of the South West Branch.

Northern Branch news

At the AGM of the Northern Branch held 8th March, 1983, officers elected for 1983/84 are: *Branch Chairman* – Mr M. H. Smith *Hon Secretary/ Treasurer* – Mr G. Baxter, 11 The Resolution, Nunthorpe, Middlesbrough, Cleveland TS7 OH2

Harland Roberts retires

On October 9th Mr Harland Roberts retires from his part-time post at Essex University as an Appraisal Engineer. He has held this position since May 1982, when he retired from full-time employment as Superintendent Engineer at the University.

He started working within hospitals in 1954 when he joined the Farnham Hospitals Group. He moved to Burnley Hospitals Group in 1957, to become Group Engineer, and left to join the Imperial Cancer Research Fund in 1961. His University appointment dates from 1966.

Mr Roberts was Lancashire Committee Representative on the Engineering Council from 1958-60. This year is his last as a Fellow of the Institute. We wish him well in his retirement.

FIRST-EVER EXHIBITION AT ANNUAL CONFERENCE

Not just a conference – an exhibition too . . . To complement the Annual Conference of the IHE on the 16th to 18th May, 1984, at the Dragonara Hotel, Bristol, there will be an exhibition alongside. The exhibition is to make available to delegates the latest developments in hospital engineering in fields such as construction, equipment, technology, manufacturing and supplies.

It will be organised jointly by Tully Goad Vinall, new publishers of Hospital Engineering and T. Jarvis (Exhibitions) Ltd.

For further information and details, contact John Tully, TGV, St Agnes House, Cresswell Park, Blackheath, London SE3 9RJ. Phone: 01-852 9448.

THE INSTITUTE OF HOSPITAL ENGINEERING
One Day Symposium

WORKS SUPPLIES IN THE N.H.S.

at Kensington Town Hall (Small Hall), Hornton Street, London W8 on Wednesday 23rd November 1983

In recent years there have been a number of important changes which affect the relationship between the Supplies and Works organisations and their purchasing and operational policies.

Following Health Service Supply Council guidance in SCC(81)2 the supplies service has been reorganised with a stronger Regional input and with Districts being grouped into Divisions. Works organisations have been re-organised with greater delegation to Unit level. The Central Management Services have studied the procedures used for supplying materials and the effect they have on maintenance work. Computerisation of Works management systems has introduced a further dimension to the series of changes. This Symposium provides an opportunity to examine the effect of these changes and to help to develop thoughts about the most efficient methods of procurement and control of Works stores in the future.

PROGRAMME

10.00 Coffee

10.30 OFFICIAL OPENING by DR. E. B. LEWIS MA, MB, BChir, LMSSA, FFARCS, DA
Member of Supply Council and Chairman of Technical Supplies and Services Committee

CHAIRMAN for the day:
L. G. HADLEY ESQ CEng, FIMechE, FInstE, FCIBS, MConsE, FIHospE
President, The Institute of Hospital Engineering

10.35 THE SUPPLY COUNCIL
Speaker: R. G. HALE ESQ, BSc(Hons), MInstPS.
Project Officer, Technical Supplies and Services
Health Service Supplies Council

11.15 SURVEY OF CURRENT WORKS STORES
Speaker: R. J. GREEN ESQ
Management Services Assignment Officer
Department of Health and Social Security

12.00 CONTROL OF SUPPLIES IN THE NHS
Speaker: DUNCAN EATON ESQ MInstPS, AHA
Regional Supplies Officer
North West Thames Region Health Authority

12.45 Lunch

14.15 NEEDS OF THE WORKS ORGANISATION
Speaker: F. J. WILLIAMS ESQ, MBE, CEng, MIMechE, FInstF, FIHospE District Works Officer
Coventry Health Authority

15.00 CONTROL OF WORKS STORES BY COMPUTER
Speaker: M. H. SMITH ESQ CEng, MIMechE, MBIM, FIHospE
District Works Officer Gateshead Health Authority

15.45 OPEN FORUM

16.30 Close

Booking form for the One Day Symposium on page 6, plus information on reduced-rate rail fares/hotels.

Lisbon's first symposium

The Portuguese Association of Hospital Engineers has organised its first symposium in Lisbon on 27th to 28th October. The symposium – whose theme is security in hospitals – is supported by the International Federation of Hospital Engineering. The organisers aim to foster exchanges between hospital engineering technicians.

CONCESSIONARY RAIL FARES

Members of the Institute are reminded that in certain circumstances, concessionary rail fares are available in connection with attendance at Institute activities such as the One-Day Symposia held four times each year in London and the Annual Conference.

All that is required is for an advance application be made on the appropriate form obtainable from the Institute's office.

Recently, when seeking additional forms, the Institute was advised by British Rail that as insufficient use had been made of this facility by members during the preceding 12 months, the concession might be withdrawn unless increased use occurred.

OBITUARY

Frederick Potter

It is with deep regret that we record the death of Mr F R Potter, Area Maintenance Manager, Lothian Health Board. Fred, as he was known to his many friends and colleagues, died suddenly in May, while on holiday in Ibiza. He was 59, and had been a member of the Institute for many years.

Fred began his varied career when he entered HM Forces as an engineering apprentice. He passed through various branches of the Army before leaving in 1953 to take up the post of Clerk of Works (Mechanical Services) in the War Department H.Q. Scottish Command. From there he transferred to the National Coal Board, holding the post of Assistant Area Engineer Development.

In 1958 he entered the Health Service as Superintending Engineer at Edinburgh Royal Victoria, Astley Ainslie and Edenhall Boards of Management. From 1961 to 1973 he was Group Engineer for Edinburgh South, East Lothian, Northern and Royal Victoria Boards of Management. Fred transferred in 1973 to the appointment of Group Engineer to the Board of Management of Glasgow Royal Infirmary and Associated Hospitals. In 1975 he was appointed Area Maintenance Manager, Lothian Health Board.

He undertook some original work in the field of Planned Maintenance and served for a number of years on a DHSS Working Party. He had a particular talent for finding ways and means of implementing new management methods in the practical field of maintenance, having some regard and appreciation of the staffing arrangements in hospitals, their limitations and capabilities and with special reference to the problems of communicating across the dividing lines of the multi-disciplinary organisations.

Fred also managed time to be a very active member of the Institute of Plant Engineers in which he served on two occasions as Branch Chairman and also held many other posts.

He was deeply committed to the education of the up-and-coming generation and acted as an Assessor for Plant Engineers for HND Engineering at Napier College and latterly in SCOTEC Higher Certificate in Plant Engineering for the whole of Scotland.

Fred was a man of wide interests – caravanning, wine-making, gardening, to name a few. His chief joy however, was his family, and our warmest thoughts are with his wife Babs, his daughter Joy, son Barry and their families. He will be sadly missed by all his friends and colleagues.

TICKET APPLICATION FOR ONE DAY SYMPOSIUM

To: The Secretary, The Institute of Hospital Engineering, 20 Landport Terrace, Southsea PO1 2RG.

Please send to me____ ticket(s) for the ONE DAY SYMPOSIUM entitled **Works Supplies in the NHS** to be held on Wednesday 23rd November 1983.

I enclose £______ to cover cost of £40.25 (to include VAT of £5.25) includes morning coffee and lunch). No fees will be returned for cancellations (in writing please received after midday on Thursday 17th November 1983.
VAT Registration No 339 3963 20

NAME (in capitals please)________________

ADDRESS________________

____

Position__________ Non Member (please tick)______

REDUCED RATE RAIL FARES AND HOTEL ACCOMMODATION

Substantial rail fare reductions are available for delegates attending this Symposium. The following are examples of second class fares to London (for first class add 50%) Grampian Region – £49; Glamorgan – £19; Cornwall – £30; Oxfordshire – £7.

Forum Hotels in London are prepared to offer delegates a reduction on their normal rates.

Application forms to obtain these reductions may be obtained only from The Institute of Hospital Engineering.

NB. Please note that tickets are available ONLY from The Institute of Hospital Engineering (Tel. Portsmouth (0705) 823186)

PLEASE NOTE DETAILS OF CHANGE OF PUBLISHER ON PAGE 3

Past president of the Institute of Hospital Engineering, Council member of International Federation of Hospital Engineering, Chairman Static Systems Group Ltd.

Microprocessor-based event recording – the key to managing more numerous, more sophisticated hospital systems

LAWRENCE TURNER OBE BSc CEng FIEE FIHospE

As both the direct and ancillary functions of any hospital become more numerous and more sophisticated at a time when fewer staff are available, so the task of the hospital engineer becomes more complicated.

However, recent much-publicised developments in microchip technology have provided one solution to this dilemma in the form of data logging or event recording systems.

Electronic event recording is simply the display and the printed recording of the findings, the activities, or the changes in status of crucial systems around a hospital. It permits remote monitoring and cost-effective management of such systems.

Such equipment is now usually microprocessor-based, consisting of a self-contained, microprocessor-controlled unit which records all changes of state via a visual display unit and a hard copy printer. Other types include centrally controlled computer systems with a local event recorder. However, these may rely totally on one section of their electronics which could fail and put the running of crucial systems in jeopardy.

The Static Systems microprocessor version is tailored to a Statiscan time division multiplexing (TDM) electronic fire, security and plant monitoring system. Statiscan is used in well over 30 British hospitals and can transmit up to 4000 discrete, timed signals on two or three-core cables, requiring a fraction of conventional cabling. This cuts installation costs. The microprocessor-based event recording system can also be used to monitor and record a variety of other hospital ancillary systems.

The Static Systems event recorder includes CMOS technology where appropriate to reduce electrical current consumption significantly. This economy is essential if records are to be continually displayed and printed.

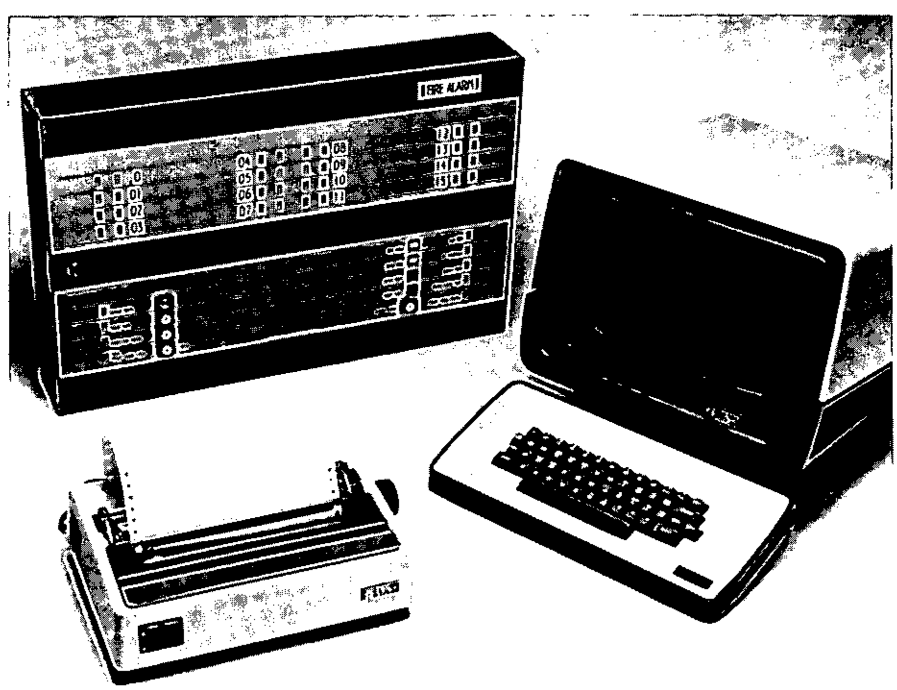
Event recording systems are used specifically to display changed situations for the hospital engineer. In the broader sense an event recorder for any system remotely monitors any events or changes of state around a hospital site.

