HOSPITAL ENGINEERING

August 1979

The Journal of the Institute of Hospital Engineering

Computers in the Bio-Medical Field

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HOSPITAL ENGINEERING

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The Journal of the Institute of Hospital Engineering

Contents

Front cover: ICL 2956 Computer.

Institute News

Electricity for Hospitals in the '80s

The case for heat pumps as a means of conserving energy and providing the best possible environmental conditions for hospital patients was made by Sir Francis Tombs, Chairman of the Electricity Council speaking at a one-day symposium on 'Electricity and Health Buildings in the 21st Century' organised by the Institute at the Institution of Mechanical Engineers in London on June 6, 1979.

Sir Francis said that heat pumps had already gained more general acceptance in North America and continental Europe than seemed to be the case in Britain. He explained that one building in this country had now been satisfactorily operating for nearly ten years as an all-electric building using the refrigeration plant as an internal source heat pump. This was not a hospital, but the headquarters of the Merseyside and North Wales Electricity Board — "a building which has been well researched and monitored in energy terms".

Many buildings, said Sir Francis, had been constructed with the same conceptual approach to the mechanical and electrical services. Internal source heat pumps and heat recovery techniques, he went on, were now established with proven plant available, and heat recovery systems which produced worthwhile savings in oil and gas were being applied in industrial processes and in commercial buildings.

Sir Francis said that population growth and population dispersal throughout the country were two unpredictable influences which affected both electricity supply and health service planners. A flexible response to future events and future energy requirements was essential. Electricity was an energy form which provided an assured supply for hospitals.

"It will be wise for designers of any new hospital buildings to ensure that they satisfy the criteria of low energy, largely electric and long life. Any Regional Health Authority or private hospital owner, which pursues this design approach will rely solely on us for their energy supply. But such an approach will automatically protect hospitals against major fossil fuel uncertainties.

"The mix of our generating capacity solidly based on indigenous British coal assures your requirements in the immediate years ahead. The present important contribution from nuclear energy will increase, building on the firm foundation of safety which has come from the most thorough engineering."

Nuclear power, Sir Francis said, will, by 1981, provide 20% of the electricity generated. In economic terms, he pointed out, nuclear generation is cheaper than generation by coal or oil. "I expect that it will continue to be cheaper in the years ahead, and that the gap will widen as fuel prices increase."

Sir Francis went on to say that the reliability of electricity supply in this country was extremely high. "The Area Electricity Boards particularly aim to maintain supplies to hospitals at all times. Foresight prompted the East Anglian Regional Health Authority to proceed with Britain's first all-electric hospital in Peterborough. I believe that with equal foresight the Department of Health is currently working on design studies for a super low energy hospital as an exemplar and test bed for the 1980s and beyond."

Keele goes Overseas

In 1977 the Wessex Regional Health Authority was asked by the Ministry of Health to set up an advisory team to support the Kuwait Government in its hospital development programme. A small team under the leadership of Jim Winning (Regional Works Officer, Wessex) went to Kuwait in September, 1978, for one year to help in the engineering commissioning of six new hospitals and to develop the Works Organisation. It soon became clear that the Kuwait Engineers, graduates of various universities, needed management training together with familiarisation courses on the engineering installations designed by various consultants.

The obvious way to do this was to provide a Keele type course. The engineer responsible for the management and engineering training of the Kuwait engineers is George Tuson, who is also Co-Director of the Keele Courses. Putting these two responsibilities together a Keele type course was prepared to run from March 15-28, 1979. There was some trepidation as language and culture problems were considered, which in the event proved groundless.

The course was attended by 18 senior engineers who were taken through organisation and management, operation and maintenance, management theory, staff management and the organisation of training. The course was complete with the 'Keele Visit' to Al Adan Hospital where four projects were visited: —

The Boiler House;
The Incinerator;
The Water Storage and Pumping Station;
Central Workshops and Stores.

Team reporting on the visit and cross-examination by course members was of the highest order and any fears of lack of motivation or interest were dispelled by obvious enthusiasm.

The tutorial team included Jim Winning, Derek Birks, John Elliott-Smith, Richard Shearing and George Tuson. Dr Mohammad Nawawi, Assistant Chief Engineer, also provided tutorials on the Kuwait organisations which collaborate with the Ministry of Public Health.

In all, the course was a further validation of the Keele method and showed that hospital engineers have the same motivations wherever they may be.

Birthday Honours List

It is with considerable pleasure that we record the inclusion in the recent Birthday Honours List of Hugh Howorth who has become an OBE. Members will recall Mr Howorth was

President of the Institute from 1975-1977 during which time the Institute owed much to his leadership and enthusiasm.

Keele Management Courses Tutor Honoured

Duncan Macmillan received the MBE in the recent Honours List and the pleasure at this award will be widely shared.

Duncan Macmillan was Group Engineer in Inverness before moving South to a similar post with the then South Worcester HMC and after re-organisation was appointed Area Works Officer to the Trafford AHA.

Mr Macmillan became, in 1970, a tutor on the Engineering Management Courses run by the Institute and held at the University of Keele and continued in this capacity when the Courses were moved to the NHS Hospital Engineering Centre at Falfield. He is therefore well-known throughout the NHS.

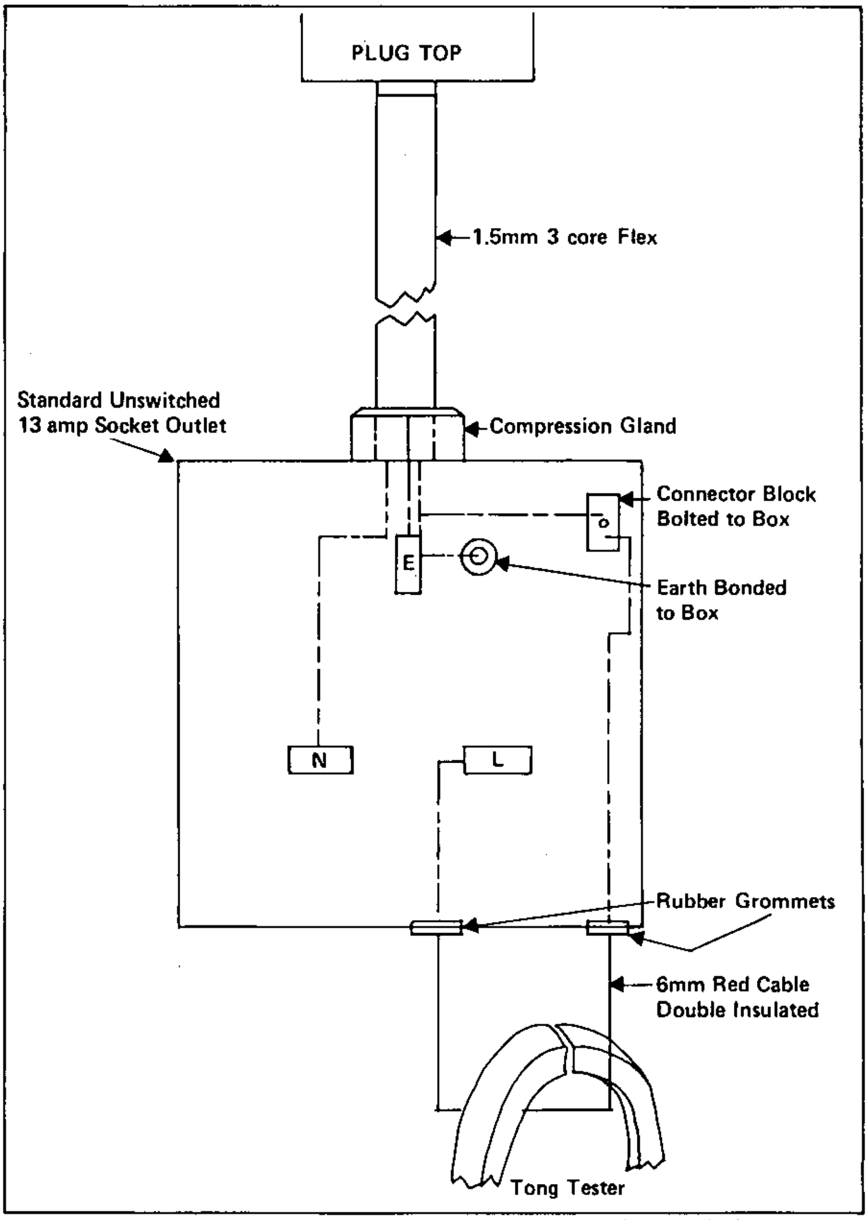
New Regional Engineer for the Northern Regional Health Authority

Mr James McDowell FIHospE of Jesmond, Newcastle, has recently been appointed Regional Engineer for the Northern Regional Health Authority.

Mr McDowell began his career as an apprentice draughtsman in Manchester. After national service he joined the Manchester office of a consulting engineering practice. Later he moved to the UK Atomic Energy Authority as an assistant design engineer. He then progressed to head of mechanical services in the design office at Runcorn New Town.

In 1967 he joined Oxford Regional Hospital Board to set up and develop an in-house design team. On June 1 he joined the Northern Regional Health Authority as the Regional Engineer.

Mr McDowell enjoys badminton and intends to devote some spare time to exploring the region with his three children. He is a keen member of the Institute and has taken part in a number of Institute activities.



Reader W. A. Harley, Hospital Engineer at Craig Dunain Hospital, Inverness, points out that, to carry out the self-financing Incentive Bonus Scheme and Planned Preventive Maintenance inspections, it is necessary to determine the current loading and that the thermostat is working on small heating appliances, ie hot cupboards, mini-grills, etc. This can be carried out quickly and efficiently by using the piece of equipment illustrated above.

Welsh Branch Activities

On Tuesday evening, March 27, 1979, a meeting was held at Prince Charles Hospital, Merthyr Tydfil, when Mr R. R. Morgan, Principal Assistant Engineer, Welsh Health Technical Services Organisation, presented a paper on the subject 'Mobile Radio Communications in the Health Service'. This meeting had been re-arranged from January when inclement weather had caused cancellation.

Mr Morgan described the development of mobile radio communications in the Ambulance Service since 1948 and brought members up to date with the present day use made by other NHS disciplines in addition to the Ambulance Service. He estimated that in England and Wales approximately £10m is invested in mobile radio equipment which involves about 6,000-7,000 vehicles including those used by Midwives, General Practitioners, Stores and Works Departments as well as the Ambulance Service. This investment is growing at an estimated 10% per annum.

The speaker went on to give a concise description of the considerable work involved in the planning of radio communications networks — especially as the future demand will be for multi-channel systems.

It was most unfortunate that the

visit to the South Western Branch scheduled to take place at Falfield had to be postponed. At short notice an alternative meeting was arranged on Tuesday, April 24, 1979, at the University Hospital of Wales, Heath Park, Cardiff, when a film slide/sound cassette presentation on the subject of 'Boiler Water Treatment' was shown. This forms part of the Boiler Efficiency and Safety Training Series produced by the Esso Petroleum Company. The content is designed to be of interest to those responsible for the operation of steam boiler plant, at all levels of management.

The Welsh Branch annual general meeting was held on May 19, 1979, at the Welsh Industrial and Maritime Museum, Cardiff. The officers elected for 1979/80 were:
Branch Chairman: Mr P. Jackson;
Vice-Chairman: Mr R. R. Morgan;
Hon Secretary: Mr D. Griffiths, 107 Beatty Avenue, Roath Park, Cardiff;
Hon Treasurer: Mr B. V. Williams.

The following members were elected to the Committee for 1979/80:
M. J. Back, T. Roche, D. Hackett, J. Jackson, R. Parsons, D. A. Jones, D. Lee, A. Grundy, D. V. M. Gibbon, J. Burton, P. Whitcombe.

Yorkshire Branch Officers

The following officers were elected for the Yorkshire Branch to serve for 1979-80: —
Chairman: Mr J. C. Shelton, Senior Engineer, York District Hospital;
Vice-Chairman: Mr J. Gelder, Senior Engineering Inspector, Barnsley MDC;
Hon Secretary: Mr J. Bate, Mechanical Services Supt, Wakefield MDC:
Hon Treasurer: Mr A. Duffield, Asst Engineer, Leeds General Infirmary;
Committee Members: Mr K. O'Rourke, Sector Eng, St James's Hospital, Leeds; Mr A. L. Sykes, Sector Eng, High Royds Hospital, Menston, Ilkley; Mr P. Gordon, Area Works Officer, Kirklees Area Health Authority; Mr A. E. Horvath, District Engineer, York District Authority.

North Western Branch Meeting

On May 15, 1979, the Manchester Branch visited two of the works in Manchester of Holden & Brook Ltd, where members were shown the manufacturing process of Heat Exchangers, Pressure Vessels and Pumps. Afterwards a talk was given by members of the company's staff on energy conservation in relation to their pumps and heat exchangers. A full buffet meal was provided and the evening was thoroughly enjoyed by the members who attended.

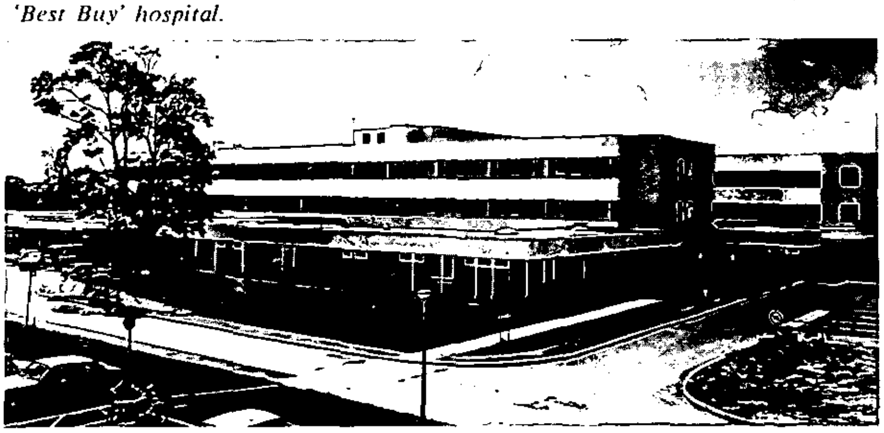
Trade Unions

The Council of Engineering Institutions has recently published a second edition of the booklet 'Professional Engineers and Trade Unions', which has been prepared by the Council's Professional Engineers and Trade Union Panel.

The booklet notes the increasing pressures on professional engineers to join a trade union and explains the need for them to consider joining appropriate unions. Nearly 45% of chartered and nearly 60% of technician engineers are already members of trade unions. Of these about three-quarters are in the public sector. The booklet seeks to provide guidance, so that professional engineers can decide which union they should consider joining.

Copies of the booklet are available price 50p, post free, from Council of Engineering Institutions, 2 Little Smith Street, Westminster, London SW1P 3DL.

Pictured below is the new £7m Withybush General Hospital, situated on the outskirts of Haverfordwest, Pembrokeshire. The 338-bed hospital was officially opened by Princess Anne in June. In their design, architects Nicol Thomas Viner Barnwell, have used a DHSS standard ward plan as evolved for the 'Best Buy' hospital.



