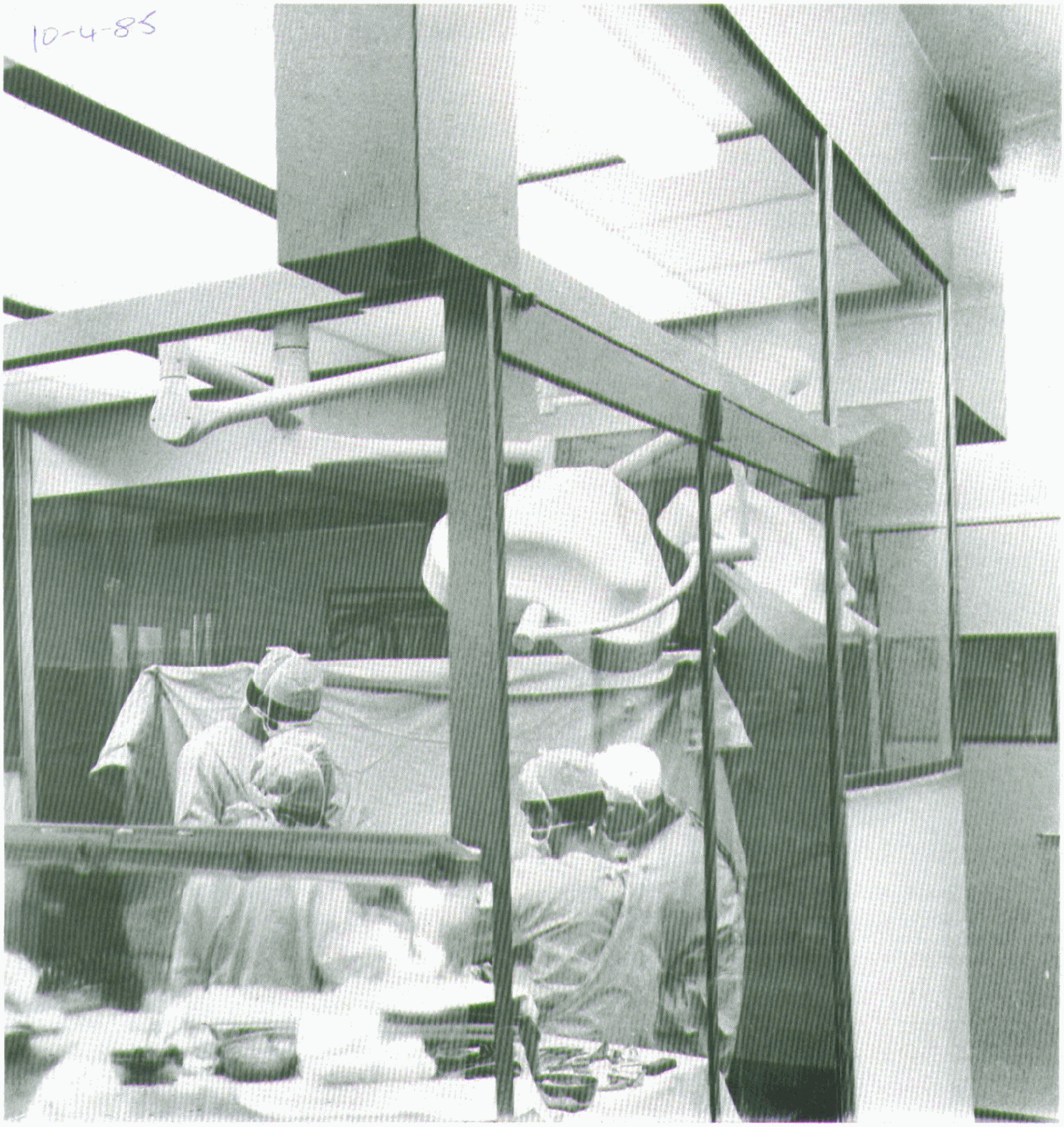
The Journal of The Institute of Hospital Engineering April 1985

HOSPITAL ENGINEERING



- Ultraclean operating theatres: cost efficiency and energy saving aspects
- Hospital developments: planning procedures and code of practice for NHS commissions

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HOSPITAL ENGINEERING

The Journal of The Institute of Hospital Engineering

Volume 39 No 4 **April 1985**

Front cover picture: Ultraclean operating theatre at Montchoisi Hospital, Switzerland

Institute News

The Presidency of The Institute

Council is most delighted to announce that the next President of The Institute of Hospital Engineering will be Mr John Bolton, Chief Works Officer and Director General of Works, Department of Health and Social Security.

The outgoing President, Mr Lawrence G. Hadley, will hand over the President's Jewel of Office at the Annual General Meeting of the Institute to be held in the Hotel Majestic, Harrogate on 24th May.

John Bolton, who was born on 30 December 1925 in Lancashire, was appointed Chief Engineer to the Department of Health and Social Security in London following an Open Competition by the Civil Service Commissioners in 1968. A reorganisation within the Department in March 1977 resulted in his appointment as the first Chief Works Officer and Director-General of Works, controlling the four Divisions in the Department concerned with the totality of Works and Estates activity, i.e. Engineering Division, Architects Division, Surveyors Division and Health Building Administrative Division. The four Divisions have since been formed into three multi-disciplinary Directorates and a Central Administrative Unit.

He served a civil engineering pupillage and mechnical engineering apprenticeship and after industrial experience entered the National Health Service in 1954 on his appointment as Group Engineer to the West Manchester Hospital Management Committee. He later became Chief Engineer to the United Liverpool Hospitals, and subsequently became Deputy Regional Engineer to the Leeds Regional Hospital Board and Regional Engineer to the East Anglian Regional Hospital Board.

Education and training have always been of interest to him. For many years he lectured on a part-time basis in engineering and building subjects, and during his stay in the Manchester area he held for some four years the part-time post of Principal of Irlam Evening Institute. The National Training Centre at Falfield, which is recognised internationally as a model training centre for Works staff, was developed during his early period as Chief Engineer to the Department. He is a Governor of Swaston Village College in Cambridgeshire — the original 'Henry Morris Village College' which caters for some 1400 pupils aged 11-16 yrs, and the various classes and events concerned with a thriving system of Community Education. Prior to this appointment he was a Manager of Shelford Primary School. He is a Freeman of the City of London and a Liveryman of the Worshipful Company of Fan Makers.

He was appointed a Companion of the most honourable Order of the Bath in the New Year's Honours List. He holds the Degree of Bachelor of Law with Honours of London University, and is a Fellow of the Institution of Civil Engineers, a Fellow of the Institution of Mechanical Engineers, a Fellow of the Institute of Energy and a Fellow of the Chartered Institute of Arbitrators. He is an Honorary Fellow of the Chartered Institution of Building Services and is the immediate Past President of the Institution. He is also an Honorary Fellow of the Institution of Public Health Engineers and an Honorary Fellow of the Institute of Hospital Engineering.

Included among his interests is writing, and he has presented many papers to International Conferences and to British Learned Societies. In addition to writing numerous technical articles for various journals over the years, he wrote the section on Steam for the 'Efficient Use of Energy' published under the aegis of the Institute of Energy and the Department of Energy, and he has contributed chapters to a number of British Hospital Export Council Yearbooks.

He is married and has three daughters, two of whom are now married, giving him three grandchildren. His youngest daughter, Sarah, takes her 'A' level examinations this year and hopes to read law at University College, London.

He finds time to involve himself in local Village activities ranging from being a Trustee of the Village Hall to reading the lessons once a month in the Village Church.

The Engineering Council New chairman

The Engineering Council announced today that Sir Francis Tombs, BSc, LLD, FEng, FIEE, FIMechE, Chairman of Turner & Newall plc, an engineering process company, is to be its Chairman from May 1, 1985, for a three-year period. Sir Francis succeeds Sir Kenneth Corfield who became the first Chairman of The Enginering Council when it was set up three years ago. Sir Francis, aged 60, is also a Director of N. M. Rothschild & Sons Limited, Rolls-Royce Limited, Shell UK Limited and Celltech Limited.

Obituary

Betty Lucas

The many friends and aquaintances of Betty Lucas will be saddened by the news of her death in February. Eversince Dr Bernard Lucas became President of the Institute in 1973, Betty has been a welcomed presence at the Annual Conference and a happy participant of the Ladies' Programme, and indeed of the entire proceedings. She will be greatly missed.

New HA Chairman

Dr Nicholas Varey has been appointed a chairman of Hull Health Authority from December 7 1984. Until his appointment Dr Varey was vice chairman of the Authority and is employed as a medical advisor to Reckitt and Colman, Hull.

West Midlands appoint RGM

West Midlands RHA has announced the appointment of Mr Ken Bales as its regional general manager. He has been the authority's regional administrator since 1973. He joined the former Birmingham Regional Hospital Board in 1962 as regional training officer.

Young Engineer for Britain 1985

Who will be the Young Engineer for Britain 1985? It could be any boy or girl aged from 12 to 19. The Engineering Council today launched this year's competition which encourages youngsters to design and develop their own engineering projects. The project can be simple or complex. Last year's overall winner was 13-year-old Richard Marsh, from the North East, with a wave power machine made partly from an old coffee tin and two watering can spouts. And three girls won a major prize with a sophisticated environmental control system, primarily to help disabled people Closing date for entries is March 31.

More details and entry forms can be obtained from Miss Janette Parsons, c/o Young Engineer for Britain 1985, The Engineering Council, Canberra House, Maltravers Street, London WC2R 3ER. Tel: 01-240 7891.

British Standards Institution

The Institute is still asked, from time to time, to nominate someone to serve on various BSI Committees. In the past most of this representation has been carried out by members of the London Branch because of the travel and cost involved but this has not been the invariable rule.

Would any member who would like to be considered for such service kindly advise the Institute's office, stating his 'speciality', so that a bank of volunteers may be built up in the Institute's records.

Needless to say, when any member's service became required we would contact him to ensure that he was still available.

Affiliate relationship with ICE

We are most pleased to be able to report that agreement has been reached with the Institution of Civil Engineers over the terms whereby the Institute becomes an Affiliate of ICE and, in turn, the basis of the Agreement has been approved by the Engineering Council.

The purpose of forming this relationship is to permit the Institute to continue to be able to sponsor for registration as Chartered Engineer any of its members who meet the necessary requirements.

Talking Point

The author is a Member of Council, Deputy Chairman of the Finance and General Purposes Committee, a member of the Education Committee and the International Affairs Committee.

Consultants are cheaper and better....

J. B. PACKER CEng FIMechE FCIBS FIHospE

'.....We must convince both governments and private firms of the value of independent consultancy.

'Why? Because our public administrations and our large companies have developed the tendency to do the engineering work themselves, or to ask the supplier to do so. We have developed chauvinistic and protectionist attitudes. We have allowed the development of expensive in-house engineering expertise to keep people occupied in our administrations and large companies.

'Fortunately, there is now a concern among those who have allowed such development to find a way to diminish their overheads. If we help the decision makers to understand that this is a wise policy, they will increasingly use outsiders to do jobs that are not in their main line of business, to give a chance to professional consultants to work more and more for public and private clients....doing jobs better and more cheaply, even with respect to what may seem to them to be relatively high fees.

'These fees are cheap compared with the huge overheads incurred by in-house engineering departments. The Americans and the Japanese understand this principle, and I don't know why the Europeans are fighting like devils in their home market and trying to gain good prices in their outside market. It should be the contrary.

'Even with high consultancy prices, I am convinced that nothing is more expensive than keeping in-house engineering services, and I speak as one with a long experience of both matters. The most expensive outside consultancy is cheaper. It is also more imaginative.'

The above comments are reprinted from the "Consulting Engineer" and represent the main theme of an address given to the Annual General Meeting of the British Consultants Bureau in October 1984 by Baron Envince Coppee.

Baron Coppee is a very distinguished Belgian Consulting Engineer with an international reputation and was focusing attention to a trend in European attitudes.