When used in conjunction with the Statiscan TDM system, it provides an economical means of transmitting information from one part of a hospital site to another – and displaying it in an easy to read 'plain English' format.

The electronic design of the system also permits any number of event recorders to be used within a complex, without any danger of affecting the operation of the TDM system itself.

The benefits of event recording generally to hospital engineers are enhanced by the fact that there may be literally a hundred buildings within a

Master annunciator of new TDM electronic fire, security and plant monitoring system which handles automatically over 4000 status signals – bringing the benefits of time division multiplexing to larger hospitals. In the foreground are a paper print-out machine and a VDU which permit permanent records of events recorded on the TDM system.



complex. The engineer may be miles away from a minor fire outbreak, boiler fracture, or sudden reduction in medical gas pressures – even a break-in. Therefore, remote monitoring permits him to be immediately aware of such developments, using fewer skilled personnel and not relying on people walking around the hospital complex taking irregular and infrequent notes of faults or danger situations.

By recording such events and having them automatically typed in hard copy with their time of occurrence, the hospital engineer can not only be aware when an event has occurred, but also has a better chance of tracing its causes.

Also in a large hospital complex, some sort of building or other construction work is often taking place and various zones controlled by a monitoring system might be isolated or accidentally disconnected. This fact must be recorded, so that the particular problem can be isolated and overcome. In the dynamic environment of a hospital, such managed maintenance is essential.

The hospital engineer can use event recording to determine priorities for his electricians and be aware when faults have been rectified.

A good example of a project where an event recording system has augmented the benefits of a TDM system is the nucleus type district general hospital, Morriston, South Wales. The contract was commissioned by the Welsh Health Technical Service Organisation, the consulting engineers are W. S. Atkins and Partners, and the electrical contractors are Drake & Scull Engineering Ltd.

When it is completed next year it will monitor fire alarm and detection; plant control; medical gas; and eventually, intruder and attack alarms. The four distinct disciplines are on a common shared multiplexing cable, linking various out-stations to master indicators, repeat indicators and to an event recorder.

This shared use of the fire alarm conductors for other essential services is now permitted in both British Standard 5839 and Health Technical Memorandum No. 82, provided that the integrity and reliability of the fire alarm system is not reduced by the presence of other services. The Fire Offices Committee have also given their approval to the Statiscan TDM fire alarm system.

The Morriston fire detection and alarm system is based on break-glass contacts, smoke detectors and heat detectors throughout the 50 acres complex. If a fire alarm is initiated in any one of the 95 sectors, that sector alone sounds the alarm signal which is also displayed on an electronic master panel annunciator in the telephone operator's room. It also shows up on a 95-way repeater in the porters' room. All this is recorded on a hard copy event recorder in the hospital engineers office in the centre of the hospital site.

Logic units in four of the plant rooms will automatically receive information from specific fire sectors under alarm condition to control fire dampers, smoke extractors and air supply fans.

Signals from approximately 400 plant transducers distributed around the site are interfaced via local indicator panels, which range from two to 76 indicator ways. The electronics of the system differentiate between high and low priority signals which are displayed on a mimic panel in the hospital engineer's office. High priority and other special category signals are repeated on a second indicator in the telephone operator's room.

Again, the hospital engineer's event recorder will also record this information, together with the time of occurrence.

Eleven independent medical gas plant manifolds located around the site have pressure switches connected to input processors. These transmit information along the time-shared line to both master and slave panels in various departments. The gas master panel in the hospital engineer's office and a repeat indicator at the telephone switchboard show the state of all eleven gas pressures at all times. Again, the event recorder will inform on and record any critical changes.

The microprocessor-based event recorder linked to the system consists of control electronics, visual display unit, hard copy printer and 'QWERTY' keyboard. All changes of state in the status of fire, various plant or medical gas throughout Morrison hospital are recorded both on the VDU and as a 30-characters print-out with a clear qualifying statement ('fire alarm healthy', for example). Software allows interrogation via the keyboard so that details of the state of the system at any particular point in time may be recorded.

The hospital engineer's problems and responsibilities are growing daily with the ever increasing range and sophistication of engineering systems. It is vital therefore that the TDM system and event recorder should not add to this burden.

The entire system has therefore been designed for high reliability and integrity and minimum down time. A set of replacement printed circuit boards will be held by the hospital engineer and it is intended that first line maintenance should be carried out by in-house staff.

A step by step operations and maintenance manual is provided for this purpose, and the nominated maintenance staff are encouraged to attend a structured 'hands on' training course both at the factory and on site.

In the future it is inevitable that the growing complexity and sophistication of hospital fire alarm and plant condition monitoring will increase rapidly.

It is essential therefore that the hospital engineer should be totally and immediately in control of any deteriorating situation, and the provision of both visual display and hard copy event recording becomes vital.

Event recording therefore, will be an invaluable aid to hospital engineers in this context.

Footnote

This article can only purport to outline the basic function and operation of the Static Systems microprocessor based event recording system.

Those wishing to gain a deeper insight into the techniques of time division multiplexing are recommended to read appendix 4 of the Health Technical Memorandum No. 82, published by the Department of Health and Social Security. This section is based on an article written by Mr. Malcolm Smith, C.Eng., MIERE, MCIBS the District Works Officer for Barnsley, which describes the operation and safeguards of the Statiscan TDM system in considerable detail.

This paper was given at the annual Six Branch Meeting, held at the National Hospital, Queens Square, London, 18th June 1983. The authors are colleagues at the Thomson Laboratories, Milton Keynes, an environmental pollution and occupational hygiene consultancy

Asbestos – evaluating the risks

STEPHEN BAILEY MSc DipOccHyg CChem MRSC MIOH
ANDREW GILLIES MSc DipOccHyg MIOH

Introduction

'Asbestos' is the family name for a group of naturally occuring fibrous minerals, mined in much the same way as coal. Six main types can be distinguished:

Chrysotile – 'White' asbestos
Amosite – 'Brown' asbestos
Crocidolite – 'Blue' asbestos
Anthophyllite
Tremolite
Actinolite

Only the first three types have been used extensively in the UK. Despite their common names they cannot be reliably identified by colour. Anthophyllite is found occasionally in older installations.

Asbestos has a unique combination of valuable properties:

1) Physical strength
2) Durability in adverse environments
3) Non-combustability
4) Good thermal and electrical insulation

This has led to a vast range of uses which have made asbestos ubiquitous. However, it is gradually being replaced by substitute materials in many applications because of the health hazards associated with it. Crocidolite has not been used in the UK since 1970 and the major use of amosite, in fire-resistant and insulating boards, ceased in 1980 as substitutes became available. Only chrysotile is still used extensively, as a reinforcement in building and engineering materials such as corrugated cement sheets and brake linings.

Large quantities of asbestos were used in older buildings. In particular:

- Pipe and boiler lagging commonly contained asbestos mixed with a binding agent such as magnesia or diatomaceous earth. The composition of the mixture varied widely and any type of asbestos could be used in proportions, typically, from 5-55%. One common procedure was to use an inner layer containing chrysotile and/or amosite and an outer hard surfacing coat composed mainly of binders with a small amount of crocidolite.
- Sprayed asbestos coatings were used to provide fire protection to structural components of buildings and for acoustic control. They contained 55-95% asbestos, usually crocidolite or amosite. No sprayed coatings were applied after 1974.
- Asbestos boards, containing 15-40% amosite, or chrysotile, were used for fire protection or insulation, eg cladding lift shafts and service ducts or as false ceilings. An estimated 40 million boards were produced over a twenty year period.

Health hazards

Asbestos only presents a health hazard in situations where it can enter the body. This can happen when fibres become airborne and are breathed into the lungs. Thus, for a health hazard to exist there must be:

- loose asbestos fibres (eg from damaged insulation)
- a source of disturbance (eg air movement)

Once deposited in the lungs the fibres remain there indefinitely and may lead to asbestos-related disease.

The three principal illnesses which have been linked with asbestos are asbestosis, lung cancer and mesothelioma.

Asbestosis Asbestos fibres deposited in the lungs cause thickening and scarring of the lung walls and so reduce gas transfer. Asbestosis is associated with severe difficulty in breathing and is eventually fatal. Its onset is insidious with a dry cough and modest loss of exercise tolerance. Later, sputum production increases. There is no treatment: death usually occurs within 15 years but removal from exposure can delay development. Asbestos workers should have routine medical examinations, including X-rays, to detect asbestosis as early as possible.

Lung Cancer About half of all asbestosis sufferers also develop lung cancer. The cancer is indistinguishable from that caused by cigarette smoke. An asbestos worker who smokes is about fifty times more likely to develop lung cancer than a person who neither works with asbestos nor smokes.

Mesothelioma This is a malignant growth of the outer lining of the lung. It has been associated mainly with blue asbestos, and it is not certain whether white asbestos alone can cause the disease. Mesothelioma appears 15-50 years after the first exposure to asbestos and often long after exposure has ceased. The cancer spreads through the chest and death usually occurs within 2-3 years. No treatment is of any value.

The likelihood of any person developing an asbestos related disease depends on three factors:

- the concentration of asbestos to which he is exposed
- the duration of exposure
- the susceptibility of the individual concerned

It is desirable, therefore, to make a considered assessment of the risk before embarking on expensive, and possibly unnecessary programmes of work.

Assessing the risk

Identification of Bulk Materials

The first stage in assessing the risk is to identify where asbestos is present and in what form. A knowledge of its typical uses will help to suggest where to look and visual inspection by an experienced person will often lead to a tentative identification. However, reliable identification of the presence and type of asbestos is not usually possible without laboratory analysis.

Several methods of analysis are possible, including X-ray diffraction, infra-red spectroscopy and differential thermal analysis, but only one method – polarised light microscopy – is suited by cost, availability and performance to the mass screening of materials for asbestos. This technique involves applying a battery of tests which together enable an unambiguous identification to be made. The most important stages of the analysis are:

1) An initial examination, visually or using a stereomicroscope, to tease out fibres for analysis and assess the percentage composition of the mixture.

2) Fibre mounting, in a special liquid chosen to match the refractive index of the fibre.

3) Microscopical examination using polarised light. Various tests are made, using crossed polars, sensitive tint plate and dispersion staining techniques.

It should be noted that the percentage composition of the sample is only estimated by visual inspection with reference to standard materials. The figure obtained is very approximate but it will suffice for most practical purposes.

The likeliest source of error in the identification of asbestos is not in the analysis but in the sampling. It is vitally important that the sample provided for analysis is representative of the original material. Lagging materials in particular may vary greatly in composition from place to place on a pipe or item of plant. Very often, traces of blue asbestos will be found in one sample but not in another from nearby. To ensure that trace constituents are identified it is necessary to take several precautions:

(i) A number of samples should be taken from different locations.

(ii) The samples should be of reasonable size. A small handful is sufficient.

(iii) Core samples should be obtained as the insulation may have been applied in layers.

If blue asbestos is discovered it is necessary to give the Health and Safety Executive 28 days notice of any work on the material.

Factors Affecting the Decision

The second stage in the assessment is to determine the level of risk created by the presence of asbestos. This depends principally upon the likelihood of fibres getting into the atmosphere and being inhaled. A number of important factors can be identified:

(1) The nature of the material The risk of fibre release is greater with low density materials of high fibre content than with high density materials of low fibre content. It is the soft, loosely bound, fibrous materials that demand most care.

A rough order of risk might be:

Sprayed coatings	Most Risk
Pipe insulation	↓
Insulation boards	
Asbestos cement	Least Risk

(2) The condition of the material If the asbestos has been damaged exposing fibres, or if it has deteriorated through age becoming friable or dusty there is more justification for action than if the material is in sound condition.