Chartered Engineers in Parliament

Two further Chartered Engineers were successful in becoming MPs in the recent General Election. As the eight Chartered Engineers in the previous Parliament were successful in retaining their seats, there are now ten Chartered Engineers in the House of Commons, five Conservative, four Labour and one Liberal.

Finals of FT Architecture Award

Of the 67 entries for the Financial Times Industrial Architecture Award this year, six schemes have been chosen as finalists. As usual the standard was very high.

Details of the winning entry will be published in the *Financial Times* on December 7 when a lunch will be held in Goldsmiths Hall to present the trophy to the winning architect.

The assessors for this year's award are Sir Charles Troughton, the lay assessor, and architectural experts Trevor Dannatt and John Partridge.

The six finalists include:
Industrial Therapy Unit, Long Grove Hospital, Epsom, Surrey.
Owner: South West Thames Regional Health Authority
Designer: Harding and Associates
Builder: Chapman Lowry and Puttick.

Fire Prevention Convention

'Firetech 79', the Fire Detection and Prevention Exhibition to be held at Brighton's Metropole Hall, September 18-21, has already attracted excellent bookings from major manufacturers.

Registrations for the conference are already being received and enquiries should be addressed to:

The Secretary, Fire Protection Association, Aldermary House, Queen Street, London EC4N 1TJ, Tel: 01-248 5222; or Mr D. S. Ramsay, The Institution of Fire Engineers, 148 New Walk, Leicester LE1 7QB. Tel: 0533 59171.

Book Review

Health Care Administration – A Guide to Information Sources

Edited by: Dwight A. Morris and Lynne Darby Morris. Published by: Gale Research Co, Detroit. Price: US$22.00.

The book is a good, well-organised bibliography of information on US health care. It will be of use to anybody who wishes to investigate a particular aspect of US health care viewed from an administrative point of view and, to that extent, I would expect it to be available in the larger University libraries.

However, the subject matter is exclusively drawn from American sources to the exclusion of books published in other countries that one would expect to be available in America as US books are available in British libraries. As a result, I consider that its relevance to the average person working in the British health system is very limited.

On the occasion of the inaugural presentation of the annual Perfectair Award made to encourage students at the Polytechnic of the South Bank, London. Mr A. G. Roberts, Chairman of Perfectair Ltd, environmental engineers, presented the cheques to Mr Barry Austin (on the left) and Mr Paul Lester (centre) who came first and second respectively in the 1978 finals of the CIBS Examination Exemption Course.

Letter to the Editor

A Solution to Hospital Refrigerator Problems

Dear Sir,

For many years in Craig Dunain Hospital, which is an 850-bed mental illness hospital, the Engineering Department encountered recurring problems with upright refrigerators. The problems were as follows: —

Strong smells from the refrigerator as a result of cracks in the lining which permitted spilt milk to seep into the insulation material;

Wire shelves buckling under the weight of the milk which is delivered to the wards only once a day;

Door linings and other door shelves cracking and breaking off;

Freezing compartment door being broken after it had become frozen in the closed position.

We could overcome the main problem of the interior lining cracking by purchasing steel lined refrigerators, but they are more expensive and the other problems still remained.

We have now found a tried and tested solution to all the above problems to the satisfaction of the ward users as well as the Engineering Department.

In October, 1977 with the co-operation of Nor-Scot Refrigeration Co, Inverness, we installed a Derby 7 cu ft chest type freezer unit fitted with a Ranco VB7 thermostat which allowed cooling but not freezing within the unit.

Note: Due to higher working temperatures and increased humidity the refrigeration pipework may corrode. This can be eliminated by replacing the pipework with copper piping at a cost of £6.50 per unit which will be carried out by the manufacturers, Maskinfabikken Derby A/S, DK 9620 Aalestrup, Denmark, on request. (Minimum order of 30 units if conversion to copper piping is requested).

The Derby chest type unit is completely sealed and lined with aluminium, capable of withstanding large quantities of milk, which can be stacked on the bottom of the unit, whilst eggs, butter, cheese etc, are contained in a basket in the top of the unit.

The Derby unit has all the features which the users and Engineering Department require: —

Milk, cheese, butter etc, are kept cool and are easily accessible;

The lid can be locked if required;

Easily kept clean by wiping out regularly;

The control switches can be covered with perspex to allow the indicating lamps to be seen and prevent the thermostat from being altered;

Reduced initial costs and maintenance costs. The cost of the new Derby unit plus new thermostat is £110 which is a saving of £56 a unit compared with purchasing a steel-lined upright unit. The maintenance costs are reduced by the fact that the Derby unit has no door or door linings or interior plastic linings which are subject to cracking or breakages.

The disadvantages of the Derby unit are not serious but should be considered: —

As it is a chest-type refrigerator it cannot be fitted under existing work surfaces and requires a larger floor area than an upright;

There are no facilities for making ice cubes, although this can be overcome by installing, in a central position to serve a number of wards, an ice cube maker.

We now have six of the Derby units in use and it is our opinion that the use of this Derby chest-type unit saves money and is more suitable to our requirements than the conventional upright refrigerator.

Yours sincerely,

W. A. HARLEY, MIHospE,
Hospital Engineer,
Craig Dunain Hospital,
Inverness, Scotland IV3 6JU

The Accounts for the Council of Engineering Institutions

ACCOUNTS FOR THE YEAR ENDED SEPTEMBER 30, 1978

BALANCE SHEET AS AT SEPTEMBER 30, 1978

1977 £	1977 £		£	£
9,662		**FIXED ASSETS** (Note 3)		14,453
		CURRENT ASSETS		
	3,619	Cash at bank — current accounts	—	
	196	Cash in hand	200	
	213,938	Cash on deposit....	204,660	
	27,085	Debtors	71,107	
	13,953	Amount due from Fellowship of Engineering	34,615	
	6,865	Payments in advance	15,367	
	265,656		325,949	
		CURRENT LIABILITIES		
	—	Bank overdraft	18,312	
	56,698	Creditors and accrued expenses	66,467	
	10,690	Examination fees received in advance	9,732	
	67,388		94,511	
198,268		**NET CURRENT ASSETS**		231,438
£207,930				£245,891
		Represented by:		
		ACCUMULATED FUNDS		
	103,417	General fund	104,541	
	38,510	Engineers Registration Board	64,679	
141,927				169,220
		PROVISIONS (Note 1)		
		Building fund —		
	17,336	For dilapidations and improvements	19,068	
	48,667	Other specific provisions	57,603	
66,003				76,671
£207,930				£245,891

JOHN ATWELL
ARNOLD LINDLEY } *On Behalf of the Council*

AUDITOR'S REPORT TO THE MEMBERS OF THE COUNCIL OF ENGINEERING INSTITUTIONS

We have examined the accounts and records of the Council of Engineering Institutions. In our opinion the accounts on pages 40 to 44 give a true and fair view of the state of affairs at September 30, 1978 and of the Revenue and Expenditure for the year ended on that date.

January 22, 1979
London EC2Y 5AL

PANNELL FITZPATRICK & CO.
Chartered Accountants

SUMMARY OF REVENUE AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED SEPTEMBER 30, 1978

GENERAL FUND

1977 £	1977 £		1978 £	1978 £
		GENERAL REVENUE		
	189,633	Subscriptions	233,447	
	14,227	Interest	13,603	
	961	Interest charged to Fellowship	1,828	
	(17)	Profit on sale of fixed assets	74	
204,804				248,952
		GENERAL EXPENDITURE		
	—	Finniston enquiry	11,766	
	289	Charter and Bye Laws	—	
	—	Smeaton Award	84	
(289)				(11,850)
		NET CENTRE COSTS		
	65,636	Administration	72,399	
	28,981	Qualifications	34,060	
	(22,855)	Examinations	(21,165)	
	17,460	Regions	24,706	
	51,495	Public affairs	74,213	
	9,010	Interdisciplinary	12,923	
	20,290	Overseas	19,298	
(170,017)				(216,434)
34,498				20,668
		APPROPRIATIONS (Note 1)		
	5,000	Chartered Engineers Register	(18,392)	
	11,316	Augmentation of Pension Fund	11,936	
	2,000	Dilapidations and improvements	4,000	
	(10,000)	Assessment of Training Programme	—	
	(14,949)	Careers development	—	
	—	1979 CEI Ballot	12,000	
	—	Rent increases	10,000	
(6,633)				19,544
41,131		**SURPLUS FOR THE YEAR**		1,124
62,286		**ACCUMULATED SURPLUS BROUGHT FORWARD**		103,417
£103,417		**ACCUMULATED SURPLUS CARRIED FORWARD**		£104,541

REVENUE AND EXPENDITURE ACCOUNT—YEAR ENDED SEPTEMBER 30, 1978
ENGINEERS REGISTRATION BOARD

1977 £	1977 £		1978 £	1978 £
	2,206	Direct expenses	4,286	
	19,037	Wages and salaries	16,115	
	3,665	Rent, rates and insurance	2,478	
	7,830	Other overheads	5,017	
32,738		**TOTAL EXPENDITURE**		27,896
(50,224)		**INCOME**		(54,065)
17,486		**SURPLUS FOR THE YEAR**		26,169
21,024		**ACCUMULATED SURPLUS BROUGHT FORWARD**		38,510
£38,510		**ACCUMULATED SURPLUS CARRIED FORWARD**		£64,679

NOTES TO THE ACCOUNTS FOR THE YEAR ENDED SEPTEMBER 30, 1978

1. PROVISIONS

	£	£
Building Fund Provision for Dilapidations and Improvements		
Balance at 1.10.77		17,336
Expenditure in the year		(2,268)
		15,068
Provision for the year		4,000
Balance at 30.9.78		£19,068
		Per Balance Sheet
Other Specific Provisions		
1979 CEI Ballot		
Provision for the year		£12,000
Setting up of Chartered Engineers Register		
Balance at 1.10.77		25,000
Expenditure in year		(6,608)
		18,392
Provision no longer required		(18,392)
		£ —
Rent Increases		
Provision for the year		£10,000
Augmentation of Pension Fund		
Balance at 1.10.77		23,667
Provision for the year		11,936
		£35,603
Total of Other Specific Provisions Per Balance Sheet		£57,603

2. PROVISION FOR THE AUGMENTATION OF PENSION FUNDS

No actuarial valuation has been carried out to determine the extent of the total provision required to provide additional pensions for senior employees. However, the Members of the Board believe the sums being provided to be adequate for the proposals still to be finalised.

3. FIXED ASSETS — OFFICE MACHINERY, FURNITURE AND FITTINGS

	1978 £	*1977* £
Cost		
At October 1, 1977	27,597	26,336
Additions in year	7,727	1,526
Disposals in year	(1,630)	(265)
At September 30, 1978	33,694	27,597
Depreciation		
At October 1, 1977	17,935	16,189
Charge for the year	2,610	1,961
On disposals in year	(1,304)	(215)
At September 30, 1978	19,241	17,935
Net Book Value	£14,453	£9,662

Depreciation is provided to write off the cost of fixed assets over their estimated useful lives using the straight line method at the rate of 10% per annum.

The author is Assistant Chief Engineer with the Welsh Health Technical Services Organisation

Computers in the Bio– Medical Field

R. G. KENSETT CEng MIMechE MCIBS MInstF MRSH MIBM FIHE

Early Use of Computers

One of the principal branches of medicine where computer techniques have become completely accepted is in the field of experimental medicine.

The value of any experiment involving a living animal be it human or otherwise is governed largely by the ability or otherwise of the investigator to control the many variables.

During the past few years this ability has steadily enhanced by the effectiveness of sample handling procedures such as accurate and rapid analysis of gas mixtures (from the lungs), blood and other body fluids and also by improving techniques of collecting and recording data, principally physiological data in relation to respiratory and cardio-vascular dynamics.

In the past advances had become so rapid that the significance that should have been noted has been lost by the inability to process the data obtained. Thus it became apparent that some new approach to the problems of data processing was required, and of course as people were quick to realise the answer lay in that great ICL 1900 machine which was spending much of its time processing salaries, stores control etc, but had long periods without use.

One may well query this last statement, but when it is realised how quickly computers operate and how it is possible to slip in other data processing problems in the milli-second pauses between calculations, the real time that is just left idle is quite astounding.

The main points in this processing of the experimental data were that it should be possible not only to anticipate and predict the trends of the physiological variables but also to modify the procedures as new information became available.

Furthermore the ability to process this data would allow the development of more complex procedures which had been previously limited by the inability of investigators to carry out the necessary calculations in the time available.

Smaller Dedicated Computers

After all I am quite sure that you will appreciate that if someone is lying on the table and you want to know the likely and predictable effect of increasing the dosage of an experimental drug he is just not going to lie there and refuse to die whilst you go off and prepare a set of predication curves. The specialist wants the answer now and of course the modern computer with its ability to complete the most complex calculation one can imagine in a matter of seconds, probably less than seconds, will give him that answer.

The early experiments were based using on-line techniques to the large general purpose machines which were, and in many cases still are, financially orientated. The difficulty of adapting the techniques, and preparing programmes, which does require quite a lot of specialist knowledge because one just cannot afford too many operator error print-outs, has led to the use of the smaller dedicated computer in this field. These smaller machines with limited store range — generally 8,000-16,000 words (that is computer words), or if you prefer computer terminology 8-16K store, provided the answer.

The more specialised nature of these machines makes them well-suited to the limited demands of the single discipline and in my own opinion these units which are also well-suited to such functions as patient monitoring systems will prove the basis for future expansion in the field of computerised medicine.

Technical Requirements

The simple system for routine use will consist of the dedicated digital computer with its input supplied directly from peripheral equipment mounted at the bed, cage or operating table or digitised signals derived from a fast analogue to digital converter. By this I mean that a blood pressure reading can be converted via a receiver into a voltage and then by means of electronic gates changed into a binary digit (0 or 1) at the computer. This A-D converter can be switched by means of a multiplex arrangement to receive signals from any one of a number of channels. The digital output from the computer can be displayed on a tele-type, which, for those who may not know, is similar to a telex machine whereby the data is typed out alpha numerically, or more conveniently, on a visual display unit. This is similar to a television screen and the data is either written out by a light pen or a trend curve drawn which has its shape modified as each fresh piece of input is received.

Trend curves can also be displayed on a digital plotter. This machine is something like a small drawing board on which the curve is actually drawn on computer paper sheets in ink as you watch. This has the advantage that you have a permanent record which is not available on the visual display, although I have seen an experimental machine at Ferranti's in Edinburgh where you get the visual display screen, the digital plotter and a final 35 mm negative produced at the same time.

This work incidentally was being

carried out under a £100,000 development program sponsored by DHSS.

The thing to remember as well as regards the use of the small dedicated computer is that compared with many scientific variables the rate of change of physiological signals is comparatively slow and one A-D Converter will handle easily and for all practical purposes simultaneously all the analogue signals from an eight-channel recorder.