In the UK this trend is recognised as 'privatisation' and given the present political and financial climate it is with us. How much more valuable therefore it would be if public debate on this subject could encompass the wider implications involved such as re-direction of effort, change in attitudes, methods of working, procedures and time-scales.

Central to the philosophy of 'privatisation' is the introduction of more competition including competitive fee bids for consultancy services. This will force consultants to act in a more positive and cost effective manner but at the same time it will place constraints and a level of discipline on the employing authority that many may find difficult to accept.

Industry and the private sector have demonstrated that in terms of overall cost effectiveness Consultants are cheaper and better, but whether the Health Service can respond to the challenge and maximise the benefits in the same way remains to be seen.

Under the Rules of the Engineering Council applicants for registration as Chartered Engineer may only be put forward by a Chartered Institution or a Charter Affiliated Institution.

Council is most pleased to have developed this relationship with The Institution of Civil Engineers.

New Chief Inspector of Factories

David Eves, has been named Chief Inspector of Factories by the Health and Safety Executive in succession to Jim Hammer, recently appointed deputy director general of the HSE.

Mr Eves took up his post on 1 January, 1985. He was previously a deputy chief inspector of factories with responsibilities for the area offices of the Factory Inspectorate in the Southern half of Great Britain plus liaison with policy branches of the Executive on hazardous substances and overall control of staff, resources and planning for the Inspectorate.

General Manager for New Riverside Health Authority

Mr David Knowles, 43, has been appointed to head the proposed central London Riverside Health Authority, which is due to take over the responsibilities of two existing authorities in April.

At present district administrator for one of the constituent authorities, Victoria, Mr Knowles becomes general manager (designate) for the new Riverside H.A., which, subject to consultation, will take over the roles of Victoria, and Hammersmith and Fulham Health Authorities on April 1, 1985.

The new authority will cover a large area of central London and will manage the Westminster, St Stephen's, St Mary Abbotts, Charing Cross and West London Hospitals, in addition to wide ranging community health responsibilities and management of two major mental illness hospitals in Surrey — Horton and Banstead — which are due to merge.

1985 MacRobert Award

The Fellowship of Engineering acting on behalf of the MacRobert Trusts, makes an annual award of

A GOLD MEDAL AND A PRIZE OF £25,000

for an oustanding innovation in engineering or the other physical technologies which enchances the prestige and prosperity of the United Kingdom.

Submissions for the 1985 award are invited by 1st May.

Rules and conditions from: The MacRobert Award Office, 2 Little Smith Street, London SW1P 3DL. Tel: 01-222 2688.

East Anglian RHA Appoints Regional General Manager

East Anglian RHA has appointed an outsider to the post of regional general manager. Mr Mike King, 50, a management consultant and previously group managing director of Heatrae Sedia International Ltd, takes up his appointment on March 1st 1985 on a three-year fixed-term contract at a salary of £45,000.

The table shows the sources of recruitment of general managers at regional and district level

Occupation before appointment	Region	District
NHS administrator	9	61
NHS treasurer	1	3
NHS doctor	1	5
NHS nursing officer	1	—
Total NHS officer	12	69
Non-NHS employment	1	7
Total appointments to date	13	76
Occupation before appointment	Region	District
Outstanding appointments	1	116
Eventual total	14	192

The Engineering Council

The Engineering Council was established by Royal Charter to advance the education and training of engineers and technologists, and to promote the science and practice of engineering for the public benefit. The Council is concentrating on three main objectives:

(1) To increase public awareness of the vital role of engineering in society, and to demonstrate the direct and beneficial impact good engineering has on everyday life

(2) To improve the supply of qualified engineers and technologists

(3) To set up and maintain relevant professional, education and training standards.

The Engineering Council has the full support of the 51 professional engineering institutions. It has the power and duty of accrediting all engineering academic courses and training programmes and of registering all qualified engineers. Part of its work is to clarify standards of qualifications for Chartered Engineers, Technician Engineers and Engineering Technicians, and to ensure the increased recognition of these categories.

The Engineering Council is therefore a focal point for engineers of all kinds, industry who needs them and the academics who teach them.

Focus on Engineering

In its short life, the Engineering Council has gained a remarkable record of achievement. Its work is important because it fundamentally affects the status and quality of British engineering and the training which young engineers receive. Formed in the aftermath of the Finniston report it appeared to have so much to do on such a wide spread of problems that its critics felt that failure was inevitable. After three years what has it achieved? What is its relevance to young graduate engineers?

Weakness

One of the major weaknesses of engineers in this country used to be that the large number of bodies, each claiming to speak with some authority for their particular branch of engineering were rarely able to reach complete agreement on policy. The conviction required to convince government, industry or the academic world that changes should be made could rarely be summoned.

The Engineering Council has managed to produce a broad measure of agreement between the 51 chartered and non-chartered engineering institutions. By dividing them into five groups of institutions representing similar areas of engineering, it has emphasised the similarities between the bodies concerned and opened the way for mergers if they become appropriate. One driving force will inevitably be that the 36 non-chartered bodies will be able to use their association with the 15 chartered bodies as a route by which their members can reach the status of chartered engineer.

The five groups broadly cover mechanical and production engineering; civil, structural and water engineering; electrical and electronic engineering; chemical, metallurgical and mining engineering and finally, transport. Within the fourth group the Institute of Metallurgist and the Metals Society are merging to form the Institute of Metals.

Over the next few months the Engineering Council is setting up 20 regional offices. In each region six engineers of any engineering discipline will be elected to regional committees and all 120 representatives will take part in a national engineering assembly, a move which will encourage the democratic processes within the profession.

Before the formation of the Engineering Council, the Council of Engineering Institutions had already obtained a considerable degree of unanimity between institutions on the fundamental requirements of education and training for professional membership. The Engineering Council has continued this process but on a higher plain, taking into account the Finniston proposals. Last year a discussion document was issued on the *Standards and routes to registration of chartered engineers, technician engineers and engineering technicians*. This December a final document will be published.

The standards adopted and the routes to professional membership will have a profound effect on engineering graduates. Those with degrees in engineering subjects which are accredited by the chartered bodies will find it much easier to reach chartered status within the profession while those graduates with degrees which are not accredited will find the route to professional status longer and more difficult.

Government cuts

When the government announced its cuts in the financing of universities in 1981, it was envisaged that engineering departments would be less seriously affected than other university faculties. In the event it is now common knowledge that the opposite has happened and the number of engineers graduating in the next few years will be declining at a time when the demand for their services is expected to rise strongly.

The Engineering Council is pushing strongly for a switch of university resources to engineering faculties and away from subjects less directly related to industry's manpower needs. A 10 per cent switch of resources in the direction of engineering and science courses has been urged. Because engineering courses are much more expensive to mount than those in the arts, and require much more sophisticated equipment and machinery, this would not produce a swing in numbers of that magnitude but the engineering council believes that a 55 to 45 per cent ratio of technical to non-technical graduates can be achieved.

More women

One per cent of Britain's professional engineers are women — there are just 2,200 of them. In the universities and polytechnics, however, the number of women studying engineering degree courses is growing rapidly. Seven per cent of engineering graduates are now female although there is a range among the disciplines from virtually none in mining engineering to 12 per cent among chemical engineers. In liaison with the Equal Opportunities Commission and the Engineering Industry Training Board the Engineering Council has been encouraging girls to consider a career in engineering through the current Women in Science and Engineering (WISE) year. So much has been written about female engineers recently that many more girls must now be aware of the many career opportunities within the engineering profession, but there is still considerable reluctance amongst the majority of school girls to study the physical sciences and engineering. However, the rate of increase in the number of female graduate engineers is encouraging.

Focal point

By acting as a focal point for all matters concerned with engineers, the Engineering Council has been able to increase the awareness of the public at large of the problems engineers face. The 'Young engineer of the year' competition and 'The Prince of Wales award for industrial innovation and production' are just two projects which help us all to better understand the relevance of engineering to everyday life. Projects in the first competition included a wind-vane with a self-steering mechanism, an automatic levelling device for caravans, a stair climbing aid for the disabled and a blood glucose monitor. Competing projects for the industrial innovation competition included a laserspec eye tester, an electronic garden spray and a graphic plotter. All these ideas demonstrate vividly the direct and beneficial impact good engineering can have on everyday life.

The government financed the setting up of the Engineering Council and has continued to do so until now. Next year the basis of its funding will change and industry will be asked to contribute to its financial development. On the basis of what the council has achieved so far, this will be money well spent.

Dr Neil Harris

Careers adviser, Imperial College

Published in "Graduate Post" November 1984. Publisher: New Opportunity Press.

Branch News

THE NORTH WEST

The North-West Branch programme for the first half of the 1984/85 Session has included two technical meetings, two visits and one social event. The Session started in September with a technical presentation by A.F.A. Minerva Limited at their offices in Manchester Central Fire Station. The evening included talks by A.F.A. Minerva engineers on Fire Alarms, Gas Extinguishing Systems, Building Energy Management Systems and a visit to the Control Room of the Fire and Security Systems. Twenty-five members attended this very interesting presentation.

The October event was a visit to West Cheshire Hospital at Chester, which is the first Nucleus pattern hospital to be completed in the North-West. The party was most hospitably received by the Hospital Administrator and the Works Officer. The conducted tours were guided by Works Department staff, many of whom are Institute members. The departments visited included the new General Wing, The Coronary Care Unit, Operating Theatres, Plant Rooms, Kitchens and the Oxygen Concentrator Plant. A total of 26 members attended, many of whom travelled from Manchester Area and Merseyside.

The social event took place early in November when a party of 32 members and wives took part in a Jacobean Banquet at Worsley Old Hall. The banquet comprised traditional courses complete with wine and mead. Throughout the evening guests were entertained by the Marshall of The Court with his Herald, Musicians and Ladies of The Household who, in addition to being 'Serving Wenches' at tables, provided an excellent choir. A most enjoyable evening was had by all.

Also in November, 25 members took part in a full day event when two British Nuclear Fuels Establishments were visited, these being the Fuel Re-processing Plant at Springfields near Preston, and the new Design Centre at Risley.

At Springfields the time available only allowed us to tour the Fuel Canning Plant and have an illustrated talk on the various processes, which proved so interesting that many Members asked if a longer visit could be arranged so that other processes could be seen. The Design Centre at Risley is a new building which incorporates many interesting engineering features including a novel uplighting system, VAV air conditioning and the largest electric storage heating installation in the UK. All the members met together at mid-day for an excellent lunch at Risley.

In December we were the guests of the Institute of Energy for a technical meeting at Salford University. The subject was a paper entitled "Hybrid Fuels and Specialist Services" which gave interesting information about fuels produced from various waste products. Our members were most hospitably received and it was a pleasant experience to meet the Institute of Energy on their 'home-ground'.

The Oxford Spring Lectures (organised by the 6 Branches)

The Oxford Spring Lectures (organised by the 6 Branches) will be held at the John Radcliffe Hospital, Headington, Oxford, on Wednesday, 5th June 1985.

PROGRAMME (Outline only)

09.45 Coffee.

10.10 Official opening by David L. Hall Esq., FIHospE MIPlantE MRSH MBIM LHA MIMM Chairman Midlands Branch.
Chairman for the day:
David Pickup Esq., BSc CEng FICE FIMunE FIHospE MBIM.
R.W.O. West Midlands Regional Health Authority.

10.15 **Thames Flood Barrier**
Speaker: Derek Ayres Esq, Director of Public Health Engineering, Greater London Council.

11.30 **Digital Subtraction Angiography**
Speaker: Miss L. Irvine, International General Electric.
Lazers in the Field of Medicine
Speaker: Dr Singer, Royal Nothern Hospital.

13.00 Lunch: Available at the John Radcliffe at £3 per head including wine. (Tickets to be purchased on arrival)

14.15 **Buildings and Building Services & Their Problems**
Speaker: Dr W. W. Allen, Director of Bickerdike & Allen, Building Technical Consultants.