(3) The risk of damage Situations where the asbestos is likely to be damaged, for instance by regular traffic through the area or by maintenance work, are pointers that action should be taken.

(4) The location The type of occupancy and the duration of exposure may affect the decision. For instance, a boiler house visited for a few minutes per day is a very different situation from a hospital ward full of children.

(5) The airborne levels The presence of loose fibres does not of itself mean that fibres will become airborne. There must also be a source of disturbance such as a strong draught or physical movement. This risk is best assessed by measuring the airborne concentrations under realistic conditions (see below).

(6) The feasibility of treatment If removal is contemplated it must be ascertained that there is an effective replacement available, that all traces of asbestos can be removed and that the risks caused by disturbing the material do not outweigh those from leaving it alone. If the material is to be encapsulated and left in situ, then the treatment must not affect the function of the asbestos (eg for fire protection) and regular inspections must be introduced to check on the integrity of the seal.

(7) The cost Asbestos removal or encapsulation, if performed by a reputable contractor to approved standards, is expensive. In addition to the direct cost it may be necessary to put an area out of action for a considerable length of time.

Air Sampling

Air sampling provides the most direct method of assessing the hazard from airborne fibres. However, the result of an air sample only indicates what was present at the time and in the place that the sample was taken. It must be interpreted with considerable care as there are many ways in which an inaccurate or irrelevant result can be produced. Both the person taking the samples and the person interpreting the results need to be thoroughly trained. It should always be remembered that air sampling results are an aid to decision making and not an end in themselves; they are not a substitute for careful observation or for rational thinking.

The most widely used method of sampling and analysis for airborne asbestos is the standard 'membrane filter method' described by the Health and Safety Executive in their Guidance Note EH 10. It involves drawing a known volume of air through a membrane filter which collects any airborne dust. The filter is then examined under an optical microscope using phase contrast conditions and any respirable fibres are counted. Results are calculated as the number of fibres per millilitre of air.

On a practical level, there are a number of common problems and mistakes made with air sampling which deserve to be highlighted:

(i) The filter used should be of the 'gridded' type to aid focussing of the microscope. A filter of 1.2 micron pore size will give the same results as the more conventional 0.8 micron filter but with less wear on the pump and battery.

(ii) The air flow rate through the sampling head should be checked before and after sampling. For sampling times over 1 hour it is also advisable to check and adjust the flow rate during the sampling period. Samples where the flow rate is not checked are worthless.

(iii) The duration of sampling must be sufficient to give a suitable density of deposit on the filter for analysis. In many applications where low levels are being measured this will mean a sampling time of at least one hour and preferably longer. A four-hour sampling period is becoming standard for many tests.

The effective detection limit of the membrane filter method is about 0.01 fibres per millilitre. Results below that value are indistinguishable from normal background levels. This is sufficiently sensitive to make the method suitable for routine testing in many situations, for example when checking for contamination after an asbestos stripping operation. The method also has the essential merits of being quick and inexpensive. However, there are a number of drawbacks:

(i) The analysis is not specific for asbestos. It involves counting *all* the visible fibres withing a given size range and it is not possible to identify reliably the type of fibre present. the result therefore tends to be an overestimate of the asbestos concentration, especially when very low concentrations are being measured.

(ii) Fibres less than about 0.5 microns in diameter are not visible under an optical microscope. There is some evidence that these very fine, optically invisible fibres may be the most dangerous to health.

(iii) Environmental background levels are frequently below 0.01 fibres per millilitre and therefore cannot be accurately measured.

To overcome these problems it is necessary to use a more sophisticated method of analysis. Scanning electron microscopy is capable of detecting fibres less than 0.1 microns in diameter at levels down to approximately 0.0004 fibres/ml (usually expressed on a mass basis as 10^{-8}g/m^3). The instrument can be fitted with an energy dispersive X-ray analyser to aid discrimination of fibre types. An analytical transmission electron microscope has even greater capabilities. However, both these instruments are excluded from routine use on grounds of cost and availability.

Exposure levels

Normal levels in Buildings

Measurements of asbestos levels in buildings have generally given low results. Using the standard membrane filter method, concentrations are usually below the detection limit of 0.01 fibres/ml. Even the more sensitive methods of scanning and transmission electron microscopy frequently fail to detect any asbestos. This is so even when asbestos materials in the buildings have been damaged or disturbed. It is remarkable how much disturbance is necessary to raise general atmospheric levels by a significant amount. Elevated concentrations are found only in special situations, such as where there is a high airflow (in ventilation ducts) or where there is a physical disturbance in a confined space.

Levels During Work with Asbestos

Much higher levels occur when asbestos materials are being worked. The extreme case is the dry stripping of insulation or sprayed coatings, when the concentration in the working area may exceed 100 fibres/ml. Using water sprays to dampen the material as the work progresses might reduce the levels to 5-40 fibres/ml. The difficulty of maintaining low levels in the rest of a building while stripping work is in progress is readily apparent and should be a factor in deciding whether and how to proceed with the work.

Lesser exposures will arise in the course of normal building maintenance work. Drilling or cutting amosite boards or ceiling tiles can produce concentrations of 2-20 fibres/ml near to the work. Significant improvements can be made by working carefully and using a wet spray method. In these situations it is important that the exposure of the employee is measured by *personal* sampling techniques as fixed location samplers a few feet away may measure concentrations ten times lower.

In confined spaces such as service ducts or ceiling voids maintenance workers may cause high local concentrations by inadvertantly damaging aspestos materials. Air sampling to assess the risk in such situations must be conducted when work is in progress as the normal background levels are likely to be very low.

Levels after Stripping

Experience has shown that when the removal of asbestos is properly completed levels in the working area will return to below 0.01 fibres/ml. Higher values are an indication that the area should be recleaned. However, it is quite possible to find low astmospheric concentrations when asbestos dust and debris remain on the floors or plant. This cannot be considered acceptable when an area has supposedly been decontaminated. Various methods, such as fans or physical movement may be used to try to disturb the deposits during the air sampling, but it is essential that the air tests are supplemented by a rigorous visual inspection.

Standards and action levels

The relationship between the dose of asbestos and likelihood of contracting illness is not clearly established. Many studies have been made but the results are difficult to interpret and sometimes conflicting.

At high levels of exposure there is no doubt that asbestos is dangerous. One study of insulation workers, in New York in 1965, found that 48% of them were affected. At low levels the situation is much less clear. The absence of widespread asbestosis in the general population is reassuring, but it is not known whether there is a level below which cancer will not occur. Deaths from mesothelioma have been reported after very slight exposure to blue asbestos and many authorities now believe that there is no safe level.

The Health and Safety Commission prescribe Control Limits for occupational exposure to asbestos as follows:

Chrysotile (white asbestos)	1.0 fibres/ml
Amosite (brown asbestos)	0.5 fibres/ml
Crocidolite (blue asbestos)	0.2 fibres/ml

These are not intended to be 'safe'

levels, rather they represent a level of control which is achievable for most of the asbestos industry. It has been estimated that exposure to white asbestos at a concentration of 1 fibre/ml for a working lifetime will cause 0.2-1.25% excess mortality from lung cancer and asbestosis.

The control limits are not applicable to non-occupational situations, since they apply only to adults exposed for a 40 hour working week. A lower limit is appropriate in situations where children may be affected or where exposure is continuous. Unfortunately there are no official standards for community exposure to asbestos. The best practice is to keep levels as low as practicable, which will usually mean that they should be indistinguishable from background levels, ie less than 0.01 fibres/ml.

Rational asbestos policies

Available evidence does not at present warrant the wholesale removal of asbestos from buildings. Risks to health are only likely to occur in isolated situations where airborne dust is produced. The key features of a rational asbestos policy ought therefore, to be:

1. An assessment of the likely hazards:
   - where is asbestos present?
   - how likely is it to become airborne?
   - how likely is it to be inhaled?
2. Approved procedures for removal and repair:
   - permit-to-work and permit-to-enter systems
   - training for personnel
   - provision of facilities
3. Routine inspections for asbestos left in situ. An effective record keeping system is essential.

Useful references

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3. **Public Health Risks of Exposure to Asbestos,** Commission of the European Communities, Pergamon Press (1977)
4. **Asbestos Concentrations in Public Buildings – A Preliminary Report** J M Le Guen and G Burdett, Annals of Occupational Hygiene, *24* (2), (1981)
5. **Fibre Identification using Optical Microscopy** D R Purdy and D H Williams, The Electricity Council, 30 Millbank, SW1 (1977) plus *Supplement*
6. **Abestos,** Guidance Note EH 10, Health and Safety Executive, (1983) (HMSO)
7. **Reference Method for the Determination of Airborne Asbestos Fibre Concentrations,** Asbestos International Association, 68 Gloucester Place, W1. (1979)
8. **Work with Asbestos Insulation and Asbestos Coating,** Approved Code of Practice and Guidance Note, Health and Safety Commission, (1981) (HMSO)

This paper derives from the Institute of Hospital Engineering/CIBS evening meeting 3rd February 1983. The author has combined the contributions of the three speakers – I R Alexander CEng MIEE MCIBS Area Engineer Cambridge Health Authority, M Cooper-Reade BSc(Eng) CEng MIEE, Energy Marketing Manager, Eastern Electricity Board, J Leary CEng MIMechE MCIBS Head of Environmental Engineering Section, The Electricity Council

Britain's first all-electric hospital – early operational experience

J I H LONGLEY BSc MCIBS Environmental Engineering Section, The Electricity Council

Background and Building Construction

Fenland House Hospital in Peterborough, Britain's first modern all-electric hospital, was first occupied in April 1981, and after two years' operating experience, we are able to draw some clear conclusions regarding its performance.

Fenland House was the outcome of a study, sponsored by the Department of Health and the Electricity Council, into the feasibility of an all-electric hospital. The study was carried out by a firm of consulting engineers and started with the premise that in the long term, oil and gas would become scarce and expensive, and alternative energy sources would be required.

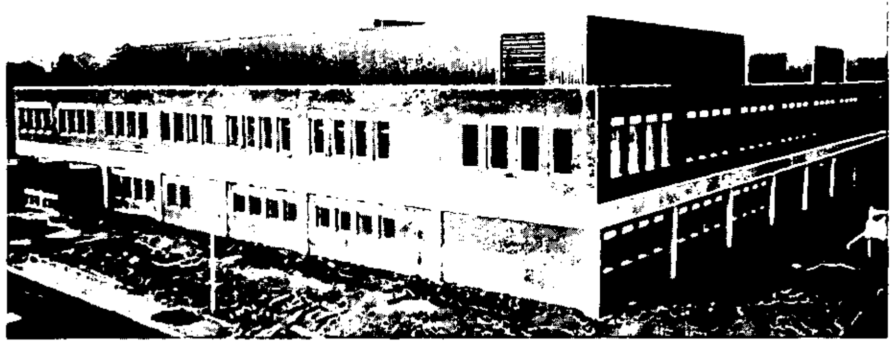
The report, published in 1972, concluded that an all-electric hospital would show considerable cost savings over its life span, compared with a conventional fossil fuel solution. The East Anglian Regional Health Authority subsequently decided to proceed with an all-electric building. This was to be a geriatric hospital with 120 beds, plus a 20 bed isolation ward, day hospital, x-ray and physiotherapy departments, staff dining accommodation and a large kitchen. The kitchen would also serve other buildings on the site, with a total of up to 600 main meals.

Fenland House is a two-storey rectangular building, 90m×50m×8m high with two internal courtyards, and with plant rooms on the roof. Figures 1 to 3 show the building layout. The total floor area is 6712m^2. The capital cost savings accrued by using all-electric services instead of fossil fuel, were invested in measures which would reduce the energy requirements. Thus the walls, roof and floor are insulated, there is sealed double glazing with external solar blinds, and full mechanical ventilation with heat recovery is employed.