The frequency of scanning will of course depend to a large extent on the rate of change of the variable under inspection.

In the case of an ECG complex the conversion may require the analysis of 300 points per second, whereas the blood pressure wave form can be analysed with a sampling rate of 100 points per second and in the case of dye dilution Cardiac output curve the rate can be as low as ten points per second.

As a general rule scanning at twice the highest frequency of the wave form component under inspection is adequate but if peaks and troughs require accurate measurement higher rates may be needed. For this reason the analogue — digital converter should be able to operate at rates of up to 1,000 points per second.

In practice before signals can be handled by the A-D converter, suitable matching units are needed to enable the output voltages from the physiolgical recording systems to be adjusted for acceptance by the computer.

Normally one finds the majority of physiological recorders operate in the range between 10 volts and 10 millivolts, whereas the present generation of computers now operate on a signal input of ± 1 volt. Once the voltage adjustments have been made, a multiplexing unit scans the incoming signals and selects them at a frequency controlled by the appropriate subroutine in the computer program.

In any computer system for use in biology and medicine the operating procedure must be brief and simple, because very few medical experimenters are likely to be trained programmers and partly because the requirements of this type of work tend to place the computer, once the novelty has worn off, in the same category as any other bench equipment.

For this reason a magnetic tape or disc orientated system is virtually mandatory and it is an added advantage if the tape or disc arrangement is an integral part of the unit.

The Applications

Virtually every physiological variable is amenable to computer analyses. The cardio-vascular measurements are of particular interest to the investigator in experimental medicine and of these measurements I think without doubt that the ECG wave form has probably been submitted to computer scrutiny more frequently than any other function.

This is probably because of the ease of recording this function, its regular and repetitive pattern and of course its diagnostic significance — after all when this goes to a straight line you have really had it.

So some of the more common and regularly used analyses programs are:
ECG Wave Form;
Dye Dilution Curves for calculating Cardiac output which as you may know is dependant on the fact that when a dye is injected into the circulatory system a characteristic dilution curve is obtained. Because the down slope of the curve follows an exponential pattern, it can be expressed logarithmically as a straight line and used to eliminate effects of the dye by extra polation to the base line. Under these circumstances the total area under the curve represents once circulated dye in a known time and if the dye dose rate is known the cardiac output can be calculated — that is the explanation of one of my medical colleagues;
Peripheral Blood Flow by means of venous occlusion;
EEG Wave Forms which illustrate the electro-encephalographic changes due to exposure to different tensions of oxygen, carbon dioxide and volatile anæsthetic agents.

These are a few examples of the use of computers in bio-medical work.

Others are patient monitoring systems as used in the intensive therapy unit — here it is useful to remember the Oxford dictionary definition of monitoring — 'something that reminds or gives warning'. The operative definition in this case being 'gives warning'.

Many patient monitoring devices are considered medically deficient and these fall into three main classes:
Problems of the patient/transducer interface;
Problems of data analysis and presentation;
Problems of data retention.
and it is in the last two aspects that computer assistance offers the greatest hope of improvement. Many studies have been made and in some cases the system has been extended to provide automatic treatment.

Other Applications in the Medical Field

Another instance is the use of computers as valuable adjuncts in radiotherapy centres.

The problem facing the radiotherapist is that of treating a defined volume of tissue with ionising radiation as uniformly as possible and at the same time avoiding the irradiation of other critical or sensitive volumes of tissue.

This may be achieved by directing a number of external beams at the area from different directions and the problem is to determine the absorbed dose from the super position of all these beams. This can only be done if the distribution in each single beam is known.

The information on distribution is provided by the physicist in the form of Isodose curves which are the loci of points of equally absorbed dose within the beam. These Isodose curves are often given special shapes by inserting specially designed absorbing filters in the beam.

If these curves are plotted out it is often seen that there is a non-uniform distribution of summated dose across the area. In order to balance the dose gradient, plain beams are added. The relative weight of the plain beam is so chosen that the whole of the treatment area is surrounded by an Isodose curve of 105% and no point inside the area reaches as much as 110%. At the same time there must be a rapid fall off outside the treatment ar· , to avoid damage to healthy tissue. This is a comparatively simple program for the computer to solve and the real power of calculating the requirements by computer is shown in complex cases, where more than three beams are used or a moving beam is used instead of several stationary ones. Again the computer can be used to resolve treatment conditions by its use as stimulator and its application can be extended so that it is used as a process controller, a monitor, and a data logger under conditions of actual patient treatment by external beams of radiation.

In this application the patient is set up on a replica of the treatment machine and is checked by X-ray films and otherwise to ensure the computed plan is satisfactory and again a visual display unit is ideal as this can be used to indicate the interfaces of the beams. When the program has been amended, the physical and geometric parameters which define it can be recorded on punch cards or paper tape including the patient's personal details and error checks, which are designed to prevent mistakes. Such a tape could then be used to control automatically the settings of the radio therapy machine leaving the radiographers to make the final adjustments and to attend to the human needs of the patients.

At the same time the computer can record all the relevant data of the Treatment as actually given, compare this with the prescribed data and thus relieve the radiographers of a lot of tedious calculations and clerical work.

Other medical applications are Out-patient lists and in-patient listing. These systems are designed to relieve the Consultant of the task and responsibility of deciding the priorities of his patients by recommending a list of priorities for interviewing and in the case of in-patients can decide the operating lists.

A further system which has been developed in the Cardiff area using a terminal linked to the main frame computer is a Pathology Laboratory System. This system revolves round three main files. The first is the Request File which will contain details of tests requested by Consultants.

Each test will be in one of two states indicating whether or not it has been included on a work list.

The second file is the Results File which will hold certain data on each patient. The data is in three types.

The first is the result format which although not a true result is conceptually the format into which it is inserted as soon as it is available.

The second is past results which is a record of all path tests previously conducted, whilst the third section is the present results which are to be written in the results format and will list changes in the state of organs, outputs from organs and predicted rates of change.

The third file is Archive File which lists all previous results of tests etc and operations performed and their effect on related organs and bodily function.

There is a further section now under development called the Prediction File whereby knowing past results from the Archives File and relating these to the current Results File, the effect on organs, and their function can be predicted. If required a rate of change in the organ or bodily function, or its rate of deterioration can be established. This will of course assist the surgeon in deciding how long an operation can be delayed where the patient is in poor physical condition generally.

Future Trends

These notes are intended to provide an idea of likely trends and current activities in the use of computers in the bio-medical field.

It is an established fact that the Health Service is increasingly involved in the computer field and as engineers, I would suggest that we need to appreciate the applications in fields of activity other than purely the works function.

Engineers are also becoming increasingly involved in bio-medical activities and I would suggest that it is to our advantage to ensure we appreciate the advances in computers now taking place, if only to be able to contribute something when our medical colleagues discuss such matters.

This paper was presented at a One-Day Symposium on 'Electricity and Health Buildings in the 21st Century', held by the Institute in London on June 6, 1979. The author is National Energy Sales Manager, The Electricity Council.

Overseas Developments for the Future

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Dependence of Hospitals on Electricity

As we move towards the 21st century, it is apparent that there will be a diminishing availability of fossil fuels both worldwide and in Britain. Whilst we are favourably placed compared with some other countries in Europe with gas and oil from the North Sea continental shelf, it is predicted by many authoritative energy organisations that these sources of supply will be peaking out towards the end of the century.

The price relativities of the different forms of energy will change. The increasing scarcity of oil will be reflected in its price, and the ultimate scarcity of natural gas is likely to result in manufactured SNG at substantially higher prices. The basic fuel for electricity generation in this country is coal and this will remain so for a long time ahead. Nuclear power is already developed and is playing an increasingly important role in electricity generation, which will increase as we move into the 21st century. This is likely to be augmented by energy from some of the renewable sources.

Hospitals are energy intensive buildings. They are also long-life buildings. Therefore, the far-sighted engineer needs to look ahead and provide an environmental services design, which will stand up in the future — within the total life of the Health Service building. It is necessary to recognise that hospitals and other Health Service buildings will become more dependent on electricity for most if not all of their energy requirements.

In good building design, account is taken at the embryo stage of the interaction between all the various elements of design, and it is demonstrable that a largely electrically powered hospital warrants special consideration of an integrated design approach.

This paper is an appraisal of some overseas hospital developments, which are either entirely or largely using electricity for all purposes. It is supplementary to an earlier paper on all-electric hospitals in Europe and North America prepared by the author in November 1976.

This survey of overseas hospital developments has been compiled from published information contained in some foreign language technical journals and supplemented by descriptive material kindly provided by electricity utilities in several countries. For this reason it is based upon actual known projects which are either wholly or largely dependent upon electricity as the energy, for the hospital's environmental services, as well as for the usual essential uses of electricity for applications such as X-ray equipment. As far as is known neither the World Health Organisation nor any other institution has compiled a register of health buildings worldwide, which are entirely dependent upon electrical energy. Therefore, this survey is not necessarily fully comprehensive, and the author will welcome knowledge of any serious omissions for inclusion in similar future surveys.

Huntington Intercommunity Hospital, California

The first example is the Huntington Intercommunity Hospital located at Huntington Beach in California, which is described as an oil and resort town. In common with the general population trends in California, this small town located south of Los Angeles close to Long Beach has been expanding during the last twenty years.

In 1960 the Orange County Community had a population of a little more than 11,000. By 1965 the number of permanent residents had escalated to almost 85,000 and by 1970 was more than 100,000.

In 1965 the city officials became concerned at the lack of any hospital facilities and particularly the absence of emergency care facilities. It was decided that this deficiency should be corrected, and during 1967, the 144-bed Huntington Intercommunity Hospital was opened. Future expansion for an additional 300 beds for acute care has been allowed for in the initial planning stage.

The hospital consists of two connected structures, a one-storey administrative and ancillary services building and a four-storey plus basement tower for medical treatment. Construction of the two buildings differs somewhat but both are encased in red brick exteriors. Strips of vertical windows are outlined with white plaster fins shaded with sun louvres.

One of the design objectives of the architect and consulting engineers was to integrate the air conditioning and water heating systems in order to retain heat energy usually wasted during periods of cooling of the interior accommodation.

The central feature of the heat recovery system is an electrically driven reciprocating compressor for water chilling. When chilled water is being used for air cooling, the heat removed from the building plus the heat generated by the compressor is transferred to another water system which warms those sections of the hospital requiring additional heat and also raises the temperature of water intended for general domestic hot water usage. When air cooling is not required, the chillers are operated with a false cooling load from the extract air such that the refrigeration compressor is then operating as an internal source heat pump. Auxiliary immersion heaters are located in the hot water storage tank to bring temperatures up to desired levels before water is distributed throughout the hospital. This approach was adopted to overcome the problem of the relatively high cost of supplying large quantities of hot water by conventional electrical heating methods. However, due to the difficulty of balancing sterile hot water requirements with the heating and air conditioning system, it later became necessary to introduce two separate systems. The sterile water system is heated by boilers using natural gas.

The hospital administrator reports that the staff have been pleased with the design of the hospital.

Boca Raton Community Hospital, Florida

Moving now from Southern California to Florida, we find that the original Boca Raton Community Hospital was also built in 1967, comprising of a four-storey building with 100-bed accommodation. Since then a five-storey vertical addition has raised the building to a design height of nine storeys with bed capacity of 250. A refinement incorporated in the second building phase is an energy saving heating, ventilating and air conditioning system, incorporating rotary air-to-air heat exchangers and electric duct heaters. The heat recovery capability of this system made it economically feasible to use 100% outside air for ventilating the upper floors.

Some of the credit for Boca Raton Community Hospital's rating as an excellent health-care facility is attributed to the quality of the ducted air heating and cooling system. As planning began for Phase II (the five-storey addition), thought was given first to designing the system for 65% outside air, the balance being obtained by recirculating return air. Subsequently, it was decided to upgrade the ventilation rate to 100% outside air. This decision brought two obvious benefits.

First, it practically eliminated the oppressive medicinal odours associated with most hospital environments. Second, the total air change aids hospital asepsis through removal of airborne contaminants.

The exchange of conditioned inside air for raw outside air normally represents a considerable energy expenditure. To put the upgraded ventilation rates on a practical economic basis the designers resorted to heat recovery techniques to reclaim the energy available from exhaust air. To achieve this they have used a rotary heat exchanger or thermal wheels.

Specially engineered for this project were five air conditioning modules, factory assembled and delivered to the construction site in packaged form. Each module consists of blowers, filters, cooling coils, heaters, spray chamber and thermal wheel all mounted integrally together on a structural steel base. The engineers have described the module as a 'mechanical room on a skid' in as much as only electric power and chilled water connections are needed to make each module operational. Heating in the five-storey addition is handled by in-duct electric heaters controlled by zone thermostats.

It is pertinent to mention that the designers had estimated that 1,934 kW of chiller capacity would be needed for the five floors with the original 65% outside air design. Use of the thermal wheel modules reduced the chiller requirement to 1,076 kW with the 100% outside air design actually used.

Engineers carried out exhaustive tests to check whether pathogenic bacteria being flushed from the building in the exhaust air could be carried into the incoming airstream. The findings proved negative and as a precaution monthly tests are still being carried out.

The cleanliness of the air is attributed to several factors, among which is the extensive filtration employed. Multi-layer filters are installed at two locations on the supply side and as a final precaution air is filtered a third time just before being returned to the wheel. The openness of the filler mesh of the thermal wheel coupled with the high velocity of the discharge air appears to obviate any tendency of bacteria to adhere to the rotating element.

The possibility of cross-contamination is further reduced by incorporation of a purging section. Purging is accomplished by returning a portion of the make-up air to exhaust after it has passed through the wheel. The purge area is a ten degree sector over the partition between inlet and exhaust chambers. Here, a U-shaped duct scoops up some inlet air and returns it back to flush out continuously the mesh before it is allowed to contact the incoming supply air actually fed into the hospital.

The thermal wheel's effectiveness depends upon a number of factors, most notably on its physical dimensions. The deeper it is, the greater will be the amount of heat exchange between output and input streams. Peak efficiency of about 90% is possible by more investment — larger equipment, more plant room space, extra fan power to overcome pressure drop through the mesh and extra power to rotate the wheel.

It is necessary to trade off the maximum efficiency attainable against the return on capital outlay, and in Boca Raton Community Hospital, the engineers have settled for 75% as the optimum applicable for their design.

Danbury Hospital, Connecticut

Still within the USA but looking at more northern latitudes we find another interesting example at Danbury in the state of Connecticut. The Danbury Hospital tower building solar energy project will include 1,766 m² of flat plate solar collectors to provide both heat and hot water for a 405-bed general hospital. This is the largest solar system on a general hospital in America and probably in the world. The hospital complex consists of ten buildings on a 750,000 m² site.

Insulated reflective and heavily insulated exterior walls and roof have been used in the fabric design to provide for low heat transfer.