15.45 Closing remarks by the Chairman.
Tea and disperse.

FORTHCOMING BRANCH MEETINGS

North West Branch: *Hon Sec: B. Duncan, North Western Regional Health Authority, Gateway House, Piccadilly South, Manchester M60 7LP. TN Manchester (061) 236 9456 ext 284.*
April 16th Visit to new laundry at Oldham District General Hospital

East Midlands Branch: *Hon Sec. E. A. Hall, C/o E. G. Phillips Son and Partners, 26 Annesley Grove, Nottingham NG1 4GW. TN Nottingham (0602) 475783.*
April 24th Visit to Watnall Weather Centre, Nottingham
June 6th Visit to Ratcliffe-on-Soar Power Station

Welsh Branch: *Hon Sec: M. J. Back, 10 Nant y Felin, Efail Isaf, Nr Pontypridd. TN Cardiff (0222) 755944 ext 2562*
April 24th Annual General Meeting — Red Lion Hotel, Pendoylen.

Please contact the respective Branch Secretary should you wish to attend any of the above meetings.

ATTENDANCE AT BRANCH MEETINGS

The 'Rolling Diary' of Branch Meetings which appears regularly in the Journal was introduced to enable considerable savings to be effected so that branches were not obliged to circularise members prior to each and every 'technical meeting'. (Total savings resulting can be to the order of £2,000 per annum).

As a refinement and added aid to Branches, in future, a 'return slip' will be printed at the foot of the page of the Journal on which the 'rolling diary' appears. Members who intend attending any particular branch meetings are urged to complete this return slip and send it in to the relevant Branch Honorary Secretary so that anticipated numbers for each meeting are known in advance.

To: The Hon. Secretary, ____________________ Branch

I would like to attend the meeting on ____________________

Name: ____________________

Tel. No: ____________________

The author is Vice President, Group Technology and Engineering, Luwa Ltd, Zürich, Switzerland. The paper was first presented at the International Orthopaedic Symposium, Utrect, May 1984.

Ultraclean operating theatres: cost efficiency and energy saving aspects

HANS H SCHICHT Dr. sc techn

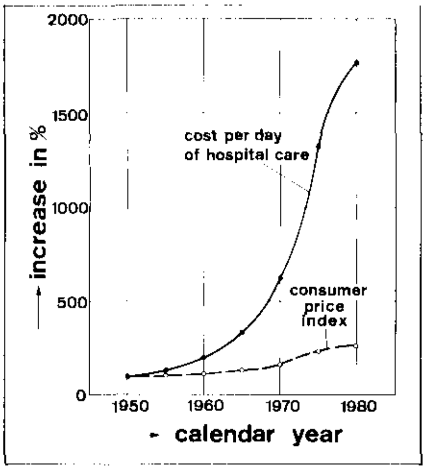

Fig.1 The average increase in cost, from 1950 to 1980, per day of hospital care in Switzerland, compared to the increase of the consumer price index, illustrates dramatically the cost explosion of public health systems [1]

1. Introduction

The cost explosion of the public health systems all over the world *(Fig.1)* has reached alarming proportions and has become a constant generator of headlines in the daily press. If costs continue to increase at this rate, then within a short time we will spend all our income — directly or indirectly — on health.

This development must obviously be checked. Therefore, only technologies distinguished by a satisfactory relation of cost and effect can in future become generally accepted.

For surgical and orthopaedic interventions with high risk of wound infection, only the application of low-turbulence displacement flow — also called laminar flow — permits maintaining an airborne germ count in the range of 0-10 colony units/m^3 considered desirable in the operating field (e.g. [2-4]). In recent years the aim has been to reduce installation and running costs of hospital laminar flow systems, without reduction of the air cleanliness levels in the critical areas.

2. The point of departure

Numerous operating theatres applying the laminar flow principle have been realised during the past 15 years all over the world, most of them as operating cabin. Fig.2 shows a typical example: laminar air flow directed vertically downwards is established by the introduction of HEPA-filtered, ultraclean air through the complete ceiling of the cabin. Glass side walls separate the cabin from the remaining operating theatre. The germs and particles released in the cabin are swept away from the critical areas with the air stream and discharged into the outside area immediately above the floor. Only the persons directly participating in the surgery are present in the cabin, while the work stations for narcosis and blood transfusion remain outside in the peripheral area. This permits limiting the size of the cabin to the absolute minimum and consequently the area where ultra-high cleanliness has to be maintained.

Due to their investment and operating cost, the use of laminar flow operating cabins remains limited to a relatively restricted number of highly specialised institutions.

3. The cost break-through: its basic parameters

In order to achieve a break-through in respect to investment and operating costs, the most effective approach is a reduction of the air flow rate. Starting from the 25-40,000m^3/h of air required for a complete laminar flow operating theatre or from perhaps 15,000 m^3/h of air required for a typical operating cabin, the aim would be to approach as closely as possible the values of 1,500-2,500 m^3/h required for a typical conventional operating theatre with turbulent flow.

How can this be achieved? Two principal paths can be exploited:

- ☐ Reduce the area protected by laminar flow
- ☐ Reduce the air velocity

Extensive tests performed in our aerodynamics laboratory have shown that for orthopaedic operations a laminar flow ceiling field of 1.20 m x 2.40 m is normally sufficient to guarantee the necessary protection for both the operation area and the instrument table, and that the flow velocity can be reduced from the customary value of 0.45 m/s to a value of 0.25-0.3 m/s. Doing so, an air flow rate results of around or somewhat below 3,000 m^3/h, a five-fold reduction as related to an average operating cabin and a value only marginally above that of a conventional operating theatre with turbulent flow.

4. The complete systems solution

Fig.3 shows schematically the air conditioning and clean air distribution system of an operating theatre built according to the new philosophy. In the air handling unit, the necessary components for temperature, humidity and noise control and for air circulation are grouped

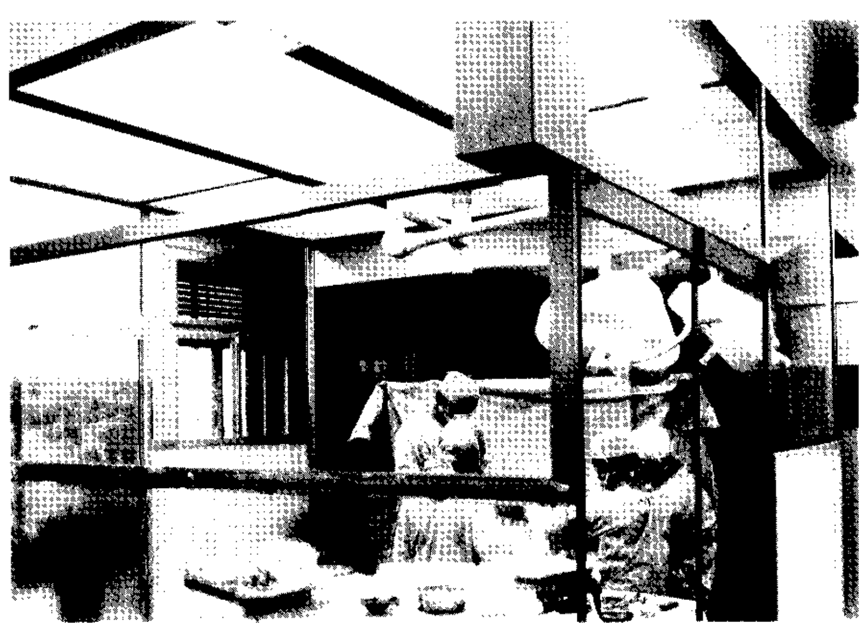

Fig.2 A highly aseptic operating cabin with vertical laminar displacement flow for implantation surgery at the Montchoisi Hospital in Lausanne/Switzerland.

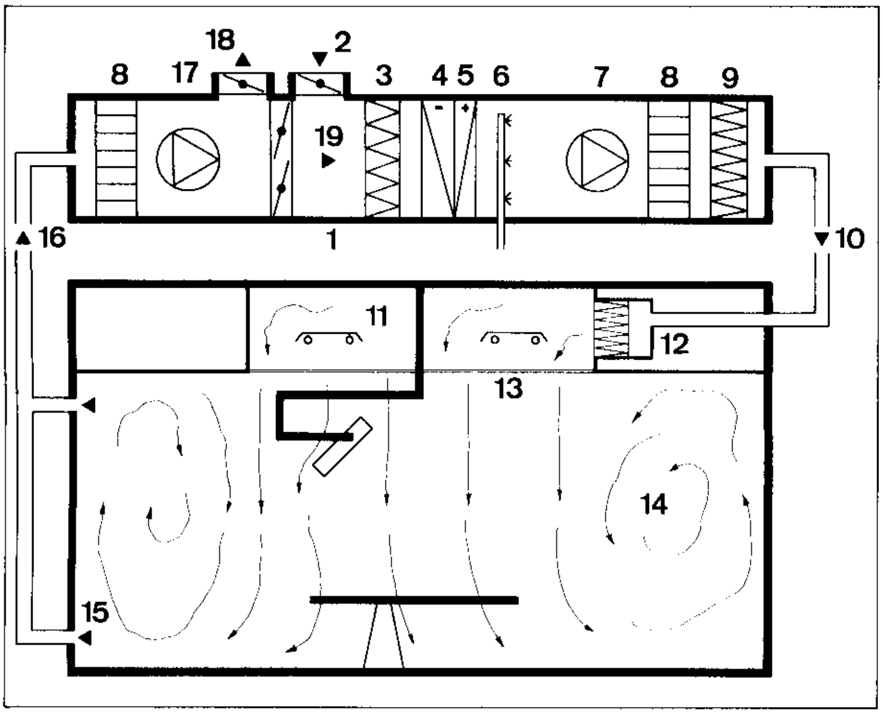

Fig.3 Schematic arrangement of the air conditioning installation, the air distribution system and the flow patterns of an ultra-clean operating theatre:
1 — air handling unit; 2 — outside air; 3 — course dust filter; 4 — air cooler; 5 — air heater; 6 — steam humidifier; 7 — supply air fan; 8 — silencer; 9 — fine filter; 10 — supply air duct; 11 — plenum chamber; 12 — HEPA filter; 13 — air inlet via Luwa® CG sterile air distributor; 14 — operating theatre; 15 — return air intake; 16 — return air duct; 17 — return air fan; 18 — exhaust air; 19 — recirculated air.

together. Three stage filtration is provided: the first filter stage is located upstream of the heat exchangers, but behind any frost protection preheater. The second filter stage is placed downstream of the last diffusion source for micro-organisms in the air handling unit. The final filter stage, i.e. the HEPA filters* to remove any remaining microorganisms from the supply air, is installed either in the false ceiling of the operating theatre or in a technical area adjacent to it.

Air is distributed by means of a special double screen of a fine mesh fabric stretched out tightly within a light aluminium frame and called the sterile air distributor. By this means, laminar displacement flow directed vertically downward is established. Thus, the operating and instrument tables are enveloped in HEPA filtered air, which sweeps away any contamination liberated by the operating team and isolates the critical areas efficiently against cross-contamination from the outer areas of the operating theatre. Low velocity turbulent flow establishes itself in the — less critical — areas outside of the influence of the central laminar flow field.

Fig.4 shows a typical ultraclean operating theatre built according to this new philosophy and commissioned recently. The limited size of the ceiling field and the ease of integrating the operating lamp carry-through into it are immediately striking. The fluorescent tubes for the basic lighting are installed behind the clean air distribution screens. Thus, very uniform lighting pleasing to the eye and devoid of any disturbance of the flow field is achieved. Fig.5 presents another example of such a new-generation operating theatre.

Operating theatres with the relatively small ceiling field as shown in Figs.4 and 5 are especially suited for operations of limited extension in space, where not more than perhaps four persons work actively in the immediate wound area. This is true for most of the orthopaedic operations like hip replacement.

There are cases, especially in open heart surgery, where higher numbers of persons and considerable quantities of equipment concentrated in the operating area require laminar flow protection. In such cases, the area of the laminar flow field should be extended. An example is given in Fig.6.