In order to eliminate any possibility of cross contamination, the ventilation is separated into 'clean' and 'dirty' areas. For the 'clean' areas, which include the general wards, day hospital and administrative areas, heat recovery using thermal wheels is employed. Run-around coils are used for the 'dirty' areas which include toilets, bathrooms, isolation ward and kitchen. Fresh air is supplied at a rate of 6 air changes per hour generally, with 10 changes in toilets and bathrooms and 15 changes in the isolation ward. A schematic drawing of one typical ventilation plant is shown in Figure 4.

With the measures taken, the fabric heat loss is 134kW, 20W/m^2. The gross ventilation loss without recovery would be 752kW, 112W/m^2, and with recovery the loss is 332kW, 50W/m^2. The latter excludes the kitchen cooker hood ventilation. To make greater use of off-peak electricity, floorwarming was installed totalling 218kW, at a maximum loading of approximately 65W/m^2, although over the total floor area the average is only 33W/m^2. This loading was limited by the requirement to confine floor temperatures to 25°C, which was felt necessary for the comfort of the nursing staff. The floorwarming was divided into eleven zones, each with a floor thermostat and external temperature based charge control. Screened floorwarming cable was used to avoid the possibility of interference with medical equipment.

The remaining heat requirement is provided by heater batteries in each of the ventilation plants totalling 339kw, 50.5W/m^2, excluding kitchen hood supplies, with a small number of terminal re-heaters in sensitive areas. The main heater batteries have a binary step control, with a proportional control temperature sensor in



Exterior of Fenland House Hospital, Peterborough, prior to landscaping

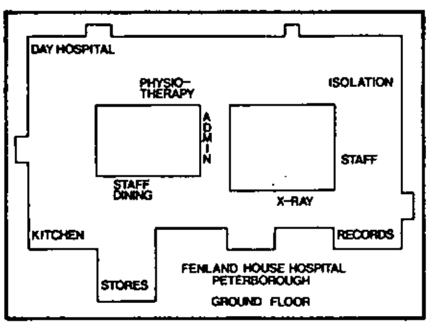


Figure 1 Ground Floor Outline Plan

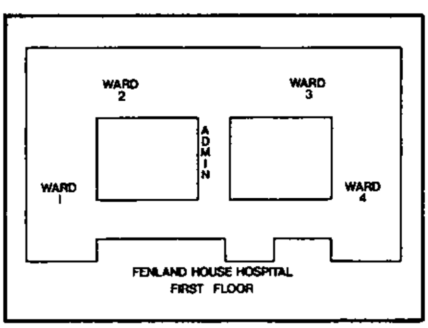


Figure 2 First Floor Outline Plan

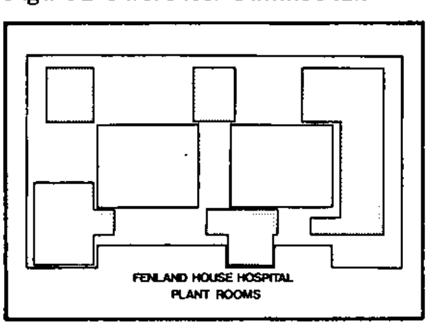


Figure 3 Location of Rooftop Plantrooms

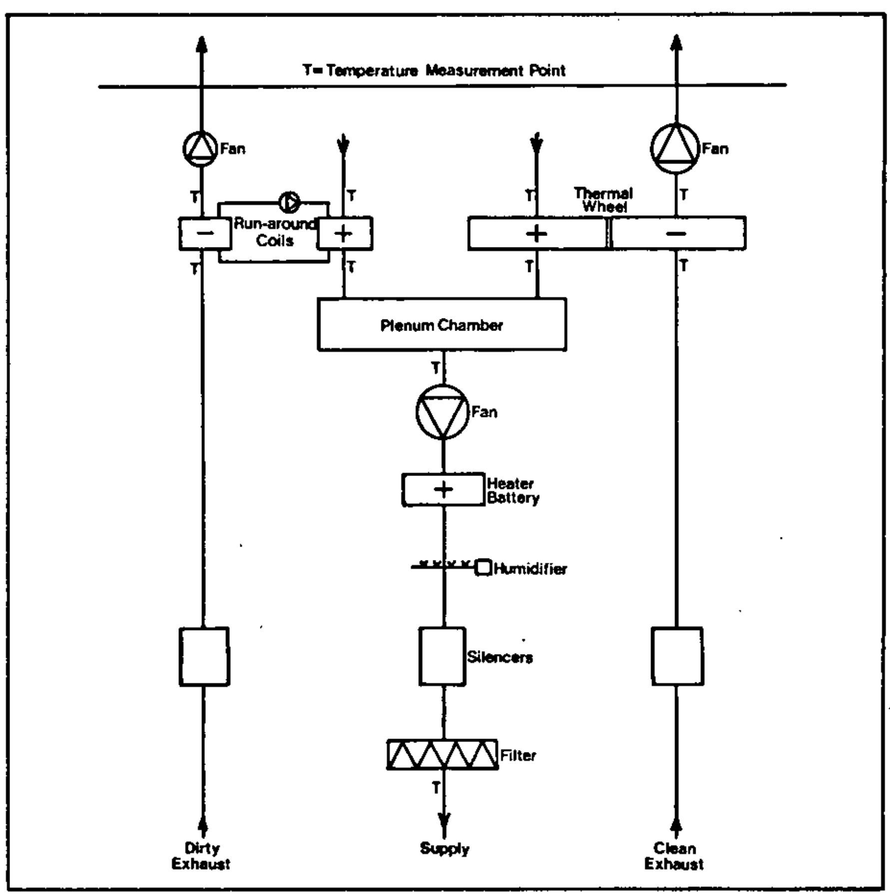


Figure 4 Ventilation and Heat Recovery Schematic

the return air duct, and integral action from a supply air sensor. The speed control for each termal wheel is also part of the same step sequence.

The winter design internal temperature is 21°C at an ambient of −3°C. Humidifiers were installed at the construction stage, but were not intended to be operated unless it could be shown that the relative humidity was unsatisfactory.

Hot water is supplied by six 2000 litre storage cylinders. These are charged overnight to 85°C by separate flow boilers, the water then being blended into a smaller vessel at 55°C and pumped round a pipe loop to the draw-off points. This latter vessel has a heater for topping-up if required, and for the kitchen dishwasher, which needs a very large quantity of hot water, the main vessel can be recharged during the day. A schematic diagram of a typical hot water plant is shown in Figure 5.

The hospital operates on a monthly Maximum Demand Tariff. Electricity taken between midnight and 07.00 is at off-peak rates, and the MD is recorded only between 07.30 and 19.00, Monday to Friday.

Since the hospital was the first of its kind, it was clear that it would be essential to monitor its performance in terms of maintained conditions, operational requirements and running costs. The Electricity Council, therefore, agreed to provide instrumentation for the first two years operation.

Instrumentation

With an all-electric building, the electricity costs are dependent on both the kWh consumption and, because of the structure of Maximum Demand Tariffs, the times at which the component loads operate. An essential requirement was, therefore, comprehensive metering of electricity usage.

This was carried out using kWh meters giving not only normal dial readings but also outputs to special recorders using magnetic tape, from which the demand in each half hour could be ascertained. The principal components were each metered as shown in Figure 6, with fan energy and general power found by difference. As each item of plant was split over a number of zones, each zone had to be covered and 42 electricity meters were required in total.

The resources required for a comprehensive investigation of all items of plant and the whole building would have been prohibitive, but selective monitoring was undertaken to obtain representative data.

To determine the typical operating efficiency, a multipoint temperature recorder was used to measure the air temperatures associated with one set of heat recovery plant. The measurement points are shown in Figure 4. Water consumption was measured for two plants, one serving a typical ward zone and the other the kitchen dishwasher, the largest user. In combination with the metered water heating energy, the efficiency of the hot water system could be assessed.

Selective internal temperature records were taken using thermographs, and the external temperature was recorded likewise, in a screen. Relative humidity measurement was included in some areas. Other measurements included recordings and spot readings of the temperatures of floorwarming panels.

Energy Consumption

Table 1 shows the energy consumption for twelve months for each element of the installation. The period taken is the latest available, to the end of February 1983. Results are shown in kWh, kWh/m^2 and % of total.

Heating and ventilation accounts for 62.7% of the total energy, with a combined consumption from heater batteries, floorwarming and fans of 280kWh/m^2. It is interesting to note the value of its three constituents. The fan energy is 87kWh/m^2, which is 19.5% of the building total and 31% of the heating and ventilation energy. This is a large amount, particularly compared with an office building, but it must be remembered that the fans not only provide a high rate of air change but operate for 8760 hours per year, whereas a typical office would record about 3000 hours.

The metered heat energy of the floorwarming and heater batteries is 193kWh/m^2, in the ratio of 34% to 66%. It is considered that the proportion of the heat provided by

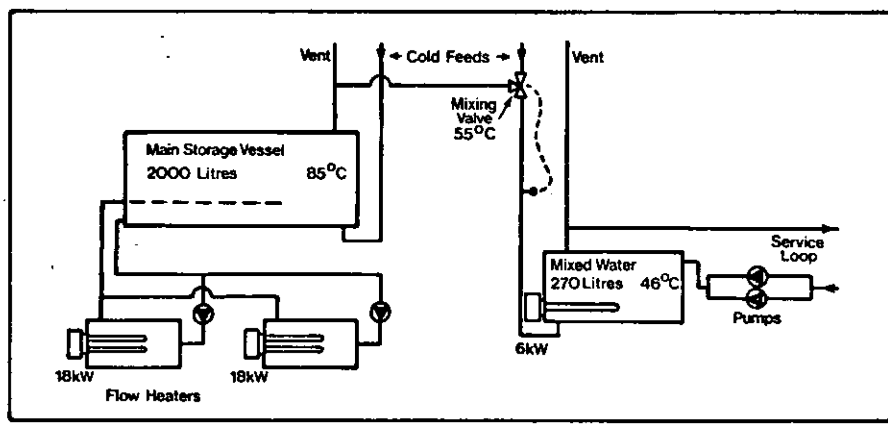


Figure 5 Hot Water Plant Schematic

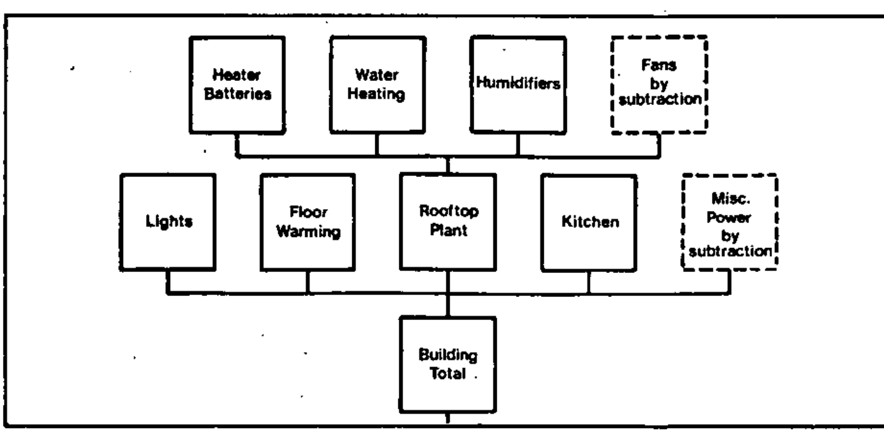


Figure 6 Electrical Metering

the floorwarming could have been greater, and this is discussed later.

Lighting energy is low, at 27kWh/m^2, which with an installed load of 16.4W/m^2, represents a load factor of only 19%. Three things contribute to this. The natural lighting level is good; patients are in bed early in the evenings, so that the evening consumption is small; and the staff are attentive to the saving of energy by switching off lights when they are not required. There are additional over-bed lights whose consumption is included in the small power, but the additional load is only 13%.