Special attention has been devoted to energy conservation throughout the project. One principal element towards energy conservation was the decision to install electric centrifugal chillers with double bundle condensers. These chillers recover heat during the winter for the pre-heating of the incoming air. Their heat recovery source is a water run-around system of coils. These are located in the heating, ventilating and air conditioning exhausts: the laundry lint collector exhaust; and even the water jackets of the emergency diesel generators to recover heat from the diesel engines when they are running. A 181,000 litre water storage tank is used to hold excess heat which can be used either to heat the building directly or as additional heat source for the chiller evaporators during unusually cold days. A central automated control system is installed for environmental monitoring and to provide for energy management. Currently, the entire complex is being topped with a flat plate solar collection system, which will encompass 889 flat plate collectors. Already 594 panels have been installed on the main roof of the building and an additional 259 panels will be installed on the lower terraces of the building.

In the design of the system the engineers looked at the loads which would benefit from a solar energy application. Space cooling was abandoned because of its complexity.

Space heating was considered for three basic systems. One system uses electric boilers for terminal re-heat, another for domestic hot water and a third uses the heat pump for the pre-heat coil in the air conditioning system. Of the three, the terminal re-heat system seemed ideal for the application of solar energy, the water temperature required being between 40°C and 50°C. This system was used for areas which needed humidity control.

The other application suitable for use of solar energy is the pre-heating of domestic hot water. The hospital uses 77,000 litres of water daily. As the incoming temperature is approximately 10°C a large amount of low grade solar energy can be used for pre-heating.

Any excess solar energy can be transferred to the 181,000 litre water storage tank employed in conjunction with the heat pumps during the winter. Such excess solar heat can be stored in the tank for use either later in the day or for upgrading by the heat pump system if required.

The system liquid is an anti-freeze and water mixture suitable for the most severe winter conditions. Unfortunately anti-freeze is toxic and breaks down into corrosive media. The toxicity problem is solved by passing the anti-freeze through one heat exchanger to transfer energy to an intermediate potable water loop, then through a second heat exchanger to provide the actual transfer of energy to pre-heat the domestic hot water. By monitoring the potability of the intermediate loop the danger of contaminating the domestic hot water can be eliminated.

A microprocessor programme monitors the minimum value for insulation and will start one of the solar fluid circulating pumps. A second pump comes into operation when the outlet temperature is in excess of the designed system temperature of 55°C. As the solar fluid enters the basement, a local pneumatically controlled valve will by-pass all the heat exchangers until fluid temperature is above freezing to prevent freeze-ups of the heat exchangers. When the temperature reaches a safe level, the feed water of the electric boilers in the re-heat system can be boosted provided there is a suitable temperature differential as determined by the controls. When the microprocessor programme calls for pre-heating of domestic water, the solar fluid will leave the first heat exchanger and enter the second. Finally if the programme calls for energy storage, the solar fluid will pass from the second to the third heat exchanger.

Flat plate collectors were selected in order to collect more energy on cloudy days, to minimise system losses on a high rise building and because of their basic simplicity. It was also estimated that for the selected applications a temperature in excess of 55°C would not be necessary. Double glazing was used because of the cold windy environment and the glass selected for the panels had a low iron content with an absorption factor of 95%. The hospital is on a hillside facing south and as ground space was scarce and vandalism could not be ruled out the collectors were mounted on the rooftop. The extra load of the collectors had to be allowed for in the steel structure of the building.

Cité de la Santé de Laval, Canada

My next example is in a more northern latitude than New England. It is one in Canada known as the Cité de la Santé de Laval, and the author wishes to acknowledge the technical data provided by Hydro Québèc based on material prepared by the consulting engineers, Desjardins, Sauriol et Associés.

The Cité de la Santé de Laval Hospital has a floor area of 37,000 m² and it was designed before the energy crisis of 1973 as a project entirely dependent upon electricity for all purposes.

The first step in the design stage was the calculation of the balance point between the internal gains and heat losses from the building. This is a commendable approach since some buildings may show a positive balance point even in the winter time, and it also provides initial guidelines regarding the sources from which heat can be recovered.

In order to have effective control of infection within hospitals, the Ministry of Social Affairs in Québèc has issued directives stipulating high air change rates. Therefore, the ventilation system design admits a large quantity of external air. The environmental design uses a refrigeration machine comprising of centrifugal chillers with double bundle condensers, and a terminal reheat system is used for air distribution. This standard refrigeration machine is also used as a reverse cycle heat pump. Of all the mechanical equipment used in the heat recovery process, it is probably the double bundle condensers which contribute most to the energy performance of the building.

From monitoring the operation of one of the chillers used at Cité de la Santé, an increase of 6°C was recorded in the water for the heating circuit after it had passed through the auxiliary condenser. By estimating the quantity of water circulating through this exchanger, it has been calculated that 1,750 kW was available for heating. This means that a contribution of 54% is made towards the demand of the building, which is approximately 3,200 kW. This energy is used both for space heating and for pre-heating the domestic hot water.

Since the sole energy source chosen is electricity and the Hydro Québèc tariff structure favours consumers with a good load factor, the designers decided to use a thermal energy storage tank to enable them to stabilise the electricity demand. Topping-up of the thermal storage tank is by two electrode boilers. The tank used has a capacity of 246,025 litres with a storage temperature varying from 12°C to 35°C. When the building has a heat surplus, the operator can raise the temperature of the water in the storage tank to 35°C. This does not incur any expenditure of energy, since the excess heat would normally have to be discharged to atmosphere through the cooling tower in a conventional system. When conditions are such that the building requires supplementary heat, this can be drawn from the thermal storage vessel.

In common with all hospitals, Cité de la Santé de Laval, uses large quantities of domestic hot water, which involves a heavy use of energy. For this reason two heat exchangers are used for pre-heating the temperature from 5°C to 32°C. Monitoring on site demonstrates that the present system of pre-heating allows for an average saving of 350 kW.

A heating circuit from the thermal storage vessel is used to supply the two pre-heating exchangers with energy. Domestic hot water is, therefore, continually pre-heated and the central controller will allow supplementary heating only if the temperature falls lower than a predetermined level.

The Cité de la Santé uses seven air-to-air thermal wheels. The energy available from the various air discharge systems is thus recovered so that it can be reclaimed for heating the considerable quantities of external air allowed into the ventilation systems to satisfy the requirements of the Minister of Social Affairs.

During the coldest periods of the winter, it is estimated that a saving of 1,000 kW has been achieved by use of the thermal wheels. Site monitoring shows an increase of 25°C in the temperature of external air allowed into the ventilation system after passing through the thermal wheel.

Every economic source of reclaimable heat has been tapped. Heat is recovered from the substation transformers; from the waste air of the cooking load; from the condensers of the cooling units in the cold storage rooms; and from the ambient air in the engine rooms.

Marien Hospital, Gelsenkirchen, W. Germany

Following these four examples in North America, let us now examine some in Europe.

The owners of the Marien Hospital in Gelsenkirchen took the decision to use electricity as the only energy source for their 600-bed hospital in 1970. This decision was taken co-operatively with the architects' engineers and all relevant authorities. The reasons given for the choice of electricity in preference to oil or gas were as follows: —

1. The initial cost of the system and its equipment.
2. The cost for depreciation and interest.
3. The maintenance costs.
4. Annual energy consumptions and running costs for the entire hospital complex.
5. Reliability of supply.
6. Environmental aspects.
7. Possible conversion of the systems to future developments.

The connected load for the hospital is 17 MW as compared with 4 MW for a conventional hospital design. There was a consequent refinement for extensive wiring, but this did not pose a problem. It has been carried out efficiently and economically by means of a busbar trunking system.

An interesting aspect is that the hospital is provided with a central process computer, programmed to minimise energy costs. The computer ensures security of supply within the hospital in order of predetermined priorities, and also optimises the use of energy within various departments to keep demand low. It is claimed that this control system reduces demand by about 20%.

In the design approach good insulation was the first step towards energy conservation. The overall U value of the exterior walls, windows, floor and roof for the hospital is 1.0 W/m²°K which is less than the minimum value of similar buildings found in West Germany which is 1.6 W/m²°K.

As with most hospitals there are some areas in the Marien Hospital which call for a specific controlled environment and these are air conditioned. Since recirculation of air cannot be permitted it was decided to use some form of heat recovery in order to make optimum use of the energy available.

The incoming fresh air is heated to 3°C by direct acting resistance heaters and from 3°C to 18°C in two stages by the refrigerating machine which is used as a heat pump.

Thermal storage radiators are used in the wards, treatment and administrative areas. Architects, engineers, manufacturers and the power supply utility co-operated in the application of storage heaters and co-ordinated their activities at an early stage. Extensive trials carried out during construction and whilst the building was still unoccupied showed that the thermal storage heaters operated satisfactorily. Basically these radiators are similar to conventional storage radiators and they have three heating elements inserted in the refractory brick which is totally insulated. A metal plate with heating elements is positioned on the front of the heater, and all components are then completely encased. The function of this front heating plate is to supplement the off-peak charge with direct acting electricity if required. The radiators have a low surface temperature for safety reasons and a polished finish, which facilitates cleaning. The surface is resistant to any damage from disinfectants.

The charge for the heaters is controlled by an outside sensor and commences at 9 o'clock at night until 6 o'clock in the morning. They also receive a midday boost for two hours.

Three electric high pressure boilers supply steam. This steam is used for sterilizing equipment and humidification of air.

The domestic hot water is supplied by four heaters each with a capacity of 10,000 litres and a load of 125 kW. Corrosion protection is employed in keeping with requirements. In order to make optimum use of energy the water is pre-heated by parallel plate heat exchangers with surplus energy available from the heat pump.

The kitchen at Gelsenkirchen is all-electric and in addition to the usual equipment it has a fully automatic multi-way dishwashing machine.

In retrospect the decision makers consider that by adopting electricity as their only source of energy they made the correct choice.

Berus Clinic, Saar, W. Germany

Another interesting but smaller development in West Germany is the Berus Clinic in the Saar. This is a private urological centre with 120 beds and was built in 1974. It has an area of 7,600 m², which is heated and air conditioned. The walls, roof and floor are well insulated, all these components have the same U value, 0.465 W/m²°K. The windows are double-glazed with an air gap of 12 mm and are fully sealed.

Heating is provided by a low pressure hot water radiator system, which is fed from two storage tanks each having a capacity of 75,000 litres. The water in the storage tanks is heated by two electric flow boilers each rated at 1,000 kW, and these are operated between the hours of 10 o'clock at night and 7 o'clock in the morning to take advantage of an off-peak tariff. Again, we find that heat recovery is incorporated in the air conditioning system and the temperature of the incoming air is raised by heat exchangers.

Diagnostic Clinic, Wiesbaden, W. Germany

My next example is the diagnostic

clinic at Wiesbaden which incorporates an area of 4,500 m^2 with electric floorwarming. To protect the medical diagnostic instruments from interference due to the magnetic field of the floorwarming cables they are shielded by a wire mesh.

The underfloor heating is operated in conjunction with direct acting equipment, which is the sole form of heating when the external temperature is above +15°C. At temperatures lower than about 15°C the underfloor heating comes into operation, and the direct acting heating equipment is then brought into use as desired by room thermostats.

The maximum floor surface temperature is 24°C at 7.30 am.

The heating panels for the floor thermal storage system are prefabricated from synthetic anhydrite having a high specific storage capacity, and they have pre-formed ducts for interchangeable heating cables.

The core of the building is air conditioned with a dual duct system and as in previous examples the system is used for heat recovery by using the three refrigeration machines as internal source heat pumps. A total output of 901 kW is recovered which is supplied to the incoming air heater batteries. The coefficient of performance for this heat pump installation is 4 : 1.

Domestic hot water is supplied by three well-insulated 10,000 litre boilers, which are charged during the off-peak period.

In this complex development designed for the future there are comprehensive features for heat recovery including thermal wheels and storage radiators in adjoining buildings.

'La Renaissance' Clinic, Marseilles, France

Turning now to developments in France, the 'La Renaissance' Clinic was built in 1974 to replace two other clinics and is situated in a quiet corner of the St Giniez district of Marseilles.

The clinic has an area of 4,400 m^2 with a bed capacity of 104. One third of the beds are for maternity cases and the remainder for surgery. The surgical unit covers an area of 1,100 m^2 and comprises six operating theatres, two delivery rooms and other ancillary rooms.

A high standard of insulation was incorporated in every component of the building shell. The floor is of concrete planking with fibreboard insulation, the walls have 60 mm of expanded polystyrene and the roof 80 mm of the same material. The windows are double-glazed set in aluminium frames and amount to 40% of the total exterior surface area.

This private clinic is air conditioned by an all fresh air system, single duct with terminal reheat, and this system serves the private wards, operating theatres and administrative offices. A heat reclaim coil is placed in the extract duct and the refrigeration machine is operated as a heat pump. This system was selected because it was necessary to have a controlled supply of large volumes of uncontaminated air. In addition the single duct terminal reheat system allows for close humidity and temperature control in areas where local control is needed for environmental requirements different from the general design conditions.

The central plant supplies the six theatres with a low velocity system. The primary air is conditioned to a constant 13°C with 93% RH all the year round and dew point control. An air thermostat in each operating suite controls the amount of reheat required in each terminal heater battery. The air handling units for the operating theatres have a throughput of 1.39 cubic metres per second and incorporate a sterilizing section with ultra-violet lamps.

For the administrative block, the central plant delivers air at medium velocity. The temperature of the primary air varies with the outside temperature up to a maximum of 22°C, which economises on the reheat load.

The primary air to the private wards is supplied from the central plant after treatment (pre-heating and humidification in winter, free cooling and de-humidification in summer) by a network of vertical distribution ducts producing four air changes per hour.

As in the administrative block, the distribution air temperature leaving the central plant varies with the outside temperature. The purpose of this arrangement is to improve the scope of heat reclaim from the extract air in the winter and thus reduce the load on the terminal heater batteries. In summer it permits the variation of the air temperature to suit the refrigeration load.

Terminal reheat is achieved by electric resistance heaters in the expansion boxes controlled by air thermostats, which can be regulated by the room occupants. To ensure economy of usage and to avoid overheating, a limit of 22°C is pre-set on the thermostats.

The high fresh air loads call for large heat requirements and this would not have been feasible without heat reclaim. This is achieved by positioning a chilled water coil in the extract duct. This coil is in the evaporator circuit of two 162 kW refrigerating machines with double bundle condensers and provides a false load in the winter. One half of both the double bundle condensers provides water for pre-heating the private wards' air handling unit. During summer, the other half of the double bundle condenser rejects heat at the cooling tower.

Immersion heaters set in four cylinders, each with a capacity of 1,500 litres, provide the domestic hot water, The total installed load for the heaters is 69 kW.

The central kitchen includes a group of hot plates, a hot air oven, a snack grill, a fryer, a pressure cooker and a steamer. All these appliances are electric with a total installed load of 150 kW. The facilities are sufficient for the serving of 300 meals each day.

The decision makers adopted the all-electric solution because of the low cost of installation, the perfect hygiene, better safety and ease of maintenance. They are well satisfied with the total costs in use of the hospital.