On the other hand, there are applications, for example in otorhinolaryngology, brain surgery or dentistry where a ceiling field of less than 1.20 m x 2.40 m can sometimes be sufficient. From the technical point of view, there is no problem in fulfilling requests for special-size ceiling air distributors, as the dimensions of the ceiling elements are completely free from any limitations, such as for example those caused by the standard filter sizes in

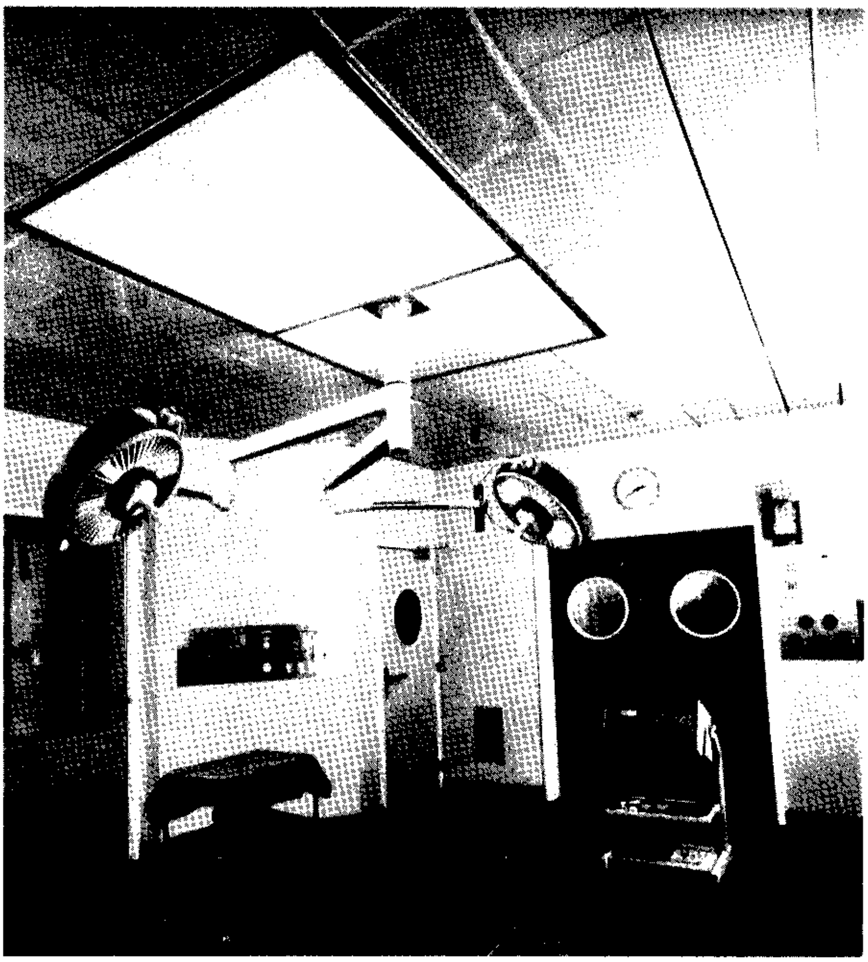

Fig.4 Ultraclean operating theatre with ceiling air distribution field of CG type with integrated basic lighting and support frame for the operating lamp at the Hospital Orthopédique in Lausanne/Switzerland. The extension of the ceiling air distribution field is 1.20 m x 2.40 m.

**HEPA filters (High Efficiency Particulate Air filters) with an efficiency of 99.97% measured with a monodisperse aerosol of 0.3 μm particle diameter and even more efficient for the removal of micro-organisms from an air stream.*

competing systems of establishing low-turbulence displacement flow.

The simplicity in concept and its dimensional flexibility is a consequence of separating the two functions filtration and air distribution from each other. This permits the HEPA filters to be located independently of any air distribution requirements, so that they can be optimised in size, shape and pressure drop. Distributing the air by means of the sterile air distributor, true laminar flow is established and a very uniform velocity field is obtained, the local velocity deviations being less than 10% from the mean value. The framing of the screens can be extremely light: as the air is HEPA filtered upstream of the screens, there are no air tightness requirements that the frames have to obey. Illumination elements for general background lighting can be installed upstream of the screens so that they do not create turbulence in the room. The screens can be easily removed for disinfection of the ceiling plenum or if access to the illumination elements is necessary. The carry through element for the operating lamp can be of simple design and of minimum dimensions, so as to present a negligible flow obstacle.

Operating lamps, as in all operating theatres with laminar flow, should be of special design: their cross-section should be minimised and their shape be defined in such a way that they present a minimum flow obstacle. It should also be noted that the traditional glass or plastic curtains for containment of the laminar flow area have been dispensed with.

Compared with this concept, the traditional filter ceiling for establishing laminar flow has the following disadvantages:

- ☐ the freedom of dimensioning the laminar flow field is restricted by the requirement that standard filter sizes have to be used, leading to an increase in the area of the clean air field and, consequently, of the air flow rates
- ☐ to build up a filter ceiling, heavy and well-levelled framing has to be used in order to guarantee a leak-free seal
- ☐ turbulence is generated by the filter frames
- ☐ the carry-through structure for the operating lamp tends to be extensive in area and a generator of turbulence

5. The energy concept

In order to reduce operating cost still further, the following additional measures are recommended, which have been proved over and over again in hospital and industrial clean room installations [5-6]:

- ☐ partial recirculation of the return air instead of operation with 100% outside air
- ☐ variation of the outside air/recirculated air flow rate as a function of the ouside air conditions in order to reduce the need for artificial chilling
- ☐ heat recovery from exhaust air
- ☐ reduction of the air flow rate outside operating hours
- ☐ conditioning of adjacent areas with less severe air cleanliness requirements by means of air spill-over from the ultraclean operating theatre
- ☐ stringent selection criteria for the systems components (e.g. high-efficiency fans)
- ☐ utilising the energy management capabilities of modern automatic control and surveillance systems

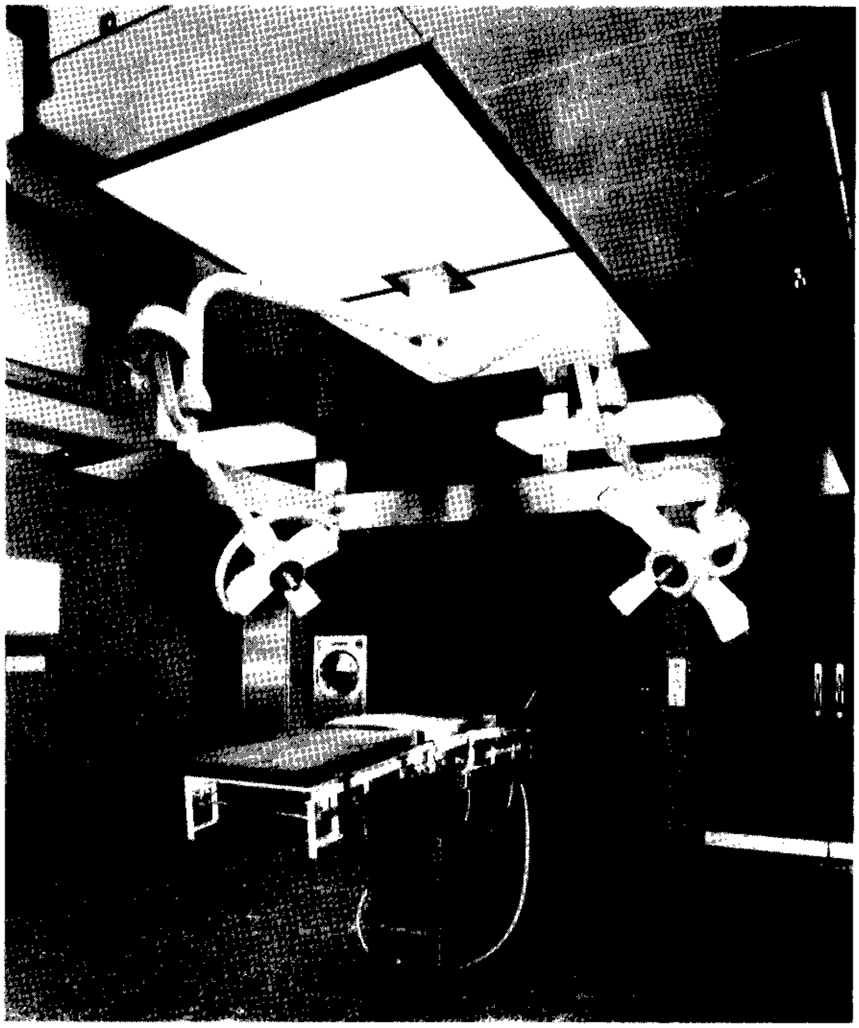

Fig.5 Another ultraclean operating theatre with ceiling air distribution field of limited extension (2.6m x 1.25 m in this case) at the University Hospital in Zurich/Switzerland.

Some of these energy saving measures may require additional investment costs. Therefore, criteria have to be defined to permit a fair evaluation of their merits. An objective and transparent decision base can be established, if each measure is evaluated individually, comparing investment and operating expenses of a minimum cost solution with the solution to be evaluated. Thereby, it is easy to establish how quickly the additionalk investment expense can be recovered by the reduced operating costs.

6. Concept validation

There can be no doubt that the concept presented is a great step forward in simplicity as well as in cost reduction. The decisive question is, however: can air cleanliness be maintained at the level required for ultraclean operating theatres?

To give a convincing answer, a two-step approach was adopted. First of all, an extensive test programme was performed in laboratories. The following results were obtained [7]:

- ☐ Room air flow pattern: The clean air distribution elements established a very uniform laminar displacement flow field. A very pronounced and distinct delimination between the clean area under laminar flow and its turbulent surroundings was observed. The utilisation of lateral flow guidance curtains or walls brought no worthwhile improvements. Outside the clean area turbulent vortex systems were established which occupy the complete outer area of the room.

Air cleanliness: Measurements during simulated operations with 5 resp. 9 persons taking part were performed under conditions of exaggerated activity, in order to gain some insight into the cross-contamination situation in the critical areas of the operating field. In spite of this movement activity the particle counts have shown that in the operating field the highest recognised cleanliness class can be achieved, i.e. Class 1 according to B.S. 5295 [12], class 3 according to VDI 2083 [8] and class 100 according to U.S. Federal Standard 209b [9]. Outside of the area covered by laminar flow, i.e. in the tur-

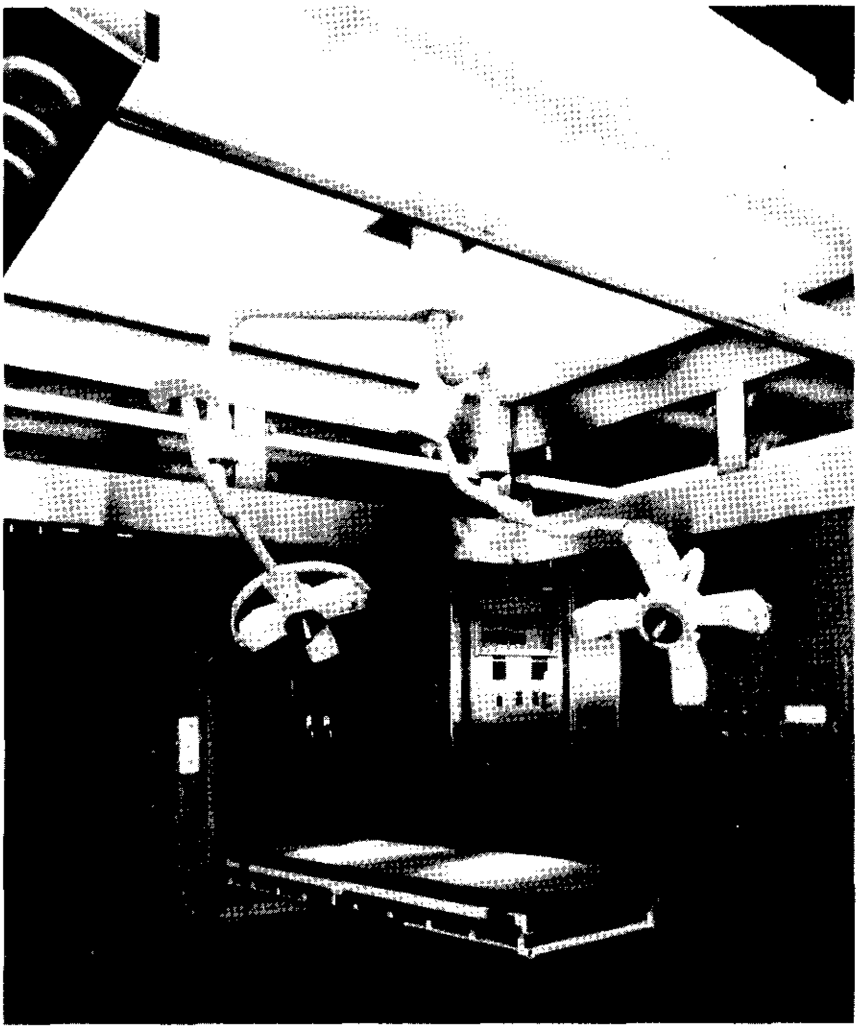

Fig.6 Ultraclean operating theatre with a more extensive (2.8 m x 2.8 m) ceiling air distribution field of CG type at the University Hospital in Zurich/Switzerland.

bulent outer area of the room, the cleanliness maintained still corresponds to class 5 according to VDI 2083 resp. class 10,000 according to U.S. Federal Standard 209b.

