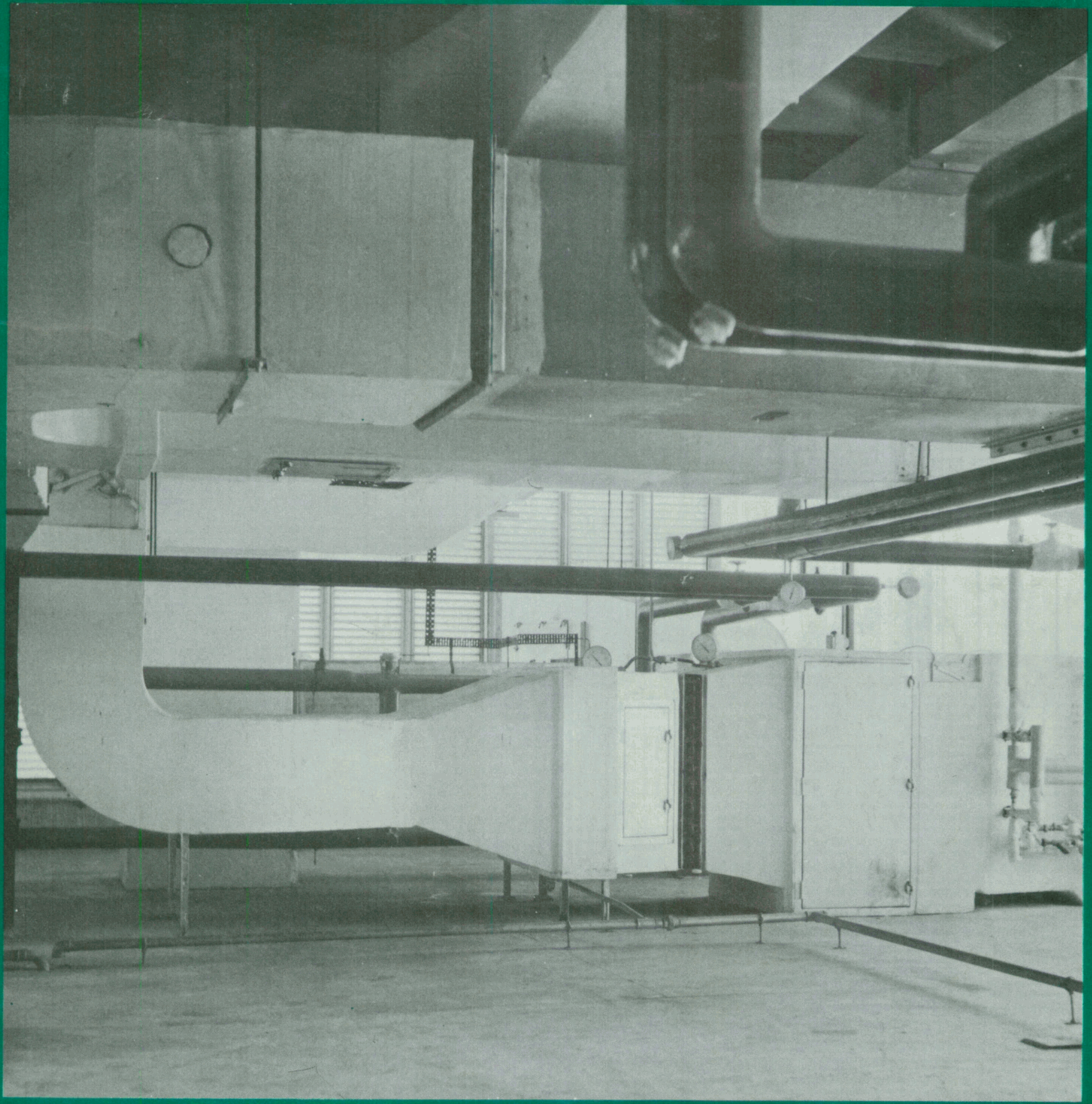
HOSPITAL ENGINEERING

November 1979

The Journal of the Institute of Hospital Engineering



Steam Humidifiers — their Use and Application

'Hospital Engineering' is published monthly, except in January and July, by Earlsport Publications