Mauriac Hospital, France

There are several similar hospitals in France to 'La Renaissance' in terms of the environmental services design. But let me now turn your attention to the all-electric hospital at Mauriac which I visited last year.

The construction of a new hospital for the town of Mauriac became a necessity in 1963, because of the strain the convalescent services were placing on the medical services, since both these facilities were housed in the same building. The new hospital was occupied in April 1976 and consisted of a combined medical and surgical block with 124 beds. The essential characteristic of this new extension is that is entirely dependent on electricity for all energy requirements. Although it might be assumed that the decision to use electricity alone was influenced by the 1973 crisis, this was not the case: The choice was made at the planning stage in 1972.

Three methods of heating were considered for the project, namely coal, oil and electricity. The electrical solution was deemed to be possible by two different options. The first option considered was to use direct acting electric heating, where all the heating is provided by convectors situated in every room. The second option to be appraised was a hybrid system with underfloor heating provided by cables embedded in concrete and electrically heated to a temperature of about 12°C. This was the selected design and the heating cables are energised only during the off-peak hours, to provide thermal energy storage in the concrete floors. The charge is regulated by two outside sensors, one on the north side and one on the south side of the building. They are set to function between −5°C and +10°C. If the mean night temperature is −5°C, the heating cables are energised for the full eight hours. If the temperature is +10°C the cables are not heated at all. Between these two values the period of charge is regulated in proportion to the mean night-time temperature.

Supplementary heating is provided by means of standard convectors individually regulated, so that the desired temperature can be obtained in any section of the hospital at any time.

The capital costs of installing a hybrid system were more than that of a direct acting system, but the reduction in running costs compensates for the additional capital costs. It is important to mention that the investment costs for the electric 'design' took into account the additional costs of the improved insulation, whereas the oil solution was calculated on a standard building. The wall has 60 mm of polyurethane whilst the roof has 80 mm of the same material. The floor has three layers of perimeter insulation, which consists of polystyrene 60 mm thick.

The ventilation is mechanically controlled which ensures a satisfactory mixture of fresh and warm air. The air conditioning system provides both heating and cooling for the operating theatres and wards.

The total electricity consumption came to 1,098,000 kWh in the first year of occupation which was approximately 29% less than the estimated consumption of 1,534,192 kWh. In the analysis of annual running costs, the cost price per cubic metre heated was 8.52F, compared with the average for similar institutions between 11F and 15F per cubic metre.

In addition to economic energy running costs, the management of the hospital consider that they are benefiting from economy of labour, reduced maintenance and the complete absence of pollution. Floor warming which provides the background temperature has not produced any detrimental health hazards such as varicosity.

Agen Hospital, France

My last example in France is the new development at Agen, which is the forerunner of ten similarly sized hospitals to be built in other regions. The Agen Hospital provides accommodation for 549 beds and was completed during 1978. The total area is 43,600 m².

The fabric of the building is well-insulated and window-to-wall ratio has been optimised. Architecturally the windows are recessed to reduce the impact of solar gain on the air conditioning system.

All the windows are double-glazed and sealed with internal Venetian blinds interposed between the two panes of glass, and controlled room by room manually.

The wards are air conditioned with four air changes per hour by a central plant heat pump which recovers heat from coil units in the exhaust air. The air is distributed by a dual duct system and the terminal units are heated electrically and are thermostatically controlled.

The general service areas have six to 15 air changes and are supplied by a single duct system. The supply air is cooled and heated by the refrigerating machine which is used as a heat pump and topped up to its design temperature with hot water from storage vessels which have thermostatically controlled units.

Other Electrically Heated Hospitals

Other hospitals throughout the world employ other proven techniques for electric heating such as the Central Hospital at Trondheim in Norway. Originally this hospital was heated by oil-fired boilers, but when new extensions were started 25 years ago they adopted the use of Eswa ceiling heating. This is not only applied in the hospital wards but also in operating theatres and hydrotherapy pools used for the treatment of rheumatic conditions.

Another example at Hawthorn in the State of Victoria in Australia makes use of storage heaters. The Kinkora Hospital is typical of many similar smaller hospitals in Australia with bed capacities varying from twenty to sixty, which have been designed as all-electric buildings using storage heaters.

Need for an Integrated Design Approach

In conclusion, the case studies I have described show that hospitals which are low energy and largely electric are not a rarity. They do not restrict the ingenuity of the designer in any way. There are examples of direct acting heating, storage systems, heat recovery, solar panels and the consistent use of the internal source heat pump.

An integrated design approach is fundamental with a particular need in all cases for a highly efficient building envelope with good standards of thermal insulation. In this respect the electricity supply industry can give assistance with their building energy estimating programme. This computer programme can quickly and reliably estimate the energy consumption of a hospital when the design parameters for internal conditions, building fabric, lighting levels, hours of occupation, heating and air conditioning are provided. Adjusting any of these parameters is a simple exercise and accurate comparisons can be obtained from the print-out which will indicate the optimum building and environmental system.

The electricity supply industry has assisted many customers in applications of the internal source heat pump for commercial buildings both in the private and public sector. Over 100 examples of these buildings have been built and are operating here in Britain, from the Grampian Regional Council offices in Aberdeen to Beagle House in London. These buildings employ exactly the same principles as those applied in many of the hospitals overseas.

Recently a respected senior consulting engineer expressed the view that I am advocating building services systems a generation ahead of the time. This review of overseas hospital developments for the future, demonstrates that technologically there are sound reasons for every new hospital building in Britain to now be designed to the criteria — low energy — largely electric.

They will then have a long life and remain economic in energy terms for future generations — into the 21st century.

The author is a director of Stellex Ltd, Calne, Wiltshire, who are specialists in the distribution of hospital meals.

The Distribution of Hospital Meals

TERRY BARRETT-GRAY MInstM

Problems of Hospital Catering

The importance of the Catering Department in hospitals has been increasingly recognised over the years, but sometimes the unique problems are not considered. How many other establishments have a number of people waiting for meals in often widely separated places, which sometimes causes meals to be transported out of doors for lengthy periods and sometimes upstairs to wards where there are no lifts? A hospital meal is not a social activity, nor a means to keep working, but a break in what can be a boring day. The hospital patient has not **chosen** to eat out. There are also the problems of coping with diets, and of ensuring the meal arrives to the patient hot, appetising and well-presented. These then are some of the problems hospital catering departments face. From these difficulties has arisen a new speciality, that of Hospital Meal Distribution. There are few companies involved in this market (probably no more than four or five) and fewer have chosen to make it their speciality.

An early conclusion reached by those valiant enough to enter this market is that no two hospitals are the same, and an easy trap to fall into is to assume that because a method works in one hospital it will work in another. What causes these variations? Surely a patient in one hospital has a similar requirement to any other, so surely the problems are the same? *You would think so-but*, it is not the case. First consideration must be given to the patient, so we immediately have the following variables:

Is the patient able to make a written choice?

If not, is the patient able to make a visual or spoken choice?

Does the patient need assistance or supervision at meal times?

Would the patient be confused or unable to cope with three courses on a tray?

Are the majority of patients ambulant?

In addition there are the problems associated with the hospital:

Is there space in the kitchen to introduce a central system?

Is washing-up to be done at ward or kitchen level?

Are there sufficient kitchen staff available?

Are there narrow doors, bad corners, slopes, cambers or bad road surfaces over which trolleys must go?

Are there wards without lifts (not an uncommon problem even now)?

Will trolleys be towed or hand pushed?

Do the staff wish to improve the present method of distribution of meals to the patients?

These variables are just the beginning of ensuring the method chosen is correct for the type of hospital. There is also the vital matter of what priorities does the catering department have — there are almost as many views on this as there are catering departments.

Methods of Meal Distribution

The sensible manufacturer reaches the conclusion that he will offer three basic methods of *meal distribution* and then by variation within these methods will try to provide a 'tailor-made' system. The three basic methods are:

Bulk meals;

Plated meals;

Tray meals.

Bulk meals are served with or without choice, by the catering department sending a heated trolley with the number of portions required. This can be the simplest method, requiring the least amount of distribution equipment. It is, however, with few exceptions the most wasteful and difficult to control, and is sometimes abused. Ward staff find it difficult to know what a correct size portion is and all too often the kitchen staff will give more than the right number of portions to compensate. Portion control is, therefore, difficult. This system also places in the hands of non-catering personnel responsibility for the delicate art of food presentation. We 'eat with our eyes' and whereas some ward staff take a pride in the way meals are presented,

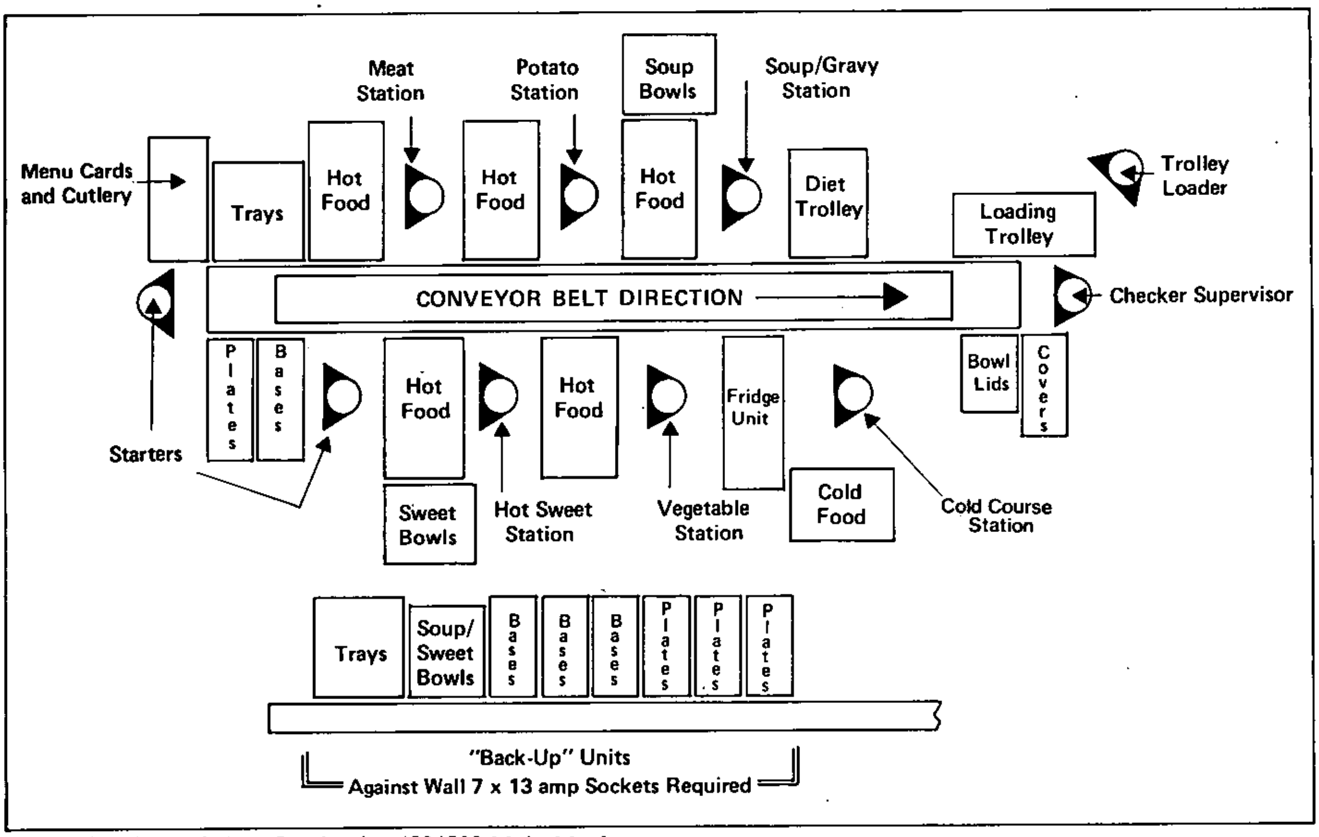


Figure 1. Central Tray Service for 450/500 Main Meals.

regretfully others do not.

The second method of meal service is plated meals, which are often confused with tray meals. Meals with a plated system are usually only the main and sweet course in plate or bowl, with soup distributed in bulk. The main and sweet courses are covered and placed in a heated trolley with an unheated or refrigerated section. A menu choice can be incorporated, but identification can be difficult where one course is hot and the other cold and the dishes are placed into different parts of the trolley. This method of meal distribution is widely used in the UK, particularly in hospitals for the mentally handicapped where some control over the eating pattern is required, and where many patients are ambulant and use tables too small for large trays. Surprisingly this method of meal distribution is used in few other countries.

Finally we come to the tray meal systems which are offered in different forms by a number of companies. One common factor is that all permit choice from a menu card, and all can provide a complete meal on a tray. The usual method is to keep the main course hot by use of either a heat storage base, or by an underplate and cover providing insulation. The soup or sweet course is kept hot or cold by insulation. In this way both hot and cold items as selected by patients are placed on the same tray and, of course, the trolley carrying the trays is unheated.

Both the plated and tray meal systems permit easy portion control and allow the catering staff to operate efficiently. With any system providing meals centrally for over 100 patients, aids are required to assist the catering staff to 'plate up or tray up' quickly. Usually, when the number of patients is over 200, a conveyor belt is considered. The use of conveyor belts causes apprehension, because, perhaps, the very name conjures up ideas of plates or trays travelling at high speed, while desperate staff attempt to serve the food. Nothing can be further from the truth, as the ideal speed for meal service conveyor belts is 26 feet/min. Any operator can cover an area of at least four feet and at this speed will have 9.2 seconds in which to perform the operation. As the number of completed trays per minute is usually required to be eight to ten, the time limit is 7.5 seconds, less than that available to cover the area under his control. A variable speed belt can cause more problems than it solves. The constant speed belt controls the number of meals per minute by varying the gap between meals and it always passes the operator at the same speed.

Figure 1 shows a typical layout for a hospital serving 450/500 main tray meals. It will be noted ten operators would be required, though this could be reduced by one. The belt length is 22 ft and this allows some six stations, five hot and one cold including the diet station. It will be usual, but by no means vital, to consider a central dish wash as part of any central service, as the full advantages of labour savings at ward level are then gained.