It is to be expected that the hot water requirement in a hospital would be very much greater than, for instance, in an office building, and the electricity consumption of 69kWh/m^2 reflects this. Metered figures for offices have been found to be from 18kWh/m^2 to as low as 2kWh/m^2, but this is very dependent on the type of system used and the associated losses. It is more important here to look at the efficiency of supply and this again is discussed later.

Of the other loads, the kitchen usage does, as has been noted, include for the provision of meals to other buildings on the site. Fenland House in isolation, could be expected to use perhaps only one third of the recorded amount, which was 38kWh/m^2. Small power, which is found by difference, includes items such as lifts, x-ray equipment, vending machines, nurse call system, and over-bed lights.

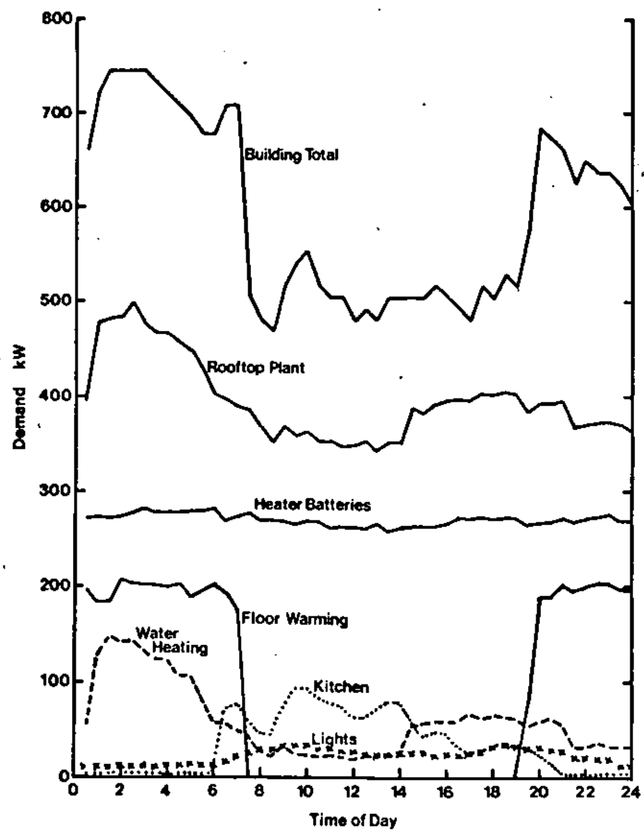


Figure 7 Electrical Demand Curve for 9 February 1983

Electrical Demands

With the tariff used, a charge is made based on the highest demand recorded each month between 07.30 and 19.00 hours. In the 1982/83 tariff the charge was £4.35/kVA in December, January and February, £1.93 kVA in November and March, and £0.31 kVA for other months. The test metering installed measured kWh and not kVA, but checks showed that the power factor was virtually unity, so there is little error in equating the two.

Figure 7 is a graph of the demands for the day having the highest chargeable demand in the year ending 28 February 1983. This was 9 February 1983. It may be seen that during the chargeable period the individual demands fit together without producing any very large peaks. The kitchen load shows a small peak at 10.00, but there is not a great deal of room for manoeuvre in the usage pattern of the kitchen.

It will be noticed that the floor warming load is operating for twelve hours here. Whilst only seven hour's electricity can be taken at night rates, the remainder is taken without incurring additional maximum demand. By storing this quantity of heat, the chargeable demand is reduced for the following day, since less direct heat is required. The floorwarming charge is shortened as the ambient temperature becomes higher.

Since the building is continually occupied, and the heater batteries are used 24 hours a day, there is of course no large preheating requirement. The annual load factor is, therefore, higher than for most commercial buildings.

Table 1 Energy Consumption for Year Ending 28 February 1983

	kWh	kWh/m^2	% of Total	% Off-peak
Building Total	2,999,600	447	100.0	38
Lighting	177,800	27	5.9	17
Water Heating	464,400	69	15.5	49
Kitchen	258,100	38	8.6	17
Heater Batteries	851,300	127	28.4	34
Floor Warming	443,400	66	14.8	74
Fans	585,900	87	19.5	29
Small Power	218,700	33	7.3	17

$$\text{Load Factor} = \frac{\text{Annual kWh Consumption}}{\text{Max. Demand} \times \text{Hours/Year (8760)}}$$

For the hospital, the load factor is 46%, while the average for large commercial buildings is 38%.

It also follows for the heater battery consumption, that all units taken during the 7-hour night period are at the off-peak rate. Since the external temperature is lower at night, slightly more than 7 twenty-fourths of the consumption is, in fact, off-peak.

The monitoring of the electrical demands enables any undesirable peaks to be identified and the load or loads concerned to be adjusted. With continuous usage, the hospital shows a generally favourable pattern, but the water heating load illustrates where adjustments can advantageously be made. In the earlier stages the water heating load was creating a noticeable load peak in the early afternoon. This has now been reduced by attention to the location of the temperature controls and adjustment of operating differentials. Figure 8 shows for comparison the load curves for 9 February 1983 and 13 January 1982. The daytime water heating demand for 1983 is 63kW less than for the previous year, which represents a saving of £274 for one winter month. A greater percentage of off-peak units is also used.

The total building daytime demand is 708kW in the case of January 1982 and 552kW in February 1983. Part of the difference is attributable to the exceptionally cold weather on the former occasion. The ambient temperature on that day fell to −14°C. The example of the water heating does, however, show how significant cost savings can be made by careful attention to the way in which plant is operated.

Day and Night Consumption

Considering again the year ending 28 February 1983, the metered electricity for the whole building contained 38% off-peak units, which represents a considerable cost saving, in the order of £21,000 per annum, as against all full-rate units.

The percentages of off-peak units for the individual loads are shown in the final column of Table 1.

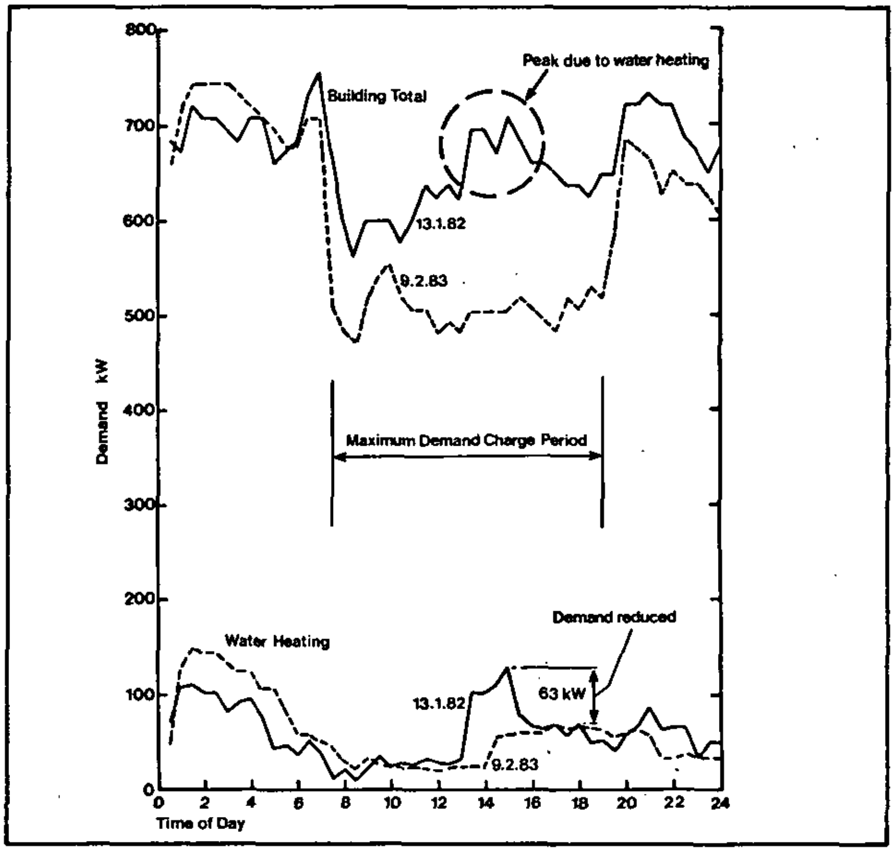


Figure 8 Demand Curve Comparison 1982/83

Running Costs

While the energy taken by a building is billed monthly at the prevailing rates, for the purposes of comparison it is simpler to cost at a single point in time, so that the figures can more easily be updated if required. The costs for Fenland House have therefore been calculated on the 1982/83 Eastern Electricity Maximum Demand Tariff with fuel costs as at March 1983.

The Demand Charges are therefore as previously stated, the unit costs are 3.43p day and 1.60p night, with a fuel cost adjustment of .0945p. Using these values, the annual costs are as follows:

Demand Charges	£ 9,363	£ 1.39/m^2
Unit Charges	£84,816	£12.64/m^2
Total:	£94,179	£14.03/m^2

A significant point concerning the running costs is the relatively low contribution made by demand charges. This illustrates better perhaps the particular advantages noted earlier whereby the continuous occupation of the hospital produces a favourable demand pattern.

The DHSS have carried out a survey of comparative energy usage and running costs in a sample of 201 geriatric hospitals, for the year ending 1 June 1982. The criteria adopted for comparison are the energy and cost per 100m^3 of occupied space. In Table 2 are shown the figures for Fenland House, for the national average, and for Hinchinbrooke Hospital. The latter is a 1976-built two-storey building having 112 beds, and therefore similar in broad terms to Fenland House. It is built to Building Regulation Standards, is naturally ventilated and heated by oil, and typical of the type of hospital being built at the time Fenland House was conceived.

CHANGE OF PUBLISHER

Please note that as from the October 1983 issue, the new publishers of HOSPITAL ENGINEERING are:

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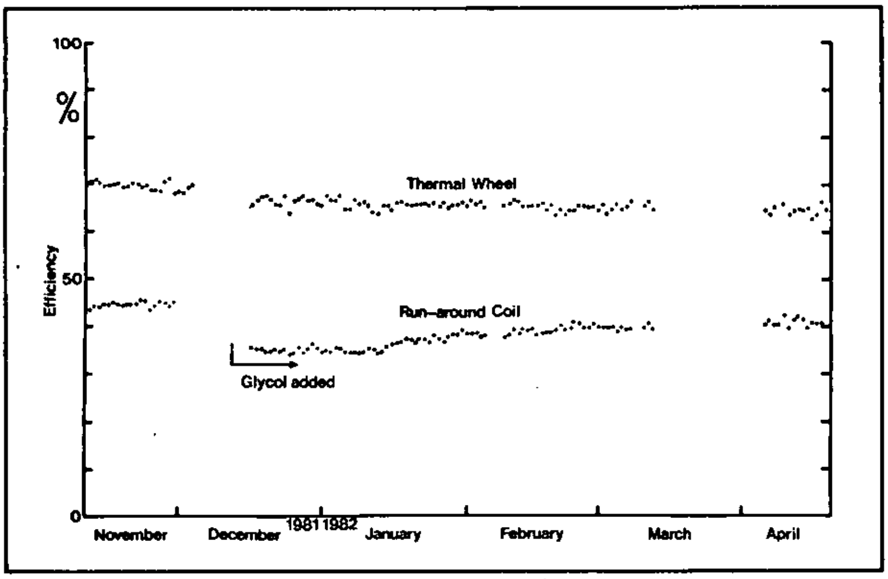


Figure 9 Measured efficiency of heat recovery devices

The values for Fenland House are adjusted for a normal use of the kitchen, rather than it serving other parts of the site; the non-adjusted figures are in parentheses. For the other hospitals, the values have been adjusted for boiler efficiency to put all values on an equal basis.