Individual copies cost
£1.95 UK postage paid

The annual subscription is UK: £16.75
Overseas: £20 Americas: $45

Average circulation per issue
(January-December 1978): 2,347

ABC

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'Hospital Engineering'
Earlsport Publications
17 St Swithin's Lane
London EC4, England
Telephone: 01-623 2235

UK ISSN 0309-7498

Printed by JB Offset Printers
(Marks Tey) Ltd
Station Approach, North Lane
Marks Tey, Colchester, Essex

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HOSPITAL ENGINEERING

Vol. 33 No. 9

November 1979

The Journal of the Institute of Hospital Engineering

Contents

Institute News

Fire Precautions Seminar a Sell-out — Repeat on December 5

The seminar, organised by the Institute jointly with the Department of Health and Social Security, on Fire Precautions in Health Buildings has been such a success that two weeks or more before the event it was fully subscribed, and many people had had to be turned away.

The Institute is therefore very pleased to announce that it has been possible to arrange a repeat performance on Wednesday December 5, with all details of the day being exactly the same as the first presentation on November 14.

The full programme was given on page 2 of the September 1979 issue of *Hospital Engineering*, and so we are not repeating it here. Basic details are that the seminar is being held at the Institute of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1, starting with coffee at 10 am and going on to 4.30 pm.

Tickets are available from the Secretary of the Institute, at the address on the contents page of this issue, for £13 each, which includes morning coffee and lunch.

The Chairman for the day will be John Bolton, Chief Works Officer, DHSS, and the speakers include P. Robinson, HM Inspector of Fire Services at the Home Office, Ceri Davies, Assistant Chief Architect DHSS, and T. Greenwood, also an Inspector of Fire Services at the Home Office.

Special Energy Saving Issue — a correction

The October issue of *Hospital Engineering*, which was devoted almost entirely to a study of energy saving in the National Health Service, and to which readers have been kind enough to give a very good reception, suffered from an unfortunate printer's error. This caused three rather similar graphs to be transposed between three articles. These were figure 1 on page 24, figure 1 on page 30, and figure 1 on page 35.

It is hoped that readers will not have found this too confusing, since each graph was clearly labelled with the hospital to which it related. However, we do apologise for any inconvenience caused.

Change of Address

The Institution of Public Health Engineers has moved from its offices in Eccleston Square. The new address is: 13 Grosvenor Place, London SW1X 7EN. Tel: 01-245 9778.

Mr Charles McQuarrie

Mr Charles McQuarrie, Area Engineer with the Lanarkshire Health Board, died suddenly as a result of a heart attack on Saturday September 15.

Mr McQuarrie, who was aged 57, joined the Health Service in 1953 as Group Engineer to the Motherwell and Hamilton District Board of Management and was until four years ago located at Strathclyde Hospital. With the re-organisation of the Health Service he became Area Engineer to the Lanarkshire Health Board.

Throughout his long service with the Health Authorities he was well respected and liked by his colleagues.

During the war Mr McQuarrie served as an officer in the Royal Navy and was torpedoed three times. Afterwards he spent some years with a cotton corporation in Sudan where his experience and his abilities to introduce innovations were of paramount importance. He worked for sometime with the Air Ministry controlling the works of Royal Air Force and other airfields before joining the Health Service.

Mr McQuarrie is survived by his wife. The funeral was at Daldowie Crematorium on Wednesday September 19.

List of New Members Elected to the Institute

Fellows

BLACHE, Louis Andre.
CUTCLIFFE, Roger Martin, West Midlands RHA.
ELLISTON, Bryan John, Mark Jennings Partnership.
FREETH, John Raymond, Hoare Lea and Partners.
HEATH, Derek Sydney, Austen Heath, Leslie and Partners.
HOLDER, Charles James, British Arabian Design Group.
HOWARTH, William, Birmingham AHA (T).
JOHNSON, Roy Alfred, Oscar Faber and Partners.
REED, Alan Frank Dowling, British Arabian Design Group.
ROUND, Cecil David, Mechanical and Electrical Design Associates.
SEAR, Roger Jack.
SOO, Ang Thian, Ang Thian Soo and Partners.
SUTTON, Keith William, Dale and Ewbank.