Advantages from a Central Service

What are the advantages of a central service? Firstly let us look at the reason the caterer is there, the patient. He is able to have a complete menu choice, often with the size of portion he requires, which is presented by trained catering staff to look appealing, and arriving in a hot appetising condition. The catering department can exercise portion control with subsequent savings in provisions, though these savings are

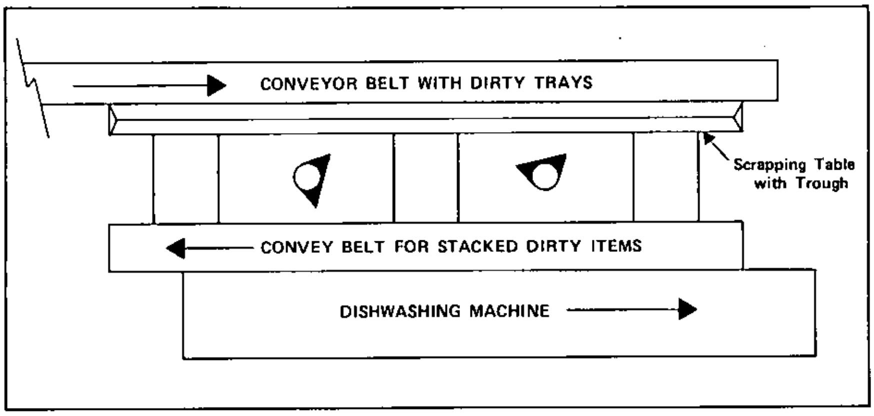


Figure 2. Use of Conveyor Belts to ensure Dishwashing Machine is used to its maximum efficiency.

usually passed on as improved choice. There is also the satisfaction of completing what is a catering function and this should not be underestimated. Cooks are kept interested and obtain more job satisfaction by being involved in the meal service. The main staff advantages are, however, to the ward staff, who now have only to distribute complete trays and collect used trays. The ward sister is able to see what her patients have ordered from the completed menu cards and in this way does not 'lose touch' with the patients' eating pattern.

The practical problems of introducing any system requiring centralised service are many and not the least of these problems is space. The system shown in *Figure 1* would require an area approximately 28 ft × 14 ft, although there is usually some saving in the trolley park area, as tray meal trolleys can be 'boxed in'. The amount of energy used should show a small saving from bulk trolleys, but the main savings in energy come from the use of an insulated dome and underplate in place of a heat storage base. Manpower savings are more a transfer from one department to another than strict savings. The catering department requires more manpower for the centralised service but hours are saved by other departments.

Possible Future Developments

What of the future? It would be a wise man who could predict the way hospital meal distribution will go, but manufacturers must also be innovators. Three important factors remain, the high cost of energy, wage costs and difficulty in finding suitable staff, and the lack of sufficient space.

It seems doubtful if the trend to centralised services will change and, therefore, the importance of equipment to save labour, or at least permit a central service without increasing labour will continue. Many of the functions associated with a central service are labour intensive and unskilled, eg wrapping cutlery, placing trays, cutlery, etc on the conveyor belt. As labour costs increase, so will the incentive to provide equipment to perform these tasks. The importance of energy savings is now being recognised, and this is reflected by the interest in the insulated underplate and cover used with the NHS plate to provide a tray meal service. It is estimated that a system recently specified for 550 patients will require approximately 15 kW for a period of seven hours per day, compared with some 45 kW on a bulk system.

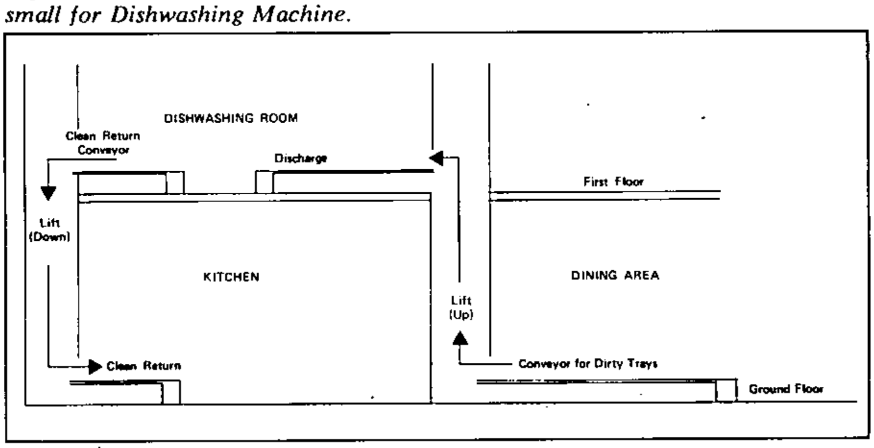
The use of conveyor belts to minimise energy and staff usage in washing dishes is spreading, although improvements can still be made (see *Figure 2*). Here the staff load a conveyor belt next to the dish-washing machine with stacks of dishes. Only when it is completely full is the dish-washing machine started. In some instances the same staff can then move to the machine and ensure it is loaded to capacity. Dish-washing machines are often used with wasted space because staff cannot load quickly enough. With this method the machine is full and unloading is quicker, as similar items have been stacked and this permits easy transfer into dispensers after washing.

The most interesting developments will take place in overcoming space problems. It is feasible to design a system that permits space to be used in other parts of a building by use of spiral or vertical lifts and conveyor belts. In this way dirty trays can be left at one point and transported to the dish-washing machine in another part of the building. Dirty trays are transported by spiral lift to a higher floor, and clean items from the dish-washing machine can be returned to the kitchen (see *Figure 3*).

There is no reason why the conveyor belt on which meals are prepared cannot be extended to feed into a vertical conveyor belt which could deliver the tray meals to the correct floor. This would save on the use of transportation trolleys and staff to push them. On each floor one or two simple trolleys could be used to distribute the trays. As a result patients would receive their meals quicker and savings in manpower could be achieved.

Whatever direction hospital meal distribution takes, hospitals can now be assured there are people interested in helping to find improved methods, and, as no-one has the monopoly on good ideas, who are interested in hearing their views.

Figure 3. Possible use of Conveyor Belts and Spiral Lifts where kitchen is too small for Dishwashing Machine.



This paper was presented at a One-Day Symposium, 'Noise Pollution — Its Effect on the Health Service', held by the Institute in London on March 21, 1979. The author works for B&K Laboratories Ltd, of Hounslow.

Noise Measurement

L. MINIKIN BSc

Definition of Noise

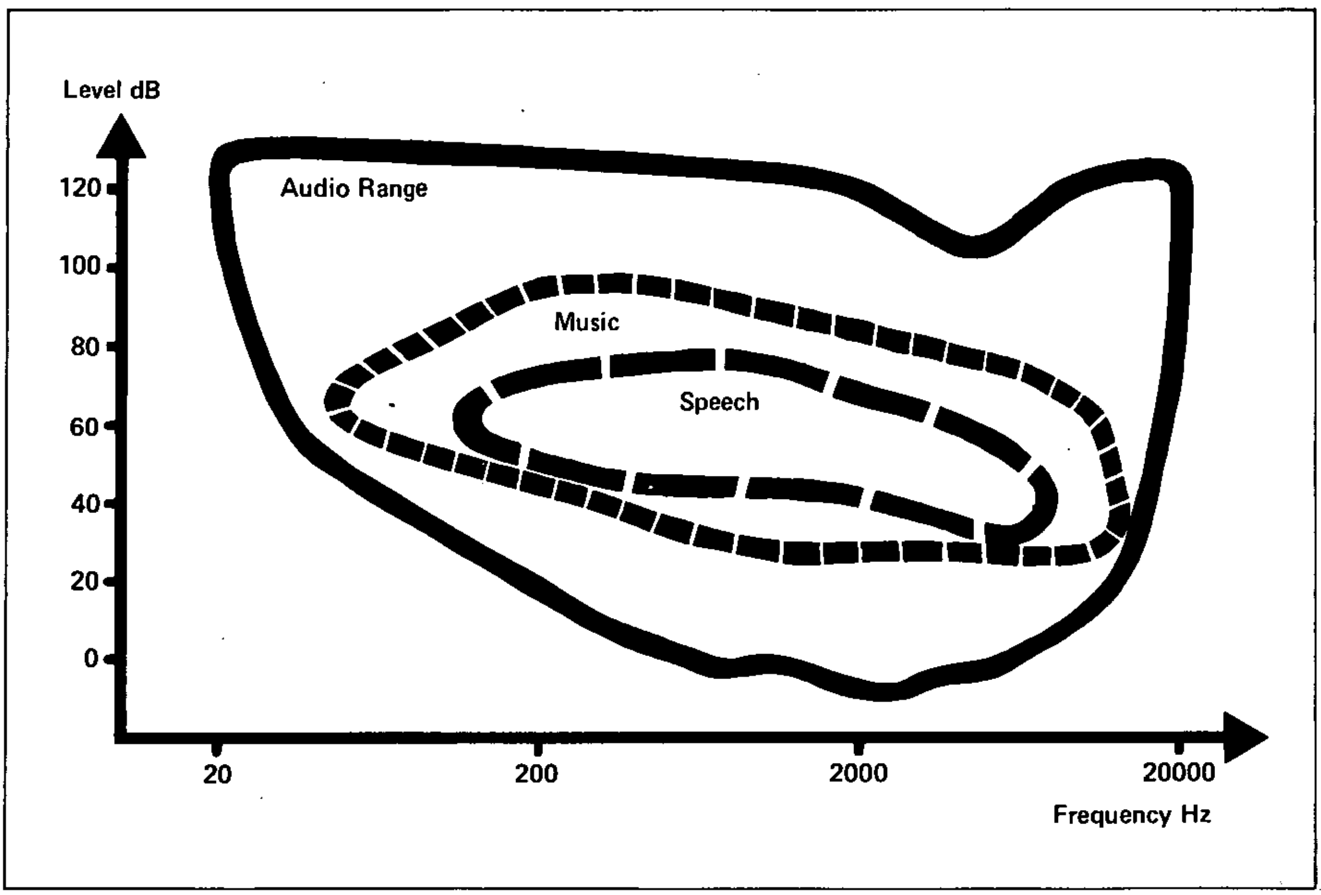
All noise measurements have one basic aim, to provide information which is meaningful and which can be used by noise control engineers. Noise is a completely variable quantity with a random variation of the amplitude, but hidden in this apparently continuously varying signal, there could be several regular variations occurring at a particular frequency. Noise is a pressure variation in the atmosphere and is therefore detected by a pressure sensitive device, which will provide a voltage waveform containing the same information and time reference. The fact that the introduction of the sensor affects the original conditions is allowed for in the design, and if the sensor is pointed at the noise source then correct measurements are possible.

Levels of Noise

Figure 1 shows the parameters used in describing noise levels and the units involved. The level scale on the vertical axis is in decibels. Because of the wide range of pressures experienced and acceptable to the ear, a linear scale is too unwieldy to use. The ear also tends to perceive a change in relative level, rather than the absolute value, so a logarithmic scale is preferred. 0 dB corresponds to the weakest level of a tone at 1,000 Hz that can be perceived by an ear, and this level is agreed by all National and International Standardisation Committees to be 20 μPa. An increase of 10 times in the level corresponds to the addition of 20 dB.

The pressure variations involved in the audio range extend from about 20 times per second (or Hz) to 20,000 (or 20 kHz). Two types of sounds to which we are all accustomed are speech and music and their extremes are indicated. The speech range obviously does not take in shouting from the point of view of level, and I feel that the music referred to is of the classical variety. Again these are average values — the 1812 Overture in the Royal Albert Hall would probably be outside the indications.

Figure 1.



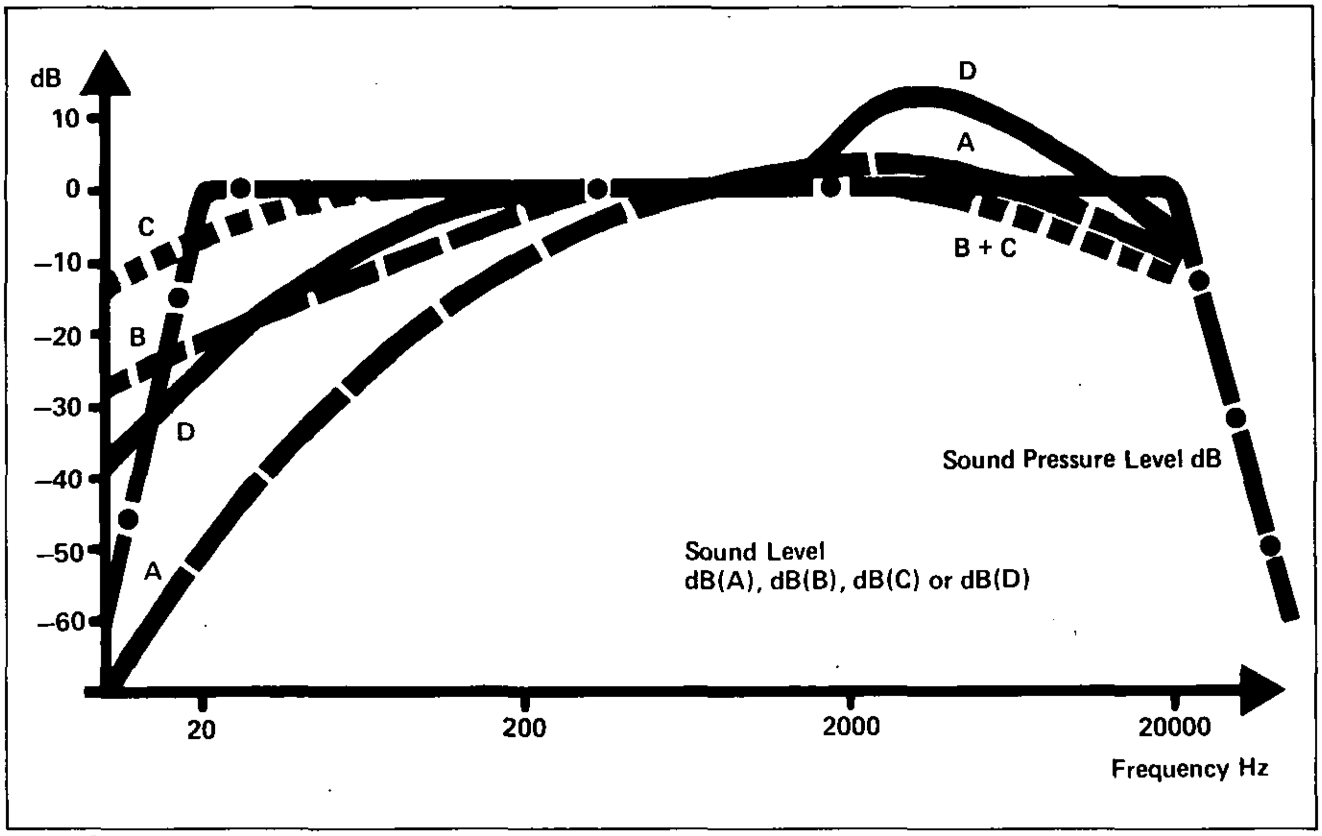


Figure 2.

The full audio range is indicated, and I would like to draw your attention to two particular areas, below 1 kHz and between 3 and 5 kHz. The bottom of the graph shows a rise as the frequency is reduced below 1 kHz. This is because the ear loses sensitivity in this region, meaning that a larger pressure variation is needed, before the ear can sense the presence of sound. This effect will be referred to later and must be taken account of, when we consider level measurements and their relation to what we hear. On the top of the graph there is a dip between 3 and 5 kHz. This is the most sensitive point of the hearing range and the line could be taken as the level at which pain or extreme discomfort is experienced. It is also the frequency at which noise-induced deafness is first noticed.