From Table 2 it may be seen that Fenland House has an energy consumption well below that for Hinchinbrooke and the national average. On energy cost it comes between the two. The figures used here in the DHSS comparison are for the first year's operation. The latest figures show an energy and cost saving due to the elimination of control problems and the use of improved operating techniques learnt from early experience. The later figures are also shown. It should be borne in mind when making a comparison that there is a considerable advantage in having mechanical ventilation. Compared with naturally ventilated buildings, there is a marked reduction in odour, which is a significant factor in a geriatric hospital.

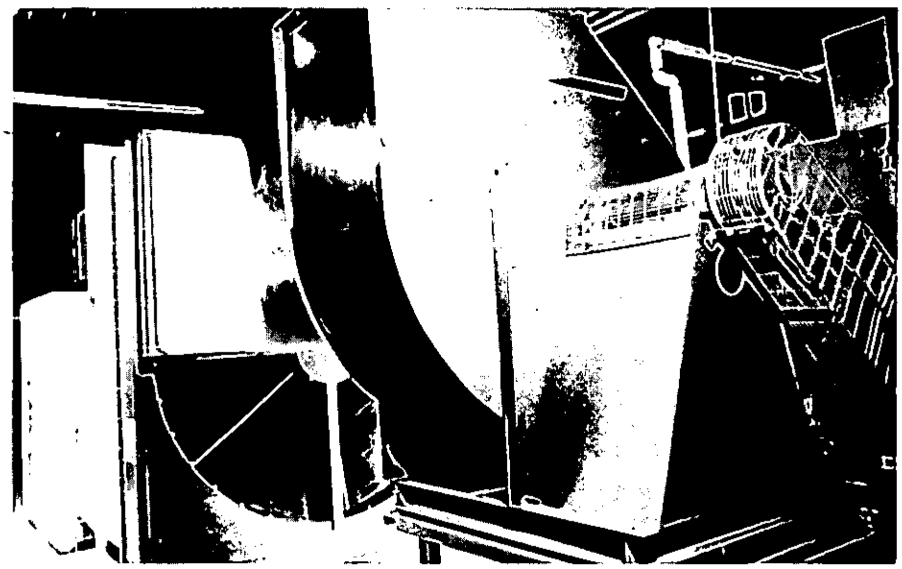
Heat Recovery

Temperature measurements of the airstreams on and off the thermal wheel and run-around coil of one plant, enabled the sensible heat recovery efficiency to be assessed. The efficiency was defined as the temperature drop of the exhaust air across the device, divided by the temperature drop if the air had been returned to its initial state, ie to the temperature of the incoming fresh air.

Figure 9 shows the values measured over a period of weeks. The values are daily averages. It may be seen that the efficiency of the thermal wheel starts at a little over 70% but slowly drops, settling to around 65-66%. This loss of performance is attributed to dust deposition.

After starting at an efficiency of 45%, the run-around coil drops to 35%. There is unfortunately a break in the record here, but during this period the coil was damaged by freezing, and a glycol mixture was added after it had been repaired. There is subsequently a gradual recovery to 40%. The reason for this has not been determined, but one possible answer is that air was not fully eliminated when the coils were re-filled, but that this air gradually worked its way out. It does seem, however, that the addition of glycol in itself caused a drop in efficiency of about 5%.

An associated point which the temperature measurements brought to light was that the heat from the fan motors raised the temperature of the



Thermal wheel installation

Table 2 Hospital Energy and Cost Comparison

		Energy Consumption kWh/100m^3	Energy Cost £/100m^3
Fenland House	1981-82	11668 (12457)	342 (365)
Fenland House	1982-83	11047 (11809)	324 (346) at 1982 prices
Hinchinbrooke	1981-82	13001	309
National Average	1981-82	15358	378

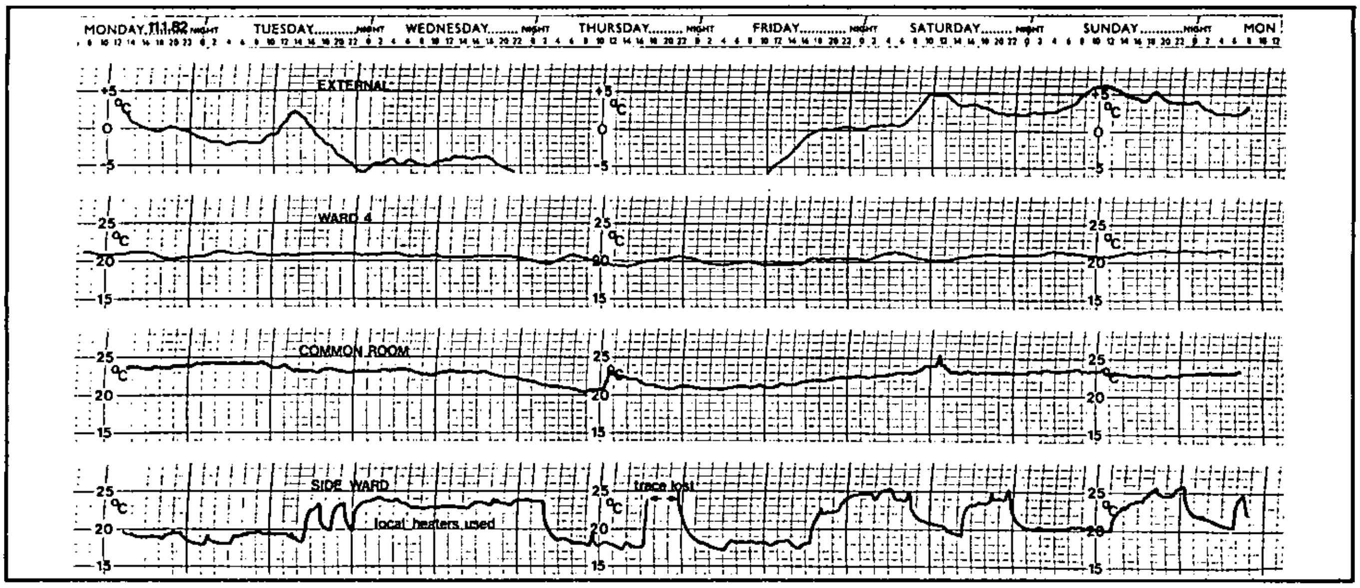


Figure 10 Thermograph Records for Cold Week

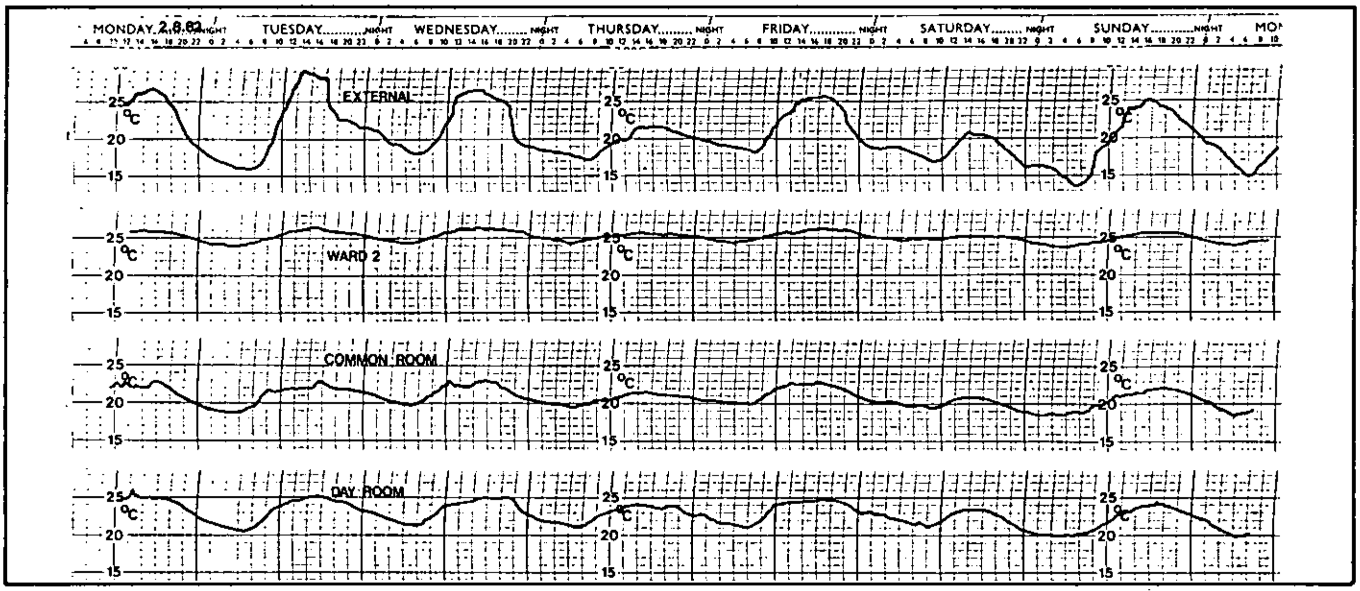


Figure 11 Thermograph Records for Hot Week

plant room by 2°C-3°C. The inlet air was taken from the plant rooms rather than directly from outside, so that the fan heat contributed to the heat requirement of the hospital. It also followed, however, that this gain was present in summer when it was not required.

As only one plant was monitored, it is not possible to know the efficiency of all the recovery devices. However, assuming a similar performance, it is calculated that the total heat recovered during the heating season was approximately 1,540,000kWh, or 230kWh/m^2. The recovered heat, therefore contributed 55% of the total heating energy.

Internal Conditions

The internal conditions of the hospital may be illustrated using thermograph records. Figure 10 shows some of these for the coldest week covered from 11th to 18th January 1982. The external ambient fell to −5°C on Tuesday night, and dropped further on the Thursday, off the thermograph chart. Other local records show that the temperature fell to −14°C. The second trace shows the temperature in one of the wards. The temperature here fell to 19.5°C during the very cold spell, but maintained 21°C in normal design weather.

Earlier in the winter there had been some difficulties in achieving the full floorwarming charge, and temperatures in some areas did not quite reach design. This had not fully been corrected at this point, but once this had been done shortly afterwards, subsequently, there were few problems maintaining comfort conditions.

Some re-balancing of the air supply was found to be necessary. This was shown up by the temperatures in some smaller individual rooms. For instance the third trace shows a common room with temperatures above design, and the last trace shows under-heating in a side ward, necessitating supplementary heaters.

For the second winter, 1982/83, temperatures throughout the building have been maintained at all times with the small exception of two side wards which have required supplementary heat. These wards have a proportionally higher heat loss which could not fully be met by adjustment of air volumes, although this partially alleviated the problem.

Summer temperatures for the hottest week, from 2nd to 9th August 1982, are shown in Figure 11. The external temperature rose to 29°C at one point, and on 5 days reached 25°C or more. The internal temperatures varied around the hospital. In some areas, for instance the ward whose temperature is shown on the second trace, the temperature remained above 24°C virtually all the time and reached 26.5°C at the highest point. In other areas, as illustrated in the next two traces, temperatures were lower and, due to the intermittent occupation, showed a greater diurnal swing.

It was originally estimated that the internal summer mean temperature should not exceed 24°C and the peak should not exceed 27°C. In the ward the mean value was slightly higher than this, but it was realised that there was potential for reducing temperature without resorting to mechanical cooling. This can be illustrated by Figure 12, which shows the air temperature on and off the thermal wheel for a typical warm summer day. It may be seen that when temperatures are at a peak, the thermal wheel does remove some heat from the inlet air. However, due to the heat gain in the plant room, from the fans and solar gain through the walls and roof, the air supplied to the wards is still warmer than ambient. It would therefore be preferable for the inlet air to be drawn directly from outside.

It should also be noted that during the night there is some heat recovery, yet the extract air is at 24°C. Using external air and with no recovery, it should be possible to pull down the internal temperature during the night, to give a pre-cooling effect which would carry over a benefit to the warm period of the day.