During tests it was also shown that the selection of an appropriate operating lamp is very important. Special designs for application in clean rooms should exclusively be used.

Although no germ counts were performed during these laboratory tests, we knew from earlier bacteriological tests performed under similar conditions that an average germ count of around 10 colony units/m^3 of air or better was to be expected [10].

In order to gain more insight, an independent expert, Prof. Dr. med. J. Beckert, director of the Hygiene Institute of the University of Lübeck/Germany, performed a detailed investigation in one of the first operating theatres built and commissioned according to the new concept [11]. The new operating theatre in the surgical ward of Dingolfing Hospital in Germany was 6.50 m long, 6.50 m wide and 3.00 m high. The supply air was introduced through a ceiling field of 1.20 m x 2.40 m with a mean air velocity over the outlet area of 0.24 m/s, giving a volumetric air flow rate of 2,400 m^3/h.

Of the return air, 80% was removed close to the floor and 20% near the ceiling.

For the tests, the operating table was located centrally below the supply air field. The two operating lamps with a connected load of 350 W each were switched on and swivelled into the supply air field.

To simulate operating staff, three dummies of human size were wrapped in 80 W electric blankets and positioned at the operating table as they would be in the real situation. A dummy wrapped in a 40 W electric blanket was used as the patient.

In order to be able to evaluate the air quality in the critical areas, a tracer method was used, with nitrous oxide (N_2O) as tracer gas.

Since the most important point of emission of airborne germs by the staff is the mouth, nitrous oxide was released at the height of the dummies' heads. Simultaneously, measurements of the gas concentration at various points in the room and at the operating table were made.

The following results can be cited from Prof. Beckert's report [11]: "The ceiling supply air system with an air distributor for operating theatres, produced a uniform, low turbulence and induction-free air flow, and this remained unchanged under operating conditions down to the height of the operating table. Interference in the flow field due to the swivelling in of operating lamps was basically limited to local upward currents, which were no longer detectable once the lamps were moved away again. In the operating area on the patient the air velocities were 0.1-0.34 m/s and it was only at the edge of the flow field that air velocities of up to 0.5 m/s occurred. The air velocities were thus lower at the location of the patient than the values which are usual in laminar flow systems of around 0.4 m/s."

As regards contamination originating from the room, Prof. Beckert remarks: "On average only 1% of the (tracer gas emission) was detectable at the location of the patient and only 3.1% at the edge of the operating table. In the operating area of the staff themselves these values rose to 7.2%, and to 7.5% at the instrument table.

Fig.7 Measurement of the germ concentration during a bone operation. The air samples are taken as near to the wound area as possible.

At the edge of the flow field outside the low turbulence flow area the gas concentrations increased to an average of 66.3%/68.5%, and in the outer areas of the room an average of 81.9& was measured."

Prof. Beckert arrives at the following general conclusions: "In operating theatres equipped with conventional air conditioning systems, concentrations of airborne germs of the order of magnitude of 200 colony units (CU)/m^3 can be found during the operating procedure. If we proceed on the basis of a concentration of 200 CU/m^3, a germ concentration of around 2 CU/m^3 would be observed at the location of the patient on the operating table, under the ceiling supply air system with CG air distributor. This means that clean room conditions prevail. In summary, it can therefore be stated that the use of the ceiling supply air system with CG air distributors for operating theatres, manufactured by Luwa, creates in the operating area a degree of air hygiene which is equivalent to clean room conditions. From a medical point of view, it is important to stress the low air velocities at the location of the patient, since these are thermohygienically of advantage to him."

7. Conclusion

The traditional cost disadvantage of laminar flow systems for operating theatres in comparison with conventional air conditioning systems with turbulent flow can be eliminated by the new concept described above: limiting the extension of the laminar flow field, reducing the flow velocity and integrating clean room technology into an optimised air conditioning system. This is true for both investment and running costs and has been achieved without a reduction in the air cleanliness level customary for laminar displacement flow.

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Successful Symposium

Hospital Developments — Planning Procedures and Code of Practice for NHS Commissions

The need for information and enlightenment on the requirement of Planning Procedures and Code of Practice for NHS Commissions was confirmed by the response to the above Symposium organised by The Institute of Hospital Engineering and held on 6 December 1984. Such was the interest that the Symposium was over-subscribed at an early stage and a second was held on 17 January 1985. The first was attended by 200 delegates with 130 applicants for the symposium in January.

From comments received, it would appear that both days proved successful, although it is recognised that the Concode documentation only being available within the NHS, some delegates were at a disadvantage during the session 'An Introduction to Concode'. As a consequence Mr Speechley has produced an abridged version of his paper and this is reprinted in this issue.

The author is Regional Quantity Surveyor for the North West Thames RHA. This is an abridgement of his paper presented at the Institute symposium on Hospital Developments.

An introduction to Concode: including appointment of consultants

F J SPEECHLEY FRICS FCIArb

What is Concode?

Since the early days of the National Health Service, first the M.O.H. then the DHSS issued guidance from time to time to the hospital and health authorities of the period on building and engineering contractual matters and on the employment of design consultants. It had been decided to bring the guidance up to date and to fill any gaps. The result was Concode, published in October 1983. Concode, like Capricode, if properly observed was a means by which DHSS could, with confidence, delegate work to Health Authorities, ensuring careful expenditure of public money on health building and engineering.

Part I Contracts

CHAPTER 1 — Selection of contract type and tender method

Regional Health Authorities and District Health Authorities were acting on behalf of the Secretary of State for Social Services in operating as principals in building and engineering contracts. These Authorities were therefore obliged to use contracting procedures that would ensure best value for money.

Various types of contract and tendering methods were described in this Chapter of Concode.

The Chapter concluded with a schedule of permitted delegations by DHSS to Region and by Region to District in respect of contracting and tendering procedures for building and engineering works.

CHAPTER 2 — Selection of tenderers for building and engineering contracts

Selective competitive tendering was the normal procedure in the Health Service. Concode referred users to the Code of Procedure for Single Stage Selective Tendering 1977 published by the NJCC for Building. In the main, DHSS supported this Code of Procedure.

Selective competitive tendering of course required the most careful appraisal of contractors for general approved lists and for lists prepared for specific contracts. The major part of Chapter 2 dealt with the quality of contractor to be used by Health Authorities. The guidance might be summarised as "no cowboys". The paragraphs covered financial and technical competence, standards of integrity, approved lists of contractors, examining audited accounts and technical appraisal.

The later part of Chapter 2 covered such matters as EEC Directives, management contracting and selection of subcontractors and suppliers.

CHAPTER 3 — Forms of contract and contractual provisions

The Forms of Contract expected to be normally used in the Health Service were set out in this Chapter and those most frequently adopted analysed in some detail. In particular Section 2 covered the JCT Standard Form of Building Contract, Local Authorities With Quantities 1980 Edition. The guidance notes in this Section were fully comprehensive and should help architects, quantity surveyors etc cope with this allegedly complicated Form of Contract. Among the very full list of contracts dealt with were the range of Model Forms of General Conditions of Contract for mechanical and electrical engineering contracts (referred to in Section 11) and in Section 13 were described the model documents issued by DHSS for measured term and other types of contract for the maintenance of buildings, engineering installations, land, gardens and grounds.

The temptation to alter standard forms of contract so as to place additional risk with the contractor should be resisted.

CHAPTER 4 — Tendering procedure and appointment of contractors, sub-contractors and suppliers

The earlier part of this Chapter dealt with matters usually covered in the "Preliminaries" of Bills of Quantities and Specifications, but with particular Health Service implications. These matters included such issues as fire precautions during construction, drying out the works, use of installed plant by contractors, etc. The speaker drew particular attention to Paragraph 2.29 covering contingency allowances which in the Health Service were to be used only for unforeseen and unforeseeable occurrences during the works.

A major theme in this Chapter was the avoidance of any practice that might seem to invite collusion or to destroy the parity

Intensive care, coronary care, recovery etc., are examples of such areas.

The protection required for these areas is again divided into two groups:

a) the limitation of current by time or magnitude

b) the equilization of potentials within a designated area.

The latter will be described first as it is fundamental to microshock protection.

Equipotential patient reference earthing (EPRE)

To start with, a current of 100 microamps is too small to reliabily operate commercial quality electrical apparatus. Apart from this, the leakage current which the circuit wiring will pass would exceed this value, and extraneous currents induced from stray fields would also be a nuisance.

Remembering that the impedance of the heart is taken as 1000 ohms, then the maximum potential which can exist across the heart for a current of 100 microamps is 100 millivolts. This leads to the solution that if the whole areas is bonded together so that come what may, there can never be a potential difference between one point and another exceeding 100 millivolts. Then theoretically there can never be a current through the heart exceeding 100 microamps. However, to achieve this object, there are several points to be determined, for instances, what is the area, where is the reference point, what resistance is required. The first question is answered by Figure 1:

The second question, the reference point, is answered by a nominated point described as the 'Equipotential Junction (EPJ)'. This may be a separate wall box with an earthing terminal marked EPJ. Alternatively, one of the earthing terminals on a multipurpose panel may be designated the EPJ.

The next question, as to what resistance is required, requires further assumptions in regard of fault current. There are two circumstances:

a) where a final sub-circuit is protected by some earth leakage device in addition to the normal thermal/magnetic protection.

b) where the circuit is only protected by normal thermal/magnetic protection.

In the case of a) the assumed maximum leakage current is taken as 1.0 amps. This recognises that an earth leakage device or isolation transformers will limit the current in the earthing system. Thus the maximum resistance from the earthed metal of any equipment connected to such a circuit must not exceed 0.1 ohms.

In the case of b) the assumed maximum current is taken as 10 amps. The electrical reticulation external to the class A area is not subject to limitation by earth leakage devices; in addition other reticulated services such as gas, water, suction which are likely to be present within the class A area may provide the earth path. Thus the maximum resistance to any exposed metal connected to any such service requires to have a maximum value of 0.01 ohms.

It is important to realise that this earthing is only an extension of the Australian Standards Association's Wiring Rules, and that the resistance of the earth between the EPJ and the neutral link in the distribution board is not particularly important. It is only necessary to meet the minimum earth conductor requirements.