There is a difference between what a METER with a linear or flat frequency response receives, and what the EAR hears. The response of the ear has a shape which is the inverse of the low frequency area of *Figure 1.* This curve is the basis of what is known as the A weighting curve, see *Figure 2.* There are the 4 standard weightings, B and C were formerly used for medium and high levels of noise respectively, but they have gradually dropped out of use as they do not appear to give the same degree of correlation with subjective assessment, as the A network. D is designed specifically for aircraft noise which has a high tonal content and you will note the emphasis in the sensitive region, 3-5 kHz. One small point is worth mentioning as it could cause some confusion at times. The two terms, SOUND LEVEL and SOUND PRESSURE LEVEL. There is a difference. For unweighted levels, ie FLAT frequency response or particular frequencies or frequency bands, SOUND PRESSURE LEVEL is used. SOUND LEVEL refers to a weighted level and should have a suffix, such as dB(A).

Measurement of Noise in the Health Service

Noise measurements in the Health Service can broadly be divided into two types, interior and exterior. Interior measurements could range from those made on standby power generators where levels will be high and the staff involved should be wearing ear defenders, to small motors etc, on patient monitoring equipment for example, when the levels will be low but with an even lower background level.

Machinery running at a constant speed will produce a level which is reasonably constant with time. If wide variations occur then the effect of the different meter responses on the sound level meter reading will be evident. Using the slow response the signal is sampled over a longer period, thus reducing the effective variation. On reciprocating machinery where the amplitude varies rapidly, special care is required and the peak or instantaneous level may also have to be measured.

Preliminary noise measurements are often used to produce a noise map of an area. Usually the different levels are indicated in colour and this document is invaluable in, for example, determining the positioning of new additional machinery, or the suitability of particular areas as a general access to facilities in constant use.

Noise measurements made in the cause of product improvement and the comfort of the occupants of various areas can often be required to provide more information than a single figure. The results should be a guide to the actual noise sources, and this is achieved by analysing or separating the noise into its individual frequency components. Some means must therefore be provided to divide the audio range of 20 Hz to 20 kHz into parts which are related to the human perception of the frequency range. The number of divisions must not, however, be too great as this would make a noise measurement a long and possibly tedious process.

Before embarking on any noise measurement programme, the object of the programme must be defined clearly, the data necessary to achieve this object should be selected, and the measurement programme organised to obtain it. Only at this stage should the detailed choice of instrumentation become of paramount interest.

Methods of Noise Measurement

The characteristics of the noise itself are the most important consideration when choosing suitable instrumentation. The noise spectrum may be wide band, with components spread over the complete audio range, eg traffic noise, or narrow band with components concentrated over a small range of frequencies, eg fans or tonal with the spectrum consisting mainly of several discrete frequencies, eg electric motors. Its level may be fairly constant, as mentioned earlier, or it may be intermittent, with intense noise separated by long quieter periods.

Two main types of frequency analysis are used for noise signals, and the filters have either a constant percentage bandwidth or a constant bandwidth.

In the first type the filter bandwidth is a constant percentage of the centre frequency of the pass band whatever its absolute value, and therefore increases as the frequency increases. This gives uniform resolution on a logarithmic frequency scale and thus can be used over a wide frequency range of three or more decades. Two special classes used in noise measurements are octave and third-octave filters. The former have a bandwidth such that the upper frequency is twice the lower and this results in a bandwidth of 70%. They are based on a reference centre frequency of 1,000 Hz. 10 octaves, therefore, cover from 22.5 Hz (lower limit of 31.5 Hz centre frequency) to 22.5 kHz (upper limit of 16 kHz centre frequency). Third-octave filters are obtained by dividing each octave band into three geometrically equal subsections and give a constant percentage bandwidth of 23%.

Conversely, constant bandwidth filters are independent of the frequency to which they are tuned, and this permits very detailed analysis of the noise signal. A linear frequency scale, however, must be used and this restricts their operation to a range of at most two decades.

Constant percentage bandwidth filters, as described, consist of separate filters to which the signal is applied in turn. For percentages less than 23% and for constant bandwidth filters it is normal to provide a means of continuous tuning over the frequency range. Another important point to remember is that the time taken for a sequential analysis depends on the bandwidth of the signal. A narrow band constant bandwidth analysis will take very much longer than the octave or third-octave constant percentage bandwidth analysis.

Figure 3. Precision Sound Level Meter and Octave Analyser.

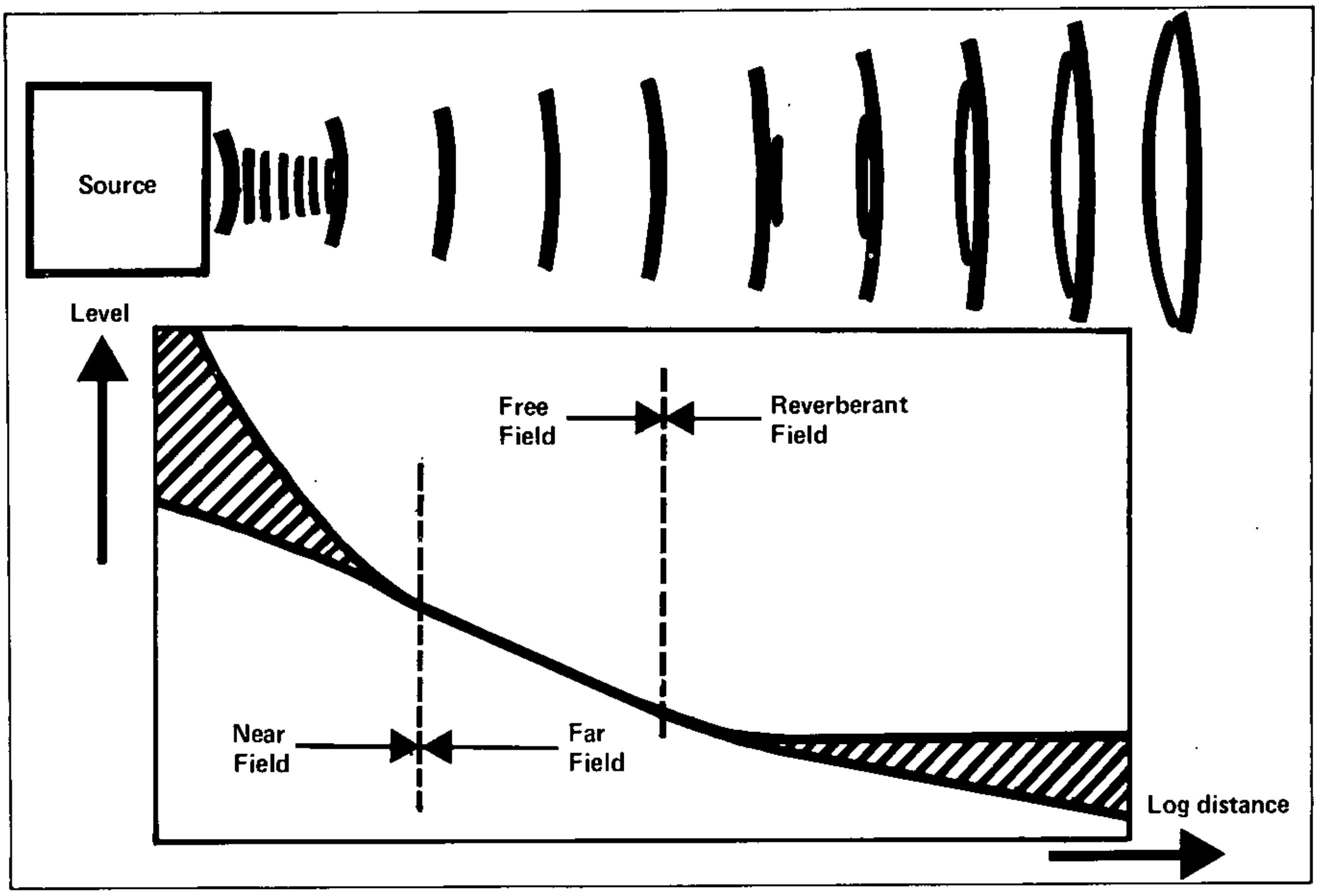


Figure 4.

The choice between the two types is governed by several factors such as the time available for analysis, but more important is the information to be obtained from the results. Detailed analysis is required especially when analysing noise emission prior to redesigning for noise reduction. Sources with many distinct harmonics, such as gear trains, and those which emit pure tones, such as electric motors, can all best be analysed by narrow band methods. On the other hand acoustic noise measurements for the purpose of estimating loudness and subjective response to environmental noise do not generally require such detailed knowledge and octaves may be adequate.

Sound pressure levels in each octave band can be taken and superimposed on Noise Rating Curves to obtain the relevant Noise Rating Number. A Noise Rating Number is often used to specify acceptable levels within rooms and the value is calculated from octave band sound pressure level readings. The NR value is the curve which the highest octave band level just touches. Very often the NR value is numerically 5 lower than the dB(A) reading for the same noise but this is not always true. For all noise measurements a complete record is essential. A report sheet should be made up which contains all the relevant facts and includes subjective comments, instruments used, sketch of measurement site and details regarding machine performance. *Figure 3* shows a sound level meter suitable for this type of measurement with both weighting networks and octave band filters built into it.

The Propagation of Sound

I would like now to consider how sound is propagated and how this influences our measurements. Sound is emitted from the source in question and propagated in circles. When viewing the source from above we ought to remember that in three dimensions these are hemispheres. We have assumed an area of free space, ie with no intervening objects. How far away should our measurement point be? As a guide we should be at least twice the largest dimension of the source. The noise level decreases with distance according to the inverse square law, and if we double the distance we reduce the noise level by one half, or 6 dB. The velocity of sound is equal to the product of the frequency and the wavelength. Under normal circumstances in air it can be regarded as a constant value of 340 m/sec and this means that, if we are 6 m from a source, this distance is equal to the wavelength of a sound at 57 Hz. At frequencies below this, for example, the 31.5 Hz OCTAVE, less than one wavelength has been established and we shall experience wide fluctuations in our readings. We are too close to obtain satisfactory results.

If we plot the distance from the source against level, both scales being logarithmic, then the sound field can be subdivided as shown in *Figure 4*. The near field should be avoided as very small variations in distance will produce large level variations and a small degree of repeatability of results. Although it may be possible to get a 6 dB fall off per doubling of distance in the far field, it is more likely to be 5 to 5.5, but this is the preferred measurement area. In the reverberant field, because of reflections from walls and other objects the level stays practically the same regardless of distance.

In all noise measurements we must be careful to maintain the accuracy of our figures, and the precision grade standard allows an overall tolerance of ± 1 dB. At the lower end of our measurement range we must ensure that the background level, that is the level which existed before the noise source was introduced, does not influence the measured result. If the difference between the total noise, of background plus source, is 10 dB or more greater than the background itself, then the influence is less than the precision grade tolerance and may be neglected. If less than 10 dB, then the appropriate correction must be applied. If the total noise is 47 dB(A), the background 40 dB(A), the difference of 7 means that we must subtract 1 dB from the total to obtain the true source noise level of 46 dB(A).

Measurement of External Noise

Let us now move outside the hospital buildings and consider external noise, either made within the site boundary and affecting adjacent properties or vice versa. How are we to quantify this? A measurement with a Sound Level Meter only refers to the instant it was taken and, if the result is plotted against time, would show wide variations. This presentation gives a certain amount of information but not enough. We could perform statistical analysis on the level and determine a figure for the noise level which is exceeded for a certain percentage of time, for example L_{10} and L_{90}. These can be used independently or together to describe the noise, for example L_{90}–L_{10} is often referred to as the noise climate. There is also the Leq, or equivalent continuous level, which is the constant level which, if it existed for the same period of time, would contain the same noise energy.

We calculate these figures by sampling the noise level at particular class intervals, and storing this information as a series of numbers. Both during and at the end of the period under investigation, the figures are continually being calculated and displayed. The full statistical details are available to us in either distributed or cumulative form. If during sampling we recorded a count in the particular class interval, we would obtain the distribution spectrum. This shows that for a large number of counts, corresponding to a large proportion of the time, the noise was at a certain level, but it decreased to a lower level and also increased to a higher level for smaller percentages of time. This information could, for example, be used in assessing the noise intrusion into a proposed quiet area and to determine the amount of noise insulation required. The cost of such procedures and the need to obtain an economically viable solution should be taken into account.

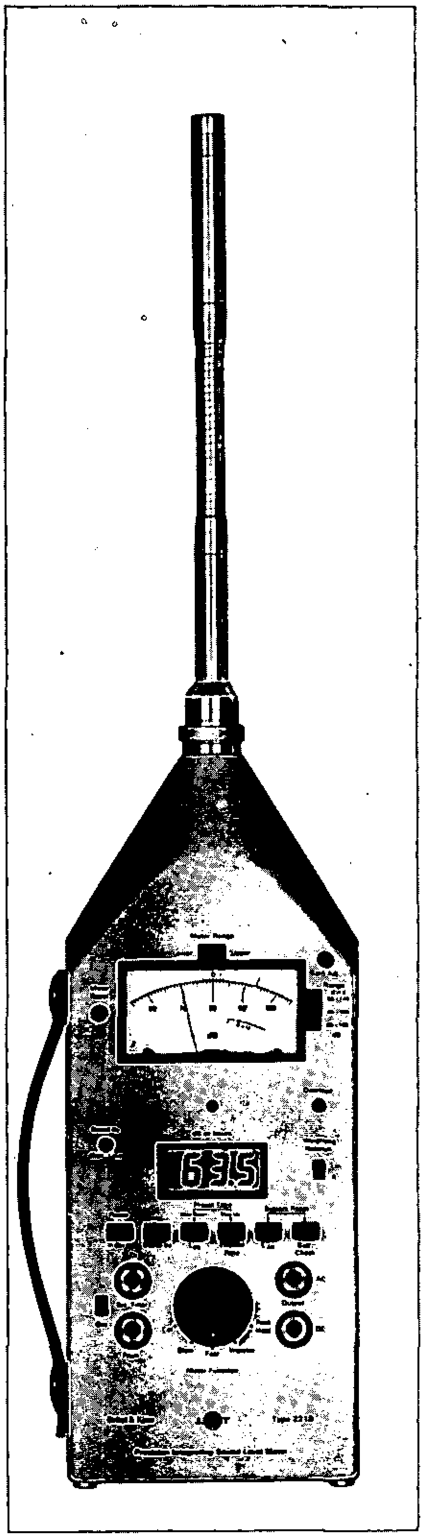


Figure 5. Sound Level Meter.

The cumulative display is obtained by recording a count in the particular class level and all levels lower than it. Thus the lowest level was exceeded for 100% of the time and the level just reached, ie 0% can be determined. The noise indices referred to previously are obtained from this information.

If a Leq value is required without the full range of statistical information, then an integration of the sound level, with the result divided by the time, is required. The sound level meter shown in *Figure 5* contains a clock which is used in the calculation process and accepts signals over a precise time, and a running value of the Leq is provided, in addition to the conventional meter display of the sound level. An extension of the energy measurement principle is the latest unit L_{ax} or single event noise exposure level. This value is determined by calculating the fixed noise level which if it occurred for one second, would contain the same noise energy as the transient noise. Transients of varying duration and level can thus be compared and there are indications that a relationship between L_{ax} and their annoyance factor exists.