Although humidifiers were installed, they were used only for a very short period in extreme conditions. Low humidity was not considered a problem, and therefore manual control was felt to be adequate.

Hot Water Efficiency

Checks were made on two hot water plants, one serving the main kitchen dishwasher and the other serving a ward zone. It was found that the former had a consumption of over 4000 litres per day, and the latter of approximately 1800 litres per day. The kWh consumption of each plant was known, and from this the operating efficiencies were estimated. This gave a value of 49% for the ward zone and 79% for the dishwasher supply. That the higher user is more efficient is to be expected, as standing losses are fairly constant. The efficiency of the ward supply is better than has been found in many hospitals, but further study of the pattern of requirements will be made to ascertain if further savings are possible.

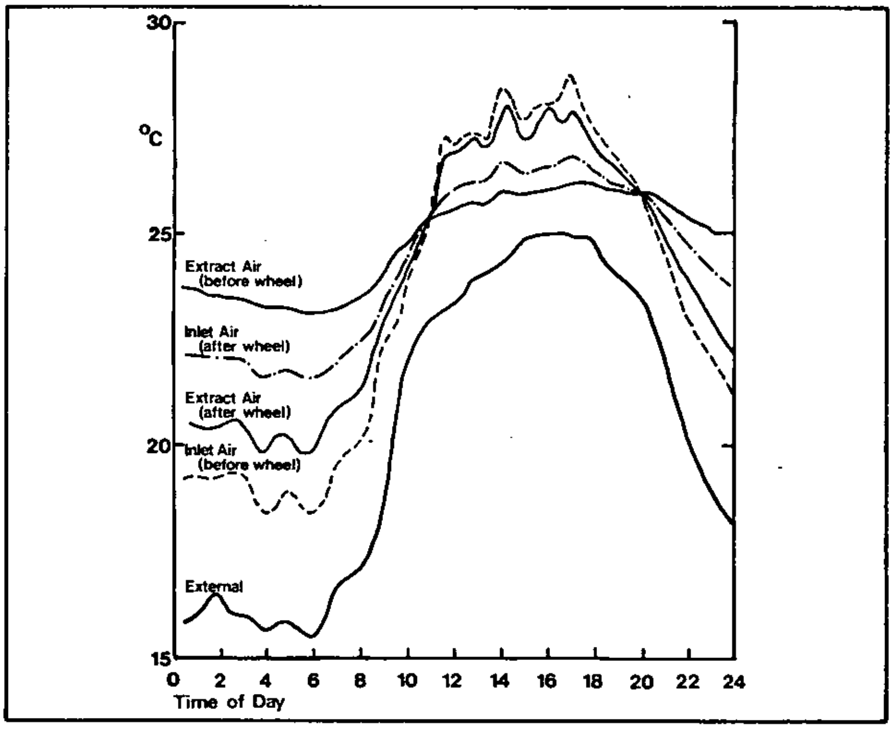


Figure 12 Air temperatures at thermal wheel – summer

Commissioning and Operational Experience

During the construction of the hospital there were contractual difficulties, which led to a delay in completion, with the plant standing idle for some time after commissioning. The effects of this were revealed after occupation when an unexpectedly high number of failures occurred in fan bearings, pump glands and bearings, and brushes on the thermal wheel motors. Once the initial spate of replacements had been dealt with, their maintenance subsequently settled into a normal pattern.

Another problem which was evident in the early stages of occupation was the reaction of staff to the new building. Complaints were made of headaches and lassitude, for which no clear reason was put forward, although there seems little doubt that the sealed windows and lack of external contact were underlying factors. The monitoring enabled the equable temperatures to be demonstrated to the staff, and it was clear from the absence of odour that the six fresh air changes were conferring great advantages. Regular meetings were held to review the matter, but with the passage of time and greater familiarity with the building, the complaints faded away.

Floor Warming

The floorwarming controls comprised, for each of eleven zones, a floor temperature thermostat and charge controller operating on external temperature. During the earlier part of the first winter's use, a shortfall was observed in the charge taken. Both of the controls were therefore examined.

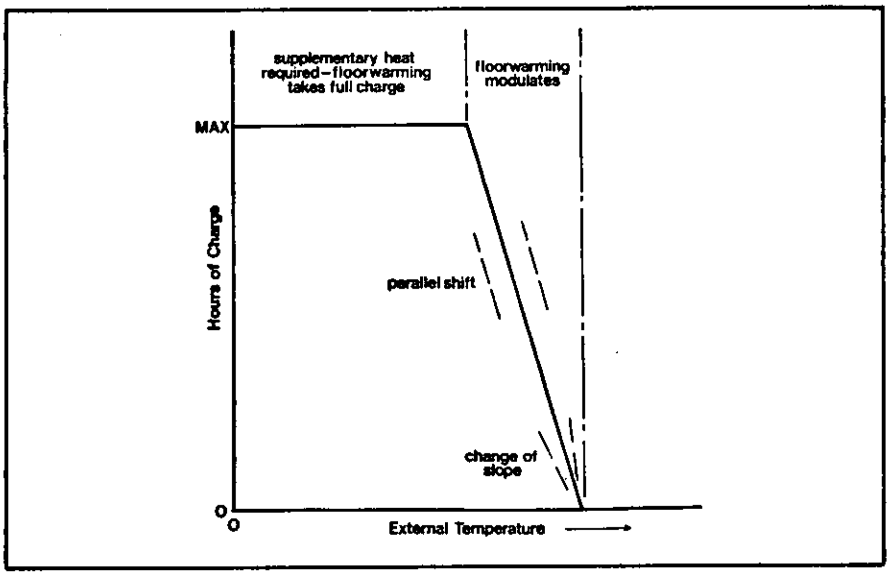


Figure 13 Floor Warming Control Characteristic

The characteristic required of a charge controller is shown in Figure 13. The maximum hours of availability are determined by a timeswitch, and the controller then imposes a time delay related to the external temperature, to modulate the charge.

As the floor warming provides only part of the heat requirement, it will require to be supplemented by the heater batteries at design temperature and in a temperature band above this until a balance is reached. The balance is when no supplementary heat is required. Until this point, a full floor warming charge can be taken, and above this point the floor warming charge should be reduced until eventually no heat is required.

In practice, the original charge controllers had an insufficient range of adjustment of the slope and intercept of the control line. It was also found that humidity affected the outside probes and consequently the charge characteristic, but although this was cured, the charge remained irregular.

Additional checks showed that the floor thermostats were switching off the charge early. Since the probes for these are necessarily sunk into the floor, yet are required to limit the surface temperature, the set points have to allow for difference across the floor screed. The necessary allowance evidently varied between zones, and the correct set points were therefore selected empirically using additional portable recorders, to show the floor surface temperatures and the switching of the power to each floor circuit.

In the course of these adjustments, it was also established that floor temperaures could be allowed to go above 25°C, and more heat could therefore be extracted. A surface temperature of 27°C was acceptable, which would in fact allow a slightly higher temperature still during the night hours. This is in line with previous practice; the initial caution in this instance being out of concern for nursing staff who spend a higher proportion of their time on their feet than occupants of, for instance, an office building.

Having satisfactorily adjusted the floor thermostats, further consideration was given to the external charge control. It was found possible to modify the control units to give a steeper slope to the characteristic. However, the ambient conditions where the floorwarming is required to modulate occur in the autumn and spring periods, when the variation between night and day temperatures can be wide. The adjustment of the charge period according to the night temperature can therefore lead to over or under-charging.

For much of the time, when the floorwarming requires to be supplemented by the heater batteries, the control has been purely on the floor thermostats. In milder weather, manual adjustment of the charge period is quite successful due to the thermal inertia of the building. Recently however, a micro-computer controller has been purchased, and a programme is being developed which will take account of a wider range of building and weather conditions over a longer period of the day. It is hoped that this will provide an improved automatic control, but for the present there is no commercially available control of this nature.

Heat Recovery

As mentioned earlier, the exceptionally cold weather of the first winter caused the run-around coils to freeze and burst. The cause and effect were clear, and repairs were quicky completed. However, in the interim period the persistent extremely cold weather made additional heating necessary to make good the shortfall. Domestic fan heaters were used, and for a short time the floorwarming was operated for 24 hours a day. The coils were refilled with anti-freeze, with some loss of efficiency as previously noted.

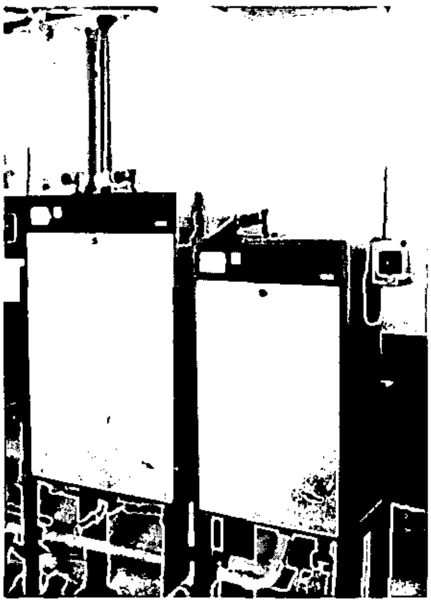
Another problem already noted briefly was the deposition of air-borne particles in the thermal wheels. The severity of this was unexpected as in theory the frequent reversal of the airflow through the wheel matrix should give a self-cleaning effect. The deposits were at first thought to come from new carpets, furnishing and bedding, but the problem remained. The principal constituent upon analysis was found to be lint from bedding.

Regular cleaning has been instituted. This is difficult, the most effective means being compressed air, although care is needed not to damage the wheel, which is constructed of thin aluminium corrugations. It is hoped to effect a permanent solution by installing additional extract filters.

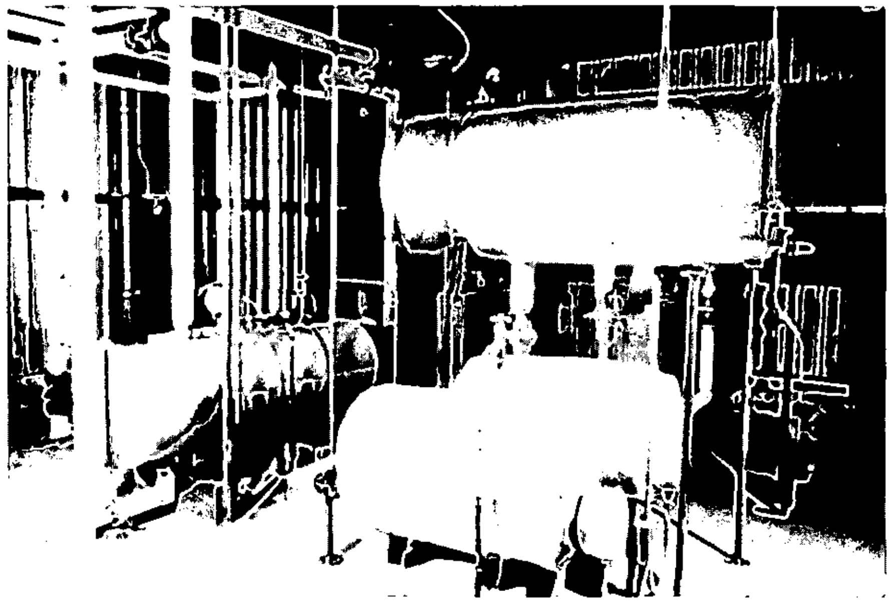
The effect of the fouling on the recovery efficiency of the wheel has been noted. On the wheel being monitored efficiency has not fully recovered after cleaning, so it would appear that there are some residual deposits which cannot be removed.