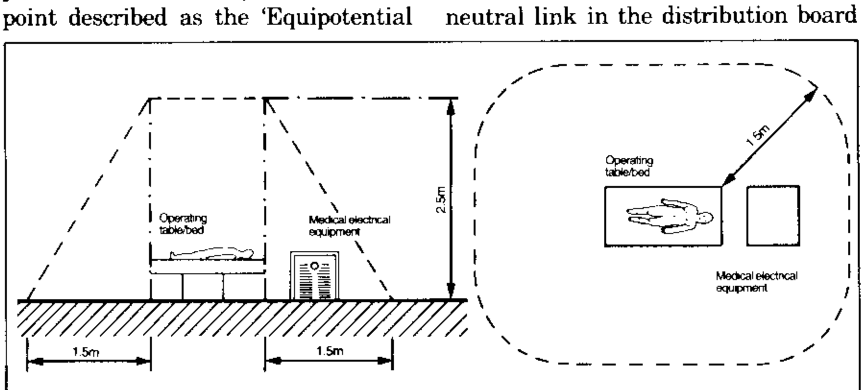

Figure 1. Patient equitpotential area (EPAREA)

Limitation of current by time or magnitude

The limitation of current by time is relevant to the first part of this article (microshock defined) in which it was stated that the vulnerable time lasts for about 40 milliseconds in a cycle time of say 1000 milliseconds. It is required that an earth leakage device should operate within a specified time – 60 milliseconds at present, although many devices are now operating within 20-milliseconds. (The sensitivity is 10 mA and 5mA min.). Hence there is an acceptable level of safety based on the probability of an earth leakage current lasting 20-60 milliseconds occurring within the 1000 milliseconds cycle at the precise moment of the 40 millisecond vulnerable period. Remember that in any case that the Equipotential Patient Reference Earthing (EPRE) system will also prevent the effect of the leakage current from causing a fibrillating current.

The limitation of current by magnitude uses an isolating transformer and monitor. The transformer is made to a high standard such that the leakage is only 50 microamps. The monitor, termed a line isolation monitor, samples the impedance of each leg of the isolated supply. The monitor itself has a leakage of 50 microamps. When a leakage from equipment occurs and earths one leg of the transformer, an alarm is raised. The alarm level is adjustable, usually 5 milliamps, and a mute switch and indicator lamp is provided. The principal difference between these two methods is that the earth leakage devices provides a positive disconnection of a faulty appliance and prevents further use, whilst the isolation transformer only provides indication that a fault has occurred and leaves the remedial action in the hands of the surgeon or medical staff.

Practical application

An operating room engaged in openheart surgery would undoubtedly be a 'class A' area complete with an EPRE system for microshock protection. Earthing leads of stranded green/yellow earthwire should be connected from the earthing studs on the wall panel to the various portable items of equipment. Protection may be either by earth leakage devices or isolation transformers. Isolation transformers would be employed on circuits supplying items such as cardiac Pulmonary By-Pass pumps due to the difficulty of manually operating these items.

An intensive care ward or coronary care ward would be a 'class A' area.

Operating rooms in which general surgery is carried out only require to be 'class B' areas. This does not give microshock protection as it is not required and avoids the costs associated with the EPRE installation; temporary upgrading can be achieved by using a portable unit comprising a IKVA transformer with live isolation monitor and EP Junction for emergency use.

Some difficulties have arisen where cleaning staff have used protected socket outlets for vacuum cleaners and cause tripping. It is advisable to provide 'cleaners' outlets' away from the classified areas.

Microshock protection

There is not much to say about microshock protection as it is automatically provided in both the 'class A' and 'class B' areas.

Conclusion

This is the 'State of the Art' for electrical safety in operating rooms and similar areas in Australia at the present time. When the Australian Standard was introduced there was a tendency for any installation that resembled an operating room to be fully equipped with 'class A' facilities. Fortunately, as medical and engineering personnel have become more confident in interpreting the standard, only the larger complexes are likely to be fully equipped to 'class A'. If any Country is in the process of producing a standard on this subject, a word of warning would not be amiss – avoid a ranking in the terminology, or better still, deliberately arrange it in reverse order.

The psychological effect of saying that 'class A' is better than 'class B' is that sometimes hospitals will require a 'class A' operating room for reasons other than purely medical.

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The author is a director of Health Building Consultants Pty. Ltd, a consortium firm established to provide planning and architectural services to the South Eastern Medical Complex. Mr Bartlett has directed the briefing, planning and functional design of the SEMC.

Queen Victoria Medical Centre – South Eastern Medical Complex – part 2

JAMES BARTLETT B Arch (Melbourne)

This is the second part of an article on the Queen Victoria Medical Centre. The author discusses in detail how the planning of the centre serves both staff and patients. Visitors to the IFHE Congress in Melbourne in November will be able to visit this hospital. (Part 1 of this article was featured in the June 1984 issue of the journal).

Level 1

The gentle slope across the site to the south permits a natural access route for trucks to the service and support departments which are located at Level 1.

As most accommodation is below ground level, every effort has been made to avoid problems associated with deep planning and the lack of contact with the external environment by the provision of a number of courtyards which penetrate working departments.

The primary circulation route connecting the four lift nodes provides this floor with a major traffic route for the horizontal distribution and collection of goods. All support departments plug into this circulation route and, as indicated on the plan, supplies, linen and food are received at the loading dock, processed through each department, and issued via the primary circulation route to lifts for vertical distribution.

Staff arriving at the hospital may travel from the car parking zones, change in local locker areas or have a quick snack at the cafeteria en-route to their working department. The dining area overlooks the gardens in approval to go to contract on this basis must be sought.

Arrangements for the approval of unorthodox procurement/contract arrangements — management contracts and the like — are set out in CONCODE (1).

The contract must be let on the basis of an approved sum for the works. The progress of the work, the incidence of contract payments and the effect and cost of variations are closely monitored to give early warning of any delays and difficulties. Variations to the work should be avoided, but where varied work is essential, the alternative ways of handling the changes (eg by carrying out work after the main contract is complete) and the likely effects on programme and costs should be reported to the client health authority before a particular course of action is authorised. The aim is to complete the work on time and settle the final account within the approved sum (net of contractual fluctuations).

STAGE 5 Commissioning

Commissioning comprises all the preparations necessary to bring the scheme into use. The process will have started before construction work is complete, particularly where staff must be recruited. Commissioning involves putting the operational criteria (including running costs) on which the design is based into practice; test running equipment and engineering services, preparing relevant operations handbooks, and training staff to run the building and the patient services it accommodates efficiently.

STAGE 6 Evaluation

Evaluation provides for feeding the experience gained and the lessons learned on a scheme back into the planning process to improve performance on future schemes. Lessons on planning and design may emerge as work proceeds and could be of immediate value to other schemes. Some schemes, particularly those which include innovation or those likely to be replicated, warrant a detailed evaluation of performance in use. This will usually be carried out once the scheme has become fully operational and the staff have had chance to properly adjust to the new working environment.

3. Why do we need it?

The fundamental justification is good management and public accountability. A consistent Capricode based approach to capital development that achieves best use of resources through the selection and construction of relevant and cost effective schemes which open on time and within budget is the sort of mechanism managers and the Accounting Officer (1) require for monitoring, control and accountability. Information about performance on individual schemes and the overall programme is available at the right time; where schemes start to go wrong a properly operated system of reporting under Capricode should give early warning and provide a framework for initiating corrective action while generating the explanations needed.

4. Scope for improvement

The health building process has attracted some adverse comment recently:

- labrinthine processes and widespread complaints of delay
- the ability of capital schemes to spawn meetings
- copious and long-term deployment of health authority staff on project teams with private consultants in attendance en masse
- procedures which stifle initiative and prevent health authorities taking a "fast track" approach to development
- procedures which inhibit the introduction of new and innovative methods of capital development.

Before taking a constructive look at how through Capricode we should seek to respond to the foregoing criticisms let me express a personal view: in terms of the overall public sector capital investment performance health building has a good record. We have one of the best systems of design guidance and cost control, a generally good and improving record of building complex schemes to programme and to budget, and high international standing for the effectiveness and quality of NHS design. The private health sector often uses DHSS building note guidance (purchased at any HMSO shop) as a basis for hospital design development. Unfortunately, given the complexity and size of some of our more important developments, if a scheme does go wrong it tends to go wrong in a big way naturally attracting attention away from the majority of schemes which run well.

5. Future of Changes?

Improved performance is possible. The NHS Managmeent Inquiry recognised the scope for streamlining and speeding up the procedures for handling major capital schemes. I believe there is scope through the review of Capricode to respond to this and the adverse comments I have highlighted.

The review of Capricode is well advanced but will not be finalised until decisions following the Reviews of Works Function have emerged; today I am only able to speculate on the future tenor of Capricode procedures. In this connection the following features are likely to be present in the new Capricode.

a. An harmonious relationship between Capricode and Estate Management procedures; both are part of the same overall process of maximising health care return from available capital resources.

b. Improved quality of decision taking based on properly organised information presented at the right time. For example; option appraisal, effective cost planning, and cost reporting arrangements which make maximum use of automatic data processing techniques such as the DHSS CONCISE system.

c. A clear identification of the management role in project team working.

d. More disciplined arrangements for briefing the design team involving the introduction of a "Certificate of Readiness to Proceed to Design" (CRPD) modelled on the successful "Certificate of Readiness to Proceed to Tender". The object of the CRPD is to secure a structured and disciplined approach to briefing and design and to inhibit late changes in client requirements.

e. Unambigous arrangements for delegation of schemes and greater delegation to District Health Authorities consistent with the resources available at that level.

f. Arrangements for the regular and routine reporting of progress and performance on schemes (allied to the management accounting framework) throughout the development process making maximum use of automatic data processing systems, eg CONCISE.

g. Less but more selective scrutiny of schemes by the higher tier authority (RHA and/or DHSS).

h. Firm budgeting for both capital and running cost elements of schemes.

In essence the revised Capricode should provide the framework for a tighter and better managed capital development process at the client health authority level coupled with a clear identification of the information requirements of management and the Accounting Officer.

(1) *The Chairman of the NHS Management Board is the Accounting Officer.*

The author is Chief Technician EBME in the Medical Engineering Unit of the Sandwell Health Authority.

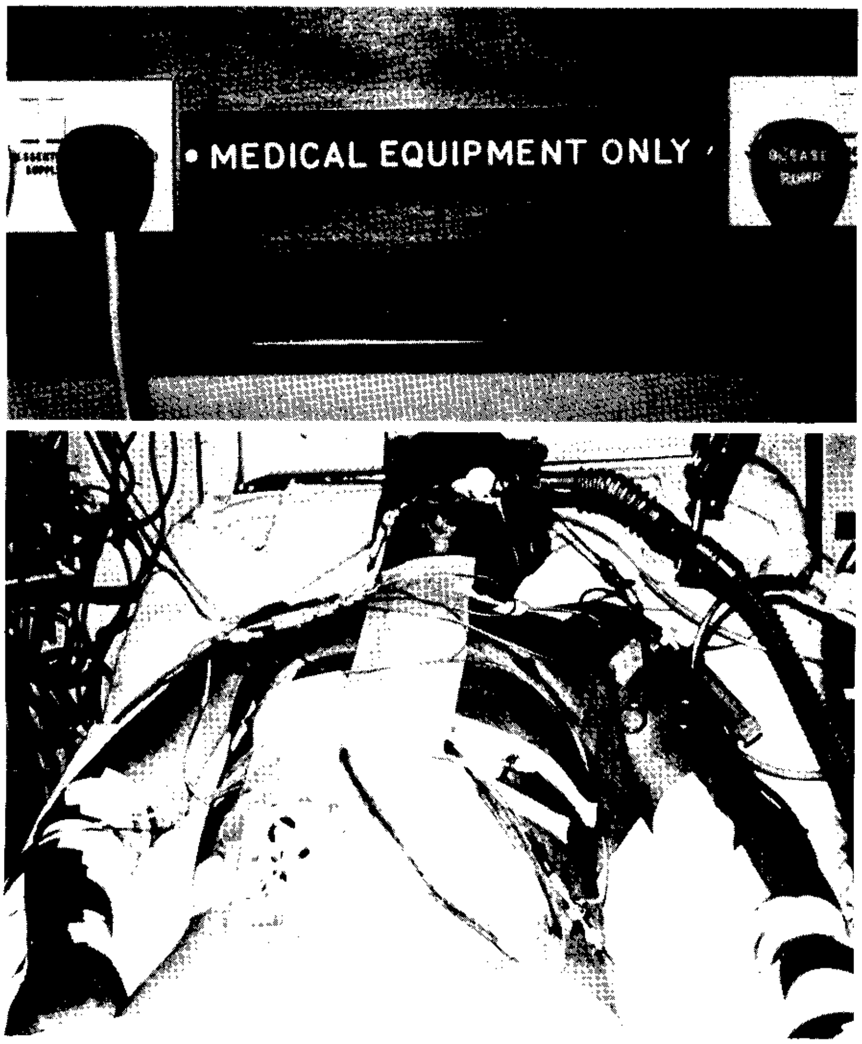
Medical equipment only

RICHARD HORTON TEng MIHospE

Manufacturers of Medical Equipment sold in the United Kingdom are now required to construct equipment to conform to minimum safety standards — these are set out in I.E.C. Document 601, part one, or British Standard 5724. (1)

The standard sets out to ensure that in the event of a fault condition occurring on an item of patient connected equipment, that the patient shall not be put at risk. Domestic electrical equipment is not subject to the same stringent safety requirements. When the two types of equipment are effectively interconnected via twin electrical outlet sockets, the added protection 'built-into' the patient connected equipment by way of isolated preamplifiers and power supplies can be effectively lost. (2)

In practical terms, domestic equipment such as vacuum cleaners, floor polishers, or even television sets ought not to be plugged into electrical sockets that are immediately adjacent to patient connected equipment such as cardiac pacemakers. E.C.G. monitors and blood pressure monitors (3). As a general rule, maximum protection can only be achieved by keeping the two types of electrical equipment as far apart as possible. For this reason, electrical sockets which are used for patient connected equipment should carry the advice 'Medical Equipment Only'.