Other Developments in Noise Measurement

During our brief look at the methods of noise measurements and the instruments necessary, I have concentrated on hand-held equipment. In cases where a more detailed analysis than can easily be made on site is required, a tape recorder may be connected to the sound level meter output. The frequency response of the tape recorder should be flat over the range of interest, to ensure that the signal is unaffected by the recording and reproduction process.

Recent advances in electronic technology and the use of micropressors have resulted in real time analysers being available which are all digital and provide instant analysis together with a pictorial presentation. They can easily be interfaced to desk top computers which are programmed to provide even more information.

What does all this mean? Briefly I feel it means that noise measuring instruments exist to cover all requirements and can provide the noise control engineer with the necessary data to help him decide upon the action to be taken.

Product News

Energy Conservation Service

Honeywell is stepping up the resources devoted to its Energy Conservation Service. This service, provided by its Commercial Division, involves the carrying out of an in-depth survey and report on any nominated building, followed by the actual conversion of the building controls, if desired, to achieve maximum energy conservation.

The survey and report stage provides, for a fixed fee, a detailed inspection of the structure, plant and control system of the building to produce a full report.

Where a building owner decides to act on the report to reduce energy waste, the service will arrange for all conversion work.

Further information on this Energy Conservation Service package is available from the Commercial Division, Honeywell Ltd, Honeywell House, Charles Square, Bracknell, Berks RG12 1EB. Tel: 0344 24555.

Medical Gas Service

N. G. Bailey (Instrumentation) Ltd of Bradford have entered the field of installing and upgrading piped medical gas, compressed air and vacuum systems, and associated plant in hospitals and clinics. The company is a member of the N. G. Bailey Organisation which has 12 branch offices throughout the UK engaged in electrical contracting work.

For further information contact: N. G. Bailey (Instrumentation) Ltd, Control House, Caledonia Street, Bradford BD4 7AW. Tel: 0274 35641.

Jet Set Pack Cuts Maintenance Costs

Many blockages in sinks, toilets, showers, washbasins and floor drains can be cleared with the use of the 'Jet Set Pack' now available from G. H. Wood & Company Ltd.

The new Jet Plumber tool is easily operated and releases freon gas under pressure so that the kinetic force created instantly clears the stoppage, however stubborn. Effective up to distances of 250 ft, the Jet Plumber has been developed to help overcome the problems of inconvenience and cost normally associated with calling in emergency, outside, maintenance contractors.

Further information is available from: G. H. Wood & Co Ltd, International Division, Wealdstone Road, Kimpton Industrial Estate, Sutton, Surrey SM3 9QN. Tel: 01-641 4719/20.

Cleaning Equipment and Materials Exhibition

The Janitorial Suppliers' Association (JANSA) is sponsoring a Cleaning Equipment and Materials Exhibition to be held at the Pavilion Suite Warwickshire County Cricket Ground, Edgbaston Road, Birmingham, on September 19 and 20. This, the third in a series of regional exhibitions, is aimed at bringing the latest developments in materials, products and services to the attention of purchasers and users in the Midlands area.

Complimentary tickets are available from 'The Organiser', Cleaning Equipment and Materials Exhibition (Birmingham), c/o Spurgeon Walker Associates Ltd, Arctic House, Rye Lane, Dunton Green, Sevenoaks, Kent. Tel: 0732 59821.

New Style Drain Adaptors

Marley Extrusions Limited has introduced a new drain adaptor, designed to connect UPVC pipework to clay drains. The drain adaptor is a simple push-fit component which fits into a standard plastic coupling for vitrified clay pipe and this connects to Marley UPVC pipe by means of a ring seal socket.

The Marley drain adaptor is available in 110 mm and 160 mm sizes.

Further information is available from: Marley Extrusions Ltd, Lenham, Kent ME17 2DE. Tel: 0622 54366.

Paint Remover

Spectra has brought out a new kind of paint stripper in a spray can, which allows the user to put the paint stripper just where he wants it at the touch of a button. No spills, the minimum amount for the job in hand, and no trying to clean stripper out of a spoiled brush or pour the corrosive stuff back into the bottle.

Spectra's spray Strip-Off has an anti-vandal function too. It can be a boon to local authorities in the removal of graffiti from the rough surface of stone work or tiles, apart from its many other household, domestic and automotive uses.

For further information please contact Mr W. O'Dell, Spectra Automotive and Engineering Products Ltd, Bridge Road, Haywards Heath, Sussex RH16 1UB. Tel: 0444 412548.

Waterproof Modulated Beam Unit for Outdoor Detection

Photain Controls Ltd, have designed a new alarm system, the Pulse Modulated Gallium Arsenide Infra-Red Beam Unit, which is contained in a waterproof housing and will provide coverage up to a distance of 50 metres. The unit (Type No. LB50/S) comprises two housings, one containing the solid state infra-red emitting device complete with optical system and associated circuitry and the other containing the photocell, optical system, de-modulator circuit and with an output relay.

Model LB50/S operates from the mains supply (110/240v 50/60 Hz) and the output contacts are rated at 5 amps 250 v AC resistive load. An alternative model LB50/W is also available operating from a 12 v DC supply.

Further details are available from: Photain Controls Ltd, Unit 18, Hangar No. 3, The Aerodrome, Ford, near Arundel, West Sussex BN18 0BE. Tel: Littlehampton 21531/2/3/4.

DKK Super-halogen Operating Theatre Lamps

We apologise that the photograph illustrating the lamps in the June issue of the journal was inadvertently published upside down. Spares and service facilities are available from Newcastle, Manchester, London, and Cardiff.

Further information regarding these lamps is available from: Staniforth Peacocks Associates, 62 Brighton Road, Surbiton, Surrey. Tel: 01-390 3760.

A Cure for Flies in Hospitals

Rentokil Limited have introduced a new insecticide known as Muscatrol which is a synthetic pyrethroid and combines the great advantage of the original pyrethrum — extreme low toxicity to man — with one advantage the original never had — it remains active for months. Four sprayed-on applications during the course of the fly's long breeding season (April-October) will ensure a continued rapid kill of flies throughout the year. Not only walls and ceilings, but also beams, suspended lights and other fittings are sprayed at a very low rate, one litre being sufficient for 1,000 square feet.

At the same time as the Muscatrol is applied, the pest control service man checks any insect electrocution devices such as Rentoflash units (which do have the advantage of retaining within a tray any flies they kill) and sprays any outside breeding sites with a formulation of fenitrothion or iodofenphos. Practical advice on proofing against flies and effective cleaning will also be given by the pest control surveyor.

Flies are among the most often tolerated of all pest insects, with least cause. Now, at last, there are sufficient weapons to minimise risks of flyborne infection.

Free surveys and further advice on fly control are available from Rentokil Pest Control Division, Felcourt, East Grinstead, West Sussex. Tel: East Grinstead 23661.

The Housefly.

Trocal Roofing System

The Trocal loose-laid PVC flat roof protection system is described in a colour brochure now available. Detailed technical advice and assistance is also available.

The Trocal roofing system has been in general use for more than ten years. It is claimed that Trocal is impervious to structure movement; can be installed in any kind of weather; is completely waterproof; can be used in either ballasted or unballasted form; and has proven long-term weather resistance.

Further information is available from Dynamit Nobel (UK) Ltd, Gateway House, 302-308 High Street, Slough, Berks SL1 1HF. Tel: Slough 35422.

New System Eliminates False Alarms

A 'ripple memory' microelectronic system developed by Notecalm Ltd, of Bedford, helps eliminate false alarm call outs. The new Notecalm DT2 portable security system was introduced to offer effective protection to meet most requirements at a retail price of under £300. It is designed to sense intruders and vandals on the outside of property and prevent entry — one portable units contains a high output (105 dB) alarm to sound for up to 4 minutes, two 150 Watt floodlights and standby batteries, and will protect up to 15,000 sq ft.

The DT2 works on an acoustic principle, sensing intruder noises in the area it is protecting, whereas most other alarms in this price bracket detect either movement or heat and are, therefore, easy to trigger accidentally. The sensitivity can be set to different levels to take account of the surrounding environment, for example, high for a quiet room in a hospital where there should be little background noise, but lower for a retail shop on a busy main road.

It should not be triggered by birds, animals or insects. The unique ripple memory ensures that only a sustained attack on the premises or a deliberate entry attempt such as that causing shattering glass or splintering wood will trigger the alarm mechanism. Batteries contained within the unit provide a stand-by power source for up to 48 hours in the event of a power failure or cut lines.

The alarm has facilities for remote arming and disarming, activation of ancillary equipment, connection to existing systems, and charging of external equipment.

It requires no wiring, installation or servicing.

Notecalm DT2 portable alarms are available from a wide range of distributors throughout the country.

Further information is available from: Notecalm Ltd, 4 Ashburnham Road, Bedford. Tel: 0234 64059.

Polyurethane Flooring System

The latest addition to Th Goldschmidt Ltd's seamless flooring systems is a solvent-free, two-pack polyurethane based compound. Known as Reinau PU 22, the new flooring is stated to give a hard wearing, high gloss, decorative finish.

It also acts as an effective sealant to concrete, cement and bituminous substrates. The manufacturers state that despite its high gloss, Reinau PU 22 offers an excellent anti-slip easily cleaned surface. It is therefore particularly suited for such floorings as hospital corridors, office reception areas, laboratories, and viewing galleries in breweries.

Further information is available from: Th Goldschmidt Ltd, Initial House, 150 Field End Road, Eastcote, Middx HA5 1SA. Tel: 01-868 1331.

Measurement Instruments

BIRAL, specialists in flow measurement and industrial research instrumentation, have introduced a new 12-page, two-colour brochure describing their range of TSI Industrial Airflow measurement instruments.

A copy of this publication is available on request from BIRAL, PO Box 2, Portishead, Bristol BS20 9JB. Tel: 0272 847787.

New BTU Meter

A new heat metering system for use with boiler and process fluid plant is now available. The system establishes the product of flow, temperature difference and specific heat. This product is termed heat flow or power and gives the amount of heat supplied or rejected within the process or building.

Further details are available from: Robertshaw Skil Ltd, Greenhey Place, East Gillibrands, Skelmersdale WN8 9SB. Tel: Skelmersdale 23671.

Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

LECTURERS

HOSPITAL ENGINEERING CENTRE
EASTWOOD PARK
FALFIELD, AVON

Lecturers are required at the above Centre located between Bristol and Gloucester which provides residential training courses for all grades of Works Staff employed in the National Health Service.

Candidates should be qualified to at least HNC standard in either Engineering or Building and have relevant mechanical, electrical or electronic engineering or building experience in either the National Health Service or industry and/or teaching experience.

Salary scale £4,641-£5,478 per annum (currently under review). Commencing salary may be *above the minimum of the scale* for a candidate whose qualifications and experience are appropriate.

Application forms and further information regarding the Centre are obtainable from the Regional Personnel Officer, South Western Regional Health Authority, UTF House, 26 King Square, Bristol BS2 8HY.

Closing date: August 17, 1979.

East Roding Health District

ASSISTANT DISTRICT ENGINEER (SECTOR)

(£5,682-£6,763 inclusive)

We require an experienced and qualified person to join a small team in a District where a major expansion is about to begin. He will be involved in the management of all engineering maintenance and minor capital programmes on behalf of the District Engineer, and will have specific responsibilities for energy *conservation* for Health Centres and Clinics.

Application forms and job description are available from Janis Patrick, District Personnel Department, King George Hospital, Newbury Park, Ilford, Essex, or ring 01-518 1702.

Informal enquiries to Alan Goffee, District Engineer, *01-554 8811, ext. 345.*

DORSET AREA HEALTH AUTHORITY
EAST DORSET HEALTH CARE DISTRICT

ENGINEER

required to assist the Senior Engineer in the organisation and maintenance of all engineering services at Christchurch Hospital and other associated units.

Applicants should have completed an apprenticeship in mechanical or electrical engineering or have otherwise *acquired a thorough practical training and possess a* minimum qualification of ONC in engineering or equivalent. A Management qualification is also desirable together with a knowledge of planned preventive maintenance systems and their operation.

Salary scale: £4,497 - £5,073.

In addition an allowance (currently 15%) is payable for the satisfactory management of the tradesmen's incentive bonus scheme.

The successful candidate will be required to participate in an 'on-call' rota.

Application forms and job description available from the District Employment Officer, D. M. T. Offices, Royal Victoria Hospital, Shelley Road, Boscombe, Bournemouth.

***Closing date for receipt of completed applications:* August 28, 1979.**

TRENT REGIONAL HEALTH AUTHORITY

ENGINEER AND TECHNICAL ASSISTANT

Due to the expansion of the Regional Sterilizer Testing Team, vacancies exist for suitably qualified Engineers and Technicians who have a sound knowledge of the performance testing and maintenance of hospital sterilizers and wish to gain further experience in this highly specialised field.

Consideration may also be given to persons who have a sound practical training in hospital engineering with a theoretical knowledge of gas/water vapour/air mixtures, the operation and fault finding of electronic/electrical control systems also steam supplies.

Salary £3,771 - £6,810 / £4,158 - £4,638 per annum (salary award pending).

Application forms (to be returned by September 6, 1979) and further details from Regional Personnel Officer, Fulwood House, Old Fulwood Road, Sheffield S10 3TH, quoting Ref ET093.

BOARD OF GOVERNORS —
ST. PETER'S HOSPITAL

We are looking for the following staff to assist the Group Engineer in the operation and maintenance of all engineering and building plant and services (including small capital works) at this group of four hospitals in the Holborn/Covent Garden area:

SENIOR ENGINEER

£5,292 - £6,072 pa inclusive

Must be experienced and preferably hold a recognised professional qualification.

ENGINEER

£4,851 - £5,427 pa inclusive

Must hold an ONC in Engineering, a higher qualification or an alternative qualification acceptable to the Secretary of State.

Applicants for both posts must have completed an apprenticeship in Mechanical or Electrical Engineering and have at least five years' relevant experience.

Application forms and job descriptions are available from the Personnel Officer, St Philip's Hospital, Sheffield Street, London WC2A 2EX. Tel: 01-242 9831, Ext 37 or 38.

Closing date: August 24, 1979.

SUNDERLAND AREA HEALTH AUTHORITY
AREA WORKS DEPARTMENT

ENGINEER

Required due to promotion. Duties include the operation and maintenance of Plant Equipment and services at the Royal Infirmary with a possibility of gaining experience at other Hospitals within the area.

Salary £4,497 - £5,073 plus incentive bonus scheme.

Qualifications ONC Mechanical or Electrical or equivalent, are a minimum.

Application form and job description from the Area Personnel Officer, Personnel Department, District General Hospital, Kayll Road, Sunderland.

Closing date: August 17, 1979.