Heater Batteries

There have been several failures of heater battery elements, and in the early days it proved necessary to change the connectors to the heater batteries for a more substantial design, as those used at first gave problems with a high temperature rise. This does illustrate the need for regu-



Steam humidifiers



Hot water plant

lar preventive maintenance, since with electrical equipment of this nature there is often no indication of a fault until a drop in output produces a complaint.

Three monthly checks are now carried out on heater batteries using a clip-on ammeter on each phase of each element.

An obscure problem concerning one plant was identified as being due to air temperature stratification. On part load, the heater elements in operation were concentrated towards the top of the duct. The resulting stratification persisted past a horizontal division into ground and first floor ducts, giving severe balancing problems. The solution was to turn the heater battery through 90 degrees.

Hot Water

Hot water is supplied from six plants as previously described and shown in Figure 5. Soon after operation commenced, failures began to occur in the flow boiler heater elements, which are rated at 18kW. The reason for this had not been identified when one of the 2000 litre vessels imploded and fractured. A general check showed that some other vessels had begun to implode under their lagging, and the plants where this occurred were those where heaters had failed.

Various contributing factors were suggested, and corrective measures applied. The main conclusions were that boiling had occurred in the flow heaters due to inaccurate control thermostats, but that an inadequate circulation had contributed to this by allowing a rapid temperature rise. Steam discharged into the main vessel rapidly condensed causing a vacuum.

Doubts were also cast on the adequacy of the system vents to relieve the vacuum. The vents from each hot water plant were taken to a common ring at first floor ceiling level, which then vented to the central cold feed tank.

Corrective measures included the redesign of the circulating pipework between the flow heaters and main cylinder, and the provision of dual pumps instead of a single pump. The pumps were located vertically instead of horizontally as before, as it was thought that the pump operation could have been impaired by collection of gases released from the water at high temperature. Additional thermostats were added to the flow heaters, and the vents were altered, being taken directly to atmosphere. This latter step obviously required the provision of trace heating along the vent pipe to avoid the risk of freezing.

One further modification was made to the system for a different purpose. As installed, the mixing valve between the main cylinder and the draw-off vessel was controlled by a temperature sensor in the mixed outlet pipe. It was found under conditions of no water draw-off that gravity circulation was sufficient to cause the valve to close. On an ensuing draw-off, there was an initial slug of cold water which activated the make-up heater. Excessive energy was therefore taken by the make-up heater, which should have come from the storage vessel. Relocation of the sensor to further down the pipe has cured this problem, and has contributed to the considerable reduction in electrical demand for hot water previously noted. The mixing valve now controls at 55°C and the make-up heater at 46°C.

The hot water system is now operating satisfactorily, although the demands of the kitchen dishwasher are such that the 2000 litre store is inadequate, and the main heaters have to be on continuous supply. The supply of meals to staff on the larger site has caused this great demand. An additional 2000 litre storage vessel is to be installed.

Ventilation

It was clear from an early stage that the provision of six air changes to the ward areas was highly beneficial in eliminating odour, and Fenland House has a superior environment in this respect.

However, even with heat recovery the provision of this quantity of fresh air requires a considerable amount of energy, for both the fans and the heater batteries. As an experiment therefore the fan pulleys on one plant were changed to reduce the airflow to four air changes. The flow to the toilets etc. was not altered.

Odour levels are notably difficult to quantify, but the change in air volume has not at present caused adverse comment in the zone affected, and for the present the experiment is continuing. Experience during the summer is expected to bring a definite conclusion as to whether the lower fresh air volume is adequate.

It has been noted that the internal environment in the summer could be improved if cooler air could be introduced. Two modifications to the ventilation plants are now in hand which will assist in this. Firstly, additional filters are to be incorporated with the primary purpose of protecting the thermal wheels. This will also however allow the wheels to be stopped completely, whereas at present they are kept running in summer at low speed to reduce fouling. Even at low speed, there is some heat recovery. Secondly, modifications are to be made to provide bypass ducting on the air inlet. This will enable air to be drawn from the plant room in winter, when the fan heat is useful, but directly from outside during the summer.

With these modifications, it is anticipated that equable internal temperatures will be maintained throughout the hospital this coming summer.

Conclusions and Recommendations

The primary conclusion which can be reached is that an all-electric hospital can be built within existing capital cost guidelines, provide a superior environment and yet exhibit comparable running costs to a modern hospital built on conventional lines with oil heating.

Hospitals are long life buildings. Present evidence suggests that both gas and oil will be scarce and expensive well within the anticipated life span of Fenland House. It is considered that the validity of the all-electric concept will be increasingly emphasised in successive years.

An important question to be asked is what changes would be made with the benefit of hindsight if Fenland House were being planned now? In answer to this, it can be said that the fundamental approach, using thermal wheels and run-around coils for heat recovery, has worked well. The alternative which would come to mind is to use heat pumps. Using the extract air as the heat source, a high coefficient of performance could be achieved, and the energy consumption would be less. Additional capital costs would be introduced, which would require several years for payback. There would also be greater maintenance costs.

If heat pumps were to be used, it would need to be on the additional basis of a cooling requirement. It has been seen that internal temperatures in summer could for preference have been lower, but the scope for reducing these with the existing plant had not fully been explored. A particular recommendation for the future is to ensure the maximum use of free air cooling on the lines suggested.

The use of floorwarming has made a worthwhile contribution to keeping down unit and maximum demand costs. However, greater use could be made of floorwarming on two counts. Firstly higher floor temperatures could be used. It is considered that 27°C is a satisfactory temperature during the main daytime period, which would allow 29°C at the end of the charge period. If a greater variation in floor temperature is accepted, it would also follow that floor loadings could be increased to allow charging over seven instead of twelve hours, such that all units were at off-peak rates.

The floor area actually utilised for floor warming was 68% of the total on the first floor and 39% on the ground floor. Obviously there are limitations in areas with fixed equipment, and floorwarming would not be provided in the kitchen. Nevertheless it is considered that further areas could have been identified to bring the totals to 75% and 55% respectively.

Having corrected the main faults with the floorwarming control, the latest consumption figures closely approach the theoretical optimum for the existing load. With an increase in load it is considered that it would be possible to provide half the metered heating energy by floorwarming, and reduce costs by a further 6-8%. This would require floor loadings of 130-150W/m^2, and close control would be needed, with smaller zones whose individual requirements could be matched.

Given that the floorwarming provides the base heating load, the close control of room temperatures is achieved using the heater batteries. At Fenland House these are central heater batteries serving whole zones, and it has been noted that there were some difficulties in achieving equal temperatures in all areas. This would be greatly simplified using terminal heaters as opposed to the present system. In a future design it would be worthwhile considering this option in some detail, although admittedly the capital cost would be increased.

Other than the problems which have been identified, and have been or are to be corrected, the story of Fenland House to date is a successful one, and it is hoped that the foundations laid will be used to advantage in future hospital building.

Table 3 Data Summary Table

Gross Floor Area	6712m^2
Number of Beds	140
Design Temperature	21°C at −3°C external
Heat Loss – Fabric	20W/m^2
Heat Loss – Ventilation	
a without recovery	112W/m^2
b with recovery	50W/m^2
Installed Loads	
Floorwarming	33W/m^2
Heater Batteries	50.5W/m^2
Annual Energy Requirement	
Heating – Metered	193kWh/m^2
– Recovered	230kWh/m^2
Building Total – Metered	447kWh/m^2
Electricity Costs – year ending 28.2.83	£14.03/m^2

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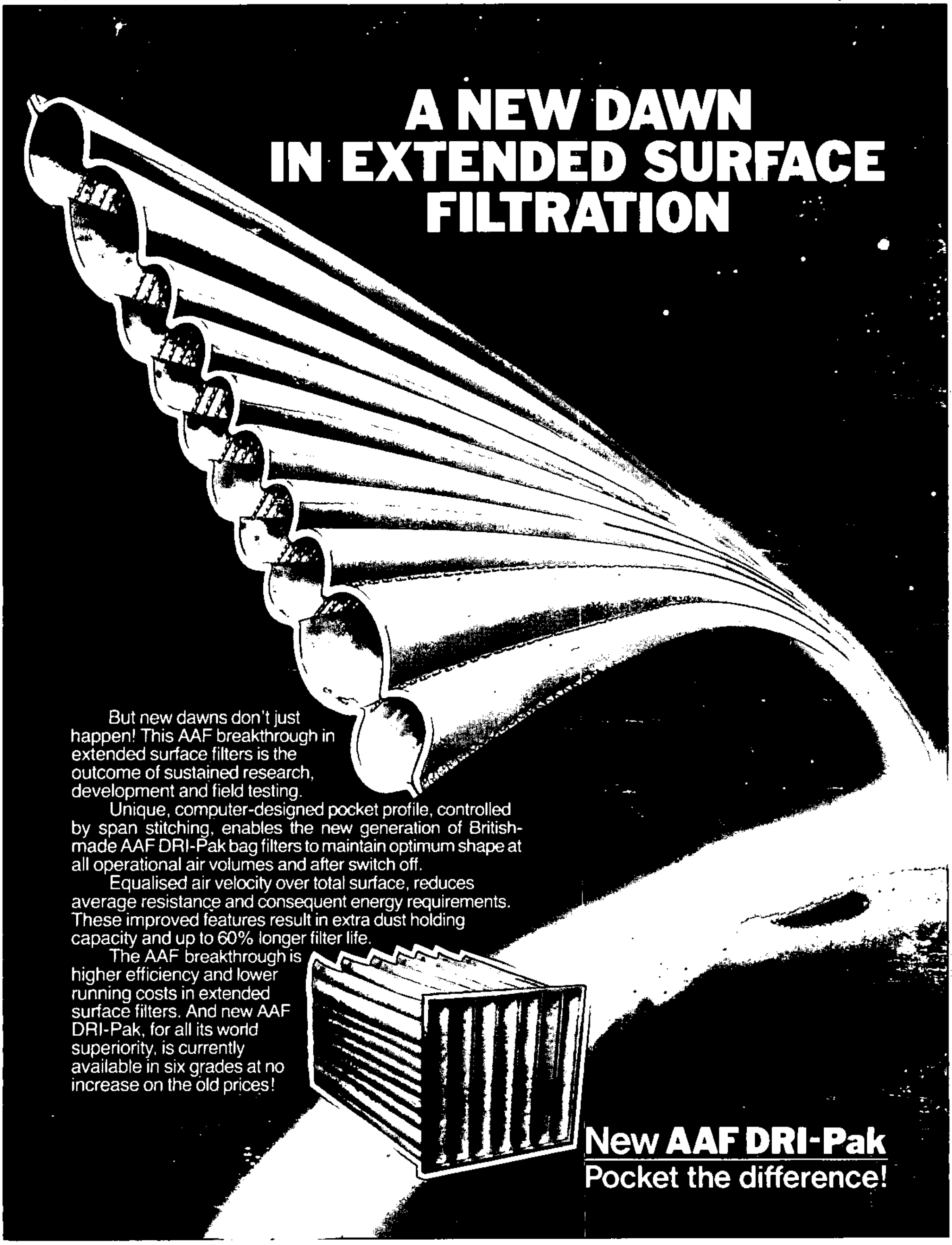
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13 October 1983

Mr B A Hermon CBE CEng MICE FIMechE FCIBS CIHospE
Regional Works Officer
South West Thames Regional Health Authority
40 Eastbourne Terrace
LONDON W2 3QR

Dear Mr Hermon

I thought you might be interested to see an advance copy of TGV's first issue of HOSPITAL ENGINEERING. You will of course receive your usual copy a little later.

We have enjoyed producing the October issue, though we hope in future the whole process will be more streamlined and efficient. Meanwhile we're doing our very best.

Please contact us with any suggestions and comments. The more feedback we receive, the better for the Journal.

Yours sincerely

Megan Jackson

pp Jenny Campbell
Editor

enc