Multiple current pathways exist for patients in critical care areas.

Cardiac thresholds

In the United Kingdom, a number of distinct thresholds are generally accepted as being detectable which differ slightly from those quoted for the United States (4) — these, very briefly, are as follows:-

(i)	Perception	typically 1mA
(ii)	Discomfort	typically 20mA
(iii)	Pain	typically 50mA
(iv)	Ventricular fibrillation	typically 70mA
(v)	Burns	typically 5 Amps

These figures might be the sorts of values measured if a current generator was connected via electrodes to the hands of a typical subject. There will be a considerable tolerance on such values caused mainly by the degree of dryness of the skin. When the skin is moist, electric current will seek the path of least resistance over the skin surface, rather than directly through the body bulk medium and may not be subjectively detected. The values quoted are for 50 Hz. a.c. current (5) (10).

Natural protection

The skin layer is the first line natural protection of the body against electricl hazards. Once the skin has been breached, the level of protection is greatly reduced and the threshold of ventricular fibrillation is also much reduced. As the external current path to the heart is made shorter, so the value of v.f. current is further diminished, until by direct cardiac connection v.f. can be induced with a current of about 10 μA (6).

The means by which the natural protection of the body may be circumvented include:- E.C.G. patient cables, temperature probes, arterial and C.V.P. lines, ventilator patient hoses and E.T. tubes, naso-gastric feeding tubes, pacing wires, endoscopes, respiration monitoring cables, I.V. lines, transcutaneous blood gas electrodes, etc., etc.

It is nowadays common to have up to half a dozen individual items of equipment connected to the patient simultaneously and hence any interactive or fault currents may find a path through the patient. (6).

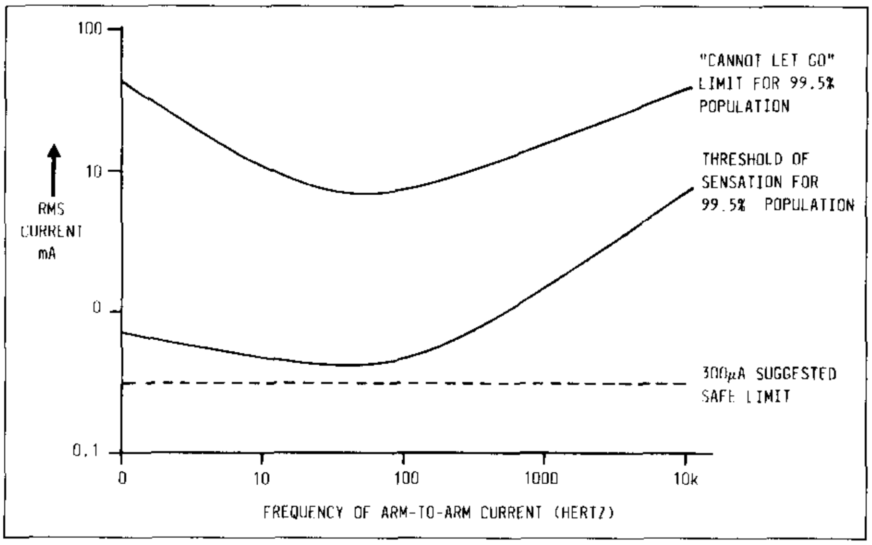
Imperfections

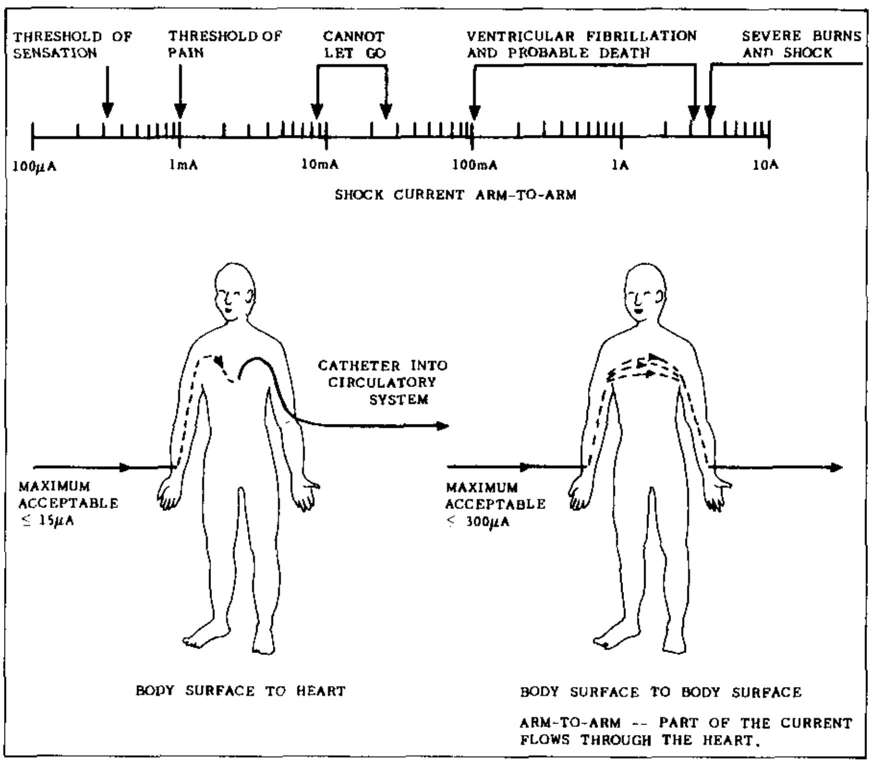
The electrical insulation and capacitive coupling of all equipment is imperfect and a measure of the imperfection is the leakage current. The normative range of patient connected equipment (CF) will be between 0-10 μA, whilst for non-patient connected medical equipment (BF) the range is between 0-500 μA. Such currents are measured in the earth lead or patient cables of all medical equipment.

Domestic electrical equipment has consistently higher leakage currents and under fault conditions may be as high as 10,000 μA or 10 mA. Clearly, if currents of this order of magnitude were to find their way into the myocardium, then the results could be catastrophic.

Practical Steps

It is quite impossible to predict every fault condition that may occur on any given





patient monitoring system, the electrical supply network or relevant physical changes in the patient environment. We must, therefore, seek to minimise the chances of untoward incidents by ensuring that only equipment which conforms to current safety standards are used in proximity to patient connected equipment (7).

For fairly obvious reasons, data on electrical shock hazard to patients is difficult to come by. However, some years ago the following table was published in the Journal of the American Medical Association 220, 1581-4 (1972) (8) which provides some food for thought.

Significant technological advances have taken place over the past decade which would greatly reduce the probability of many of the incidents listed occurring today. However, Medical Engineers must continue to be vigilant to reduce the risks to patients due to equipment interaction and susceptance to interference.

It is not always fully appreciated that the integrity of an entire patient monitoring system can be comprised by a single fault condition occurring on an item of non-medical or non-approved medical equipment in close proximity, particularly where pacemakers or invasive arterial pressure monitors are being used.

A very important facet of the management of life support equipment within Critical Care areas is susceptance to electrical interference. Much of this equipment is dependent upon digital circuiting for its normal safe operation and can be easily effected by extraneous radio-frequency fields and mains borne disturbances in the immediate vicinity.

An overview

All Critical Care areas such as Intensive Therapy Units, Special Care Baby Units, Coronary Care Units and Operating Theatres, should now be looked at with a systems approach rather than as individual items of equipment, since items that are entirely safe when used individually can become lethal when used with other equipment. Because of this fact, overall patient safety can no longer be adequately dealt with simply by individual equipment safety testing. (9).

A clear line should be drawn around areas such as I.T.U., where the application of any auxiliary equipment such as computers and peripherals might be contemplated. The Medical Engineering Section of the Maintenance Function should have overall responsibility for all equipment operating within the clinical environment, irrespective of whether it is Electro-Medical, Computers and Peripherals, Medical Electronics, domestic or battery operated equipment, or portable and mobile units. Only then can any meaningful assurance be given to clinicians that equipment is safe to use.

Total equipment safety for both patients and staff in hospitals is an unattainable goal, just as it is in the home, but a realistic

Case histories

Source	Shock Category	Outcome	Sink	Right Leg Electrode Involved
Ungrounded X-ray machine	Micro	Revived	Grounded monitor	Yes
Cardiac monitor	Macro	Fatal	ECG machine	Yes
Line-operated pacemaker	Micro	Fatal	ECG machine	Yes
Line-operated pacemaker	Micro	Fatal	ECG machine	Yes
Line-operated pacemaker	Micro	Revived	ECG machine	Yes
Line-operated pacemaker	Micro	Revived	ECG machine	Yes
Line-operated pacemaker	Micro	Revived	ECG machine	Yes
Densitometer	Micro	Revived	ECG monitor	Yes
Injector	Micro	?	ECG monitor	Yes
Injector	Micro	?	ECG monitor	Yes
Bedside lamp	Macro	Momentary shock	ECT machine	Yes
Electric bed	Macro	Fibrillation — revived	ECG monitor	Yes
Electric bed	Macro	Momentary shock	ECG monitor	Yes
Line-operated pacemaker	Micro	Fatal	Electric bed	No
Electric bed	Micro	Fatal	ECG monitor	Yes

movement towards this objective would be the effective separation of clinical equipment from domestic by means of a clearly defined 'Medical Equipment Only' policy for all critical care areas in our hospitals.

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Acknowledgements

Thanks are due to Tektronix Inc. for kind permission to reproduce the illustration of physiological current thresholds and also to Hewlett Packard Ltd for permission to use the case study illustrations.

Product News

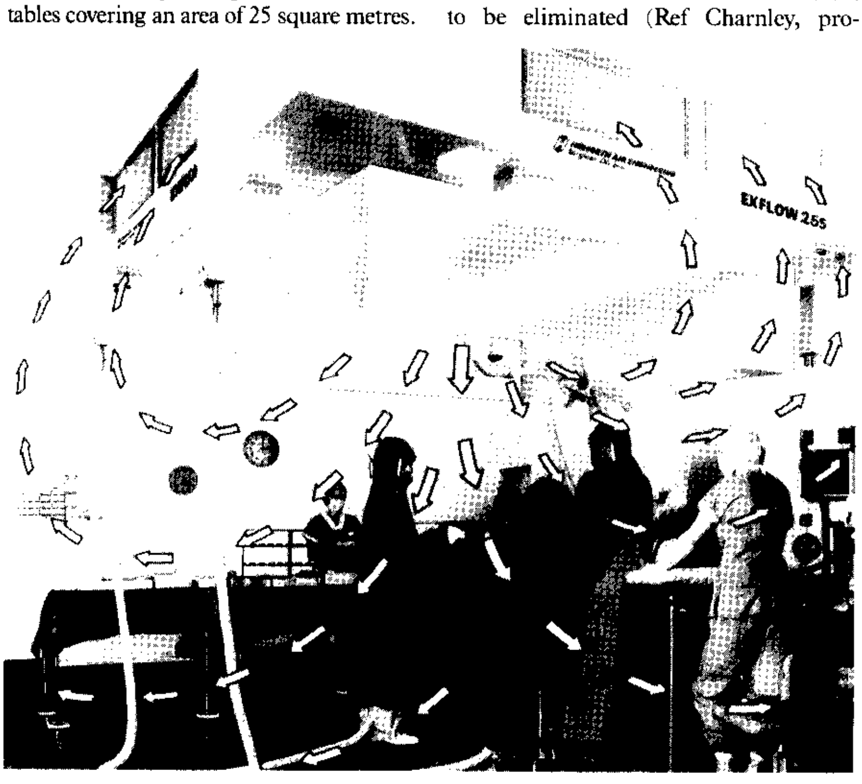
The new Charnley Howorth Exflow 25S

During extensive clinical trials carried out by the British Medical Research Council and the Department of Health (Ref BMJ 3.7.82) it was found that when joint replacement operations were carried out in Charnley Howorth aeromicrobiologically clean zones, wound sepsis was reduced by at least 50% and when the Charnley Howorth Total Body Exhaust was also used, the reduction in wound sepsis was at least 75%. When prophylactic antibiotics were used in addition to these two anti-dissemination systems then in a series of 1500 joint replacement operations, only one instance of wound sepsis was subsequently found. (Ref MRC — DHSS 1981 restricted circulation).

The Charnley Howorth Exflow 25S provides a downward and then radially outward flow of aeromicrobiologically clean air over the operating and instrument tables covering an area of 25 square metres.

Because of the unique and patented means of establishing this downward and radially outward exponentially curved, flow of aeromicrobiologically clean air, only the Charnley Howorth Exflow 25S is able to satisfy all these requirements silently and with minimal power consumption, and without the possibility of peripherally entrained contaminants entering the aeromicrobiologically clean zone of 5m × 5m. In order that the body emissions from the members of the surgical team do not contaminate this zone they should wear the Charnley Howorth Total Body Exhaust Gowns which capture, contain and remove all those body emissions of the surgical team which could reach the wound and all the instruments etc, which are to come into contact with the wound.

With the combination of the Charnley Howorth Exflow and Total Body Exhaust, an aeromicrobiologically clean zone of 5m × 5m can be be established for all forms of clean surgery. In this way wound sepsis from the airbourne route has been shown to be eliminated (Ref Charnley, proceedings of the American Hip Society, St Louis (1982)).



Microreporter takes off

Although in its infancy, the UK energy management system's market is attracting considerable interest these days. Already valued at around £30 million, it is projected by the Energy Efficiency Office to grow to over £150 million by 1990.

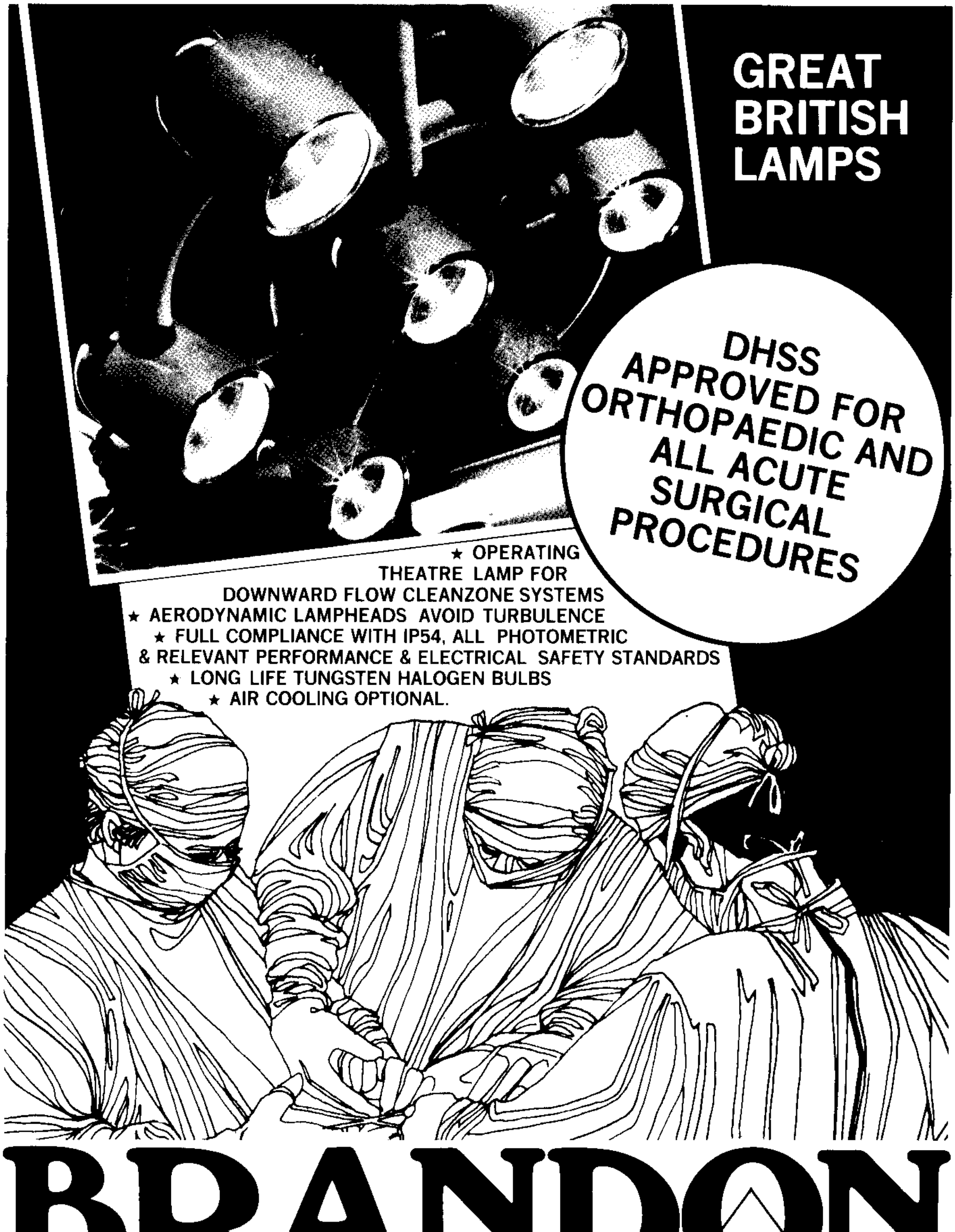
One company founded in 1982 by two top Johnson employees and funded by N. M. Rothschild Nominees and Debenhams, it developed a building management and control system which offers a refreshing new approach to the industry, called MicroReporter. It not only replaces all the traditional heating, ventilating, air conditioning controls around the building but also, for a very much lower price, provides all the building and energy management system facilities normally only available from larger systems.

Since launched in the Summer of 1983, over 70 MicroReporter systems have been sold to the public, industrial and commercial sectors. The system has proved to be robust, highly flexible and reliable in a wide variety of buiding types and, untypically in this young industry, the company enjoys a high level of customer satisfaction. To back up this exciting new British product and provide this comprehensive service, ITL have negotiated with Stacfa Control System Limited and Delta Electrical Systems Limited (part of the Delta/MEM organisation) along with awide range of local control specialists to distribute and support the MicroReporter system.

Further information: W. S. Watson Marketing Director, Information Transmission Limited, Unit One, Bone Lane, Newbury, Berkshire RG14 5PF.

Prefabricated insulation

A new type of pre-fabricated insulation for process vessels and insulated rooms, Sealsulation is waterproof, washable and resistant to microbiological and insect attack. No skilled labour is needed for quick and easy fitting, thus minimising cost and vessel downtime. Further economic advan-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tages result from the fact that it is re-usable and damaged sections are easily replaced. It is available in two finishes either white pigmented plastic or with a stainless steel covering.

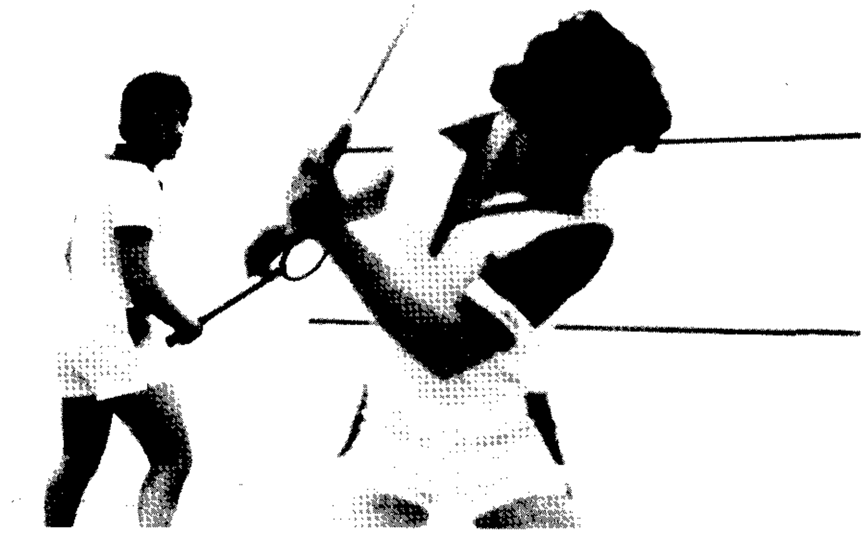
Further details from SEALSULATION, 9 Walkwood Road, Beaconsfield, Bucks. HP9 1PR. Tel: 04946 4828.

Battle Against Legionella

Chemical water treatment specialists Fospur Limited report growing demand for two of their products which are highly effective against Legionella bacteria — the cause of Legionnaire's Disease. Concern over the disease has been growing and research has shown that modern air conditioning and cooling plants may provide breeding grounds for epidemics. Fospur's Kortokil 2020 is aimed especially at air-conditioning and non-portable water systems and has been shown in extensive trials to be totally effective in killing a broad range of organisms, including Legionella bacteria. It also acts as a slimicide. For use in portable applications, where people come into direct contact with water, Fospur have developed their Fosclor range of chlorine dioxide formulations. Fosclor is a strongly oxidising biocide which is totally effective against Legionella and other bacteria, as well as acting as a slimicide, germicide and sterilant. No development of resistance to either product has been observed in long-term usage.

Further details from: Fospur Ltd, Alfreton Trading Estate, Somercotes, Derby DE55 4LR. Tel: (0773) 604321/8. Telex 377150 FOSPUR G.

Engineering Ambitions Squashed



The world of professional squash gains a new talent. Hospital engineer Bryan Beeson from Newcastle has turned professional. Since October last year, when he won the Welsh Open Championships, things have been happening fast for 24 year old Beeson. In December he reached the finals of the British Championships — without even having trained seriously, as his job in the Works Dept. at Brensham Hospital did not leave enough time for this.

Since then Beeson has won the East of Scotland Open and the North-East Open, when he beat Stuart Halestone from South Africa. Obviously, if Bryan did so well without even training, he must stand a good chance of making it successfully as a professional player. One of his sponsors is British Rail Inter-City, who have appointed him as a consultant to coach some of their clients. For this Bryan receives free 2nd class rail travel for a year. His main ambition now is to win the British Championships — then he will be able to travel *first* class!

Bryan told *Hospital Engineering* that although he had some regrets at leaving his career as a hospital engineer, he was thoroughly looking forward to being able to devote his full time and energy now to squash. He is aiming to become one of the top twenty professionals in the world. Our hospitals are always in need of qualified engineers, but their loss is the world of sport's gain, and we wish Bryan Beeson every success in it.

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