Members

BATES, Maurice Henry, Hoare Lea and Partners.
BODDISON, Brian William, Static Systems Group Limited.
CADDICK, Arthur, Rotherham AHA.
DAKIN, Roger Peter, Upton Associates.
DORAN, William John, Southern Health and Social Services Board.
DUNNETT, Christopher James Stewart, Alistair McCowan and Associates.
FISH, James Arthur, North Tees General Hospital.
HUNTLEY, John, Kingston AHA.
JORDAN, Peter David, Chelsea Hospital for Women.
LEWIS, James Henry, Cornwall and Isles of Scilly AHA.
MASON, Brian, Manchester AHA (T).
NEILL, Robert George, RGN Building Services Design.
PARISH, Michael John, Upton Associates.
PARKER, George Charles, Brent and Harrow Health Authority.
PEARCE, Alan Edward, Hoare Lea and Partners.
PEARSON, Keith William, Basingstoke District Hospital.
WARD, Douglas Donald.
WHITE, Leslie, British Arabian Design Group.
WOOTTON, Raymond Douglas, Sedgwick Forbes.
YATES, Lawrence Joseph, West Heath Hospital.

Graduates

DEANE, David Thomas, Varming Mulcahy Reilly Associates.
STYLES, Andrew John, Hampshire Area Health Authority.

Student

FORSMAN, Barugu Peter, Newcastle-upon-Tyne Polytechnic.

Associates

PAIS, Wenceslaus Frank Vincent, Al Corniche Hospital, Abu Dhabi.
PHILIP, Kuttiparampil Varshese, Dept of Health and Medical Services (Govt of Dubai).
TITCHENER, Edward Leonard, British Arabian Design Group.

North West Branch

Wednesday November 21, at 2.00 pm. Visit to Research Laboratories, British Engine Insurance Ltd m/c.

1980

Tuesday January 29, at 6.00 pm. Paper on Static Switching. St Mary's Hospital m/c. Static Systems Group.

Thursday February 7, at 6.00 pm. Hospital Lighting a new CIBS Guide. School of Architecture m/c. Joint meeting with CIBS.

Friday February 15, at 7.15 pm. The Cresta Court Hotel, Altrincham. Branch Annual Dinner Dance.

Wednesday March 12, at 6.00 pm. Ormskirk DGH. Branch Annual General Meeting. Paper on Micro Computers.

Saturday April 19, at 2.00 pm. Visit to Leighton Hospital, Crewe for husbands and wives.

Wednesday May 21, at 6.00 pm. Paper on 'Fluidised Bed Combustion' by NCB. Bolton Medical Institute. Joint meeting with Inst Plant Engs.

Wednesday June 11, at 10.30 am. Visit to Jodrell Bank, Cheshire.

Midland Branch Programme

November 6, (venue to be confirmed) Maintenance Aspects of Drainage Design by R. Payne and Associates. January 22, 1980, Micro Processors and Trends/Developments in Communication Systems at Static Systems Group, Wolverhampton. February (date to be arranged), visit to New Street Station, Birmingham.

The Papers Sub-Committee will confirm details of the February meeting later.

Letter to the Editor

Energy Education — Nationwide

Dear Sir,

Professional institutions have always had as their main objective the maintenance of high standards within their *own particular field. It is now suggested* that they should consider how energy conservation can be further extended through their own field of training. Some of our member institutions are directly concerned with one or other source or use of energy, and continually seek to spread their knowledge within the community. For others, the connection is vague, but could be emphasised by employing examples from the energy field.

The Watt Committee on Energy announced its intentions regarding education at the first meeting of the Consultative Council in November 1976. As a first step, an Education Sub-Committee was set up under the chairmanship of the Institution of Plant Engineers, representative (H. Brown). This has done useful work including the organisation, with the blessing of the Department of Energy, of a course on *Energy Management. There are now* some sixty energy managers' groups in the country, whose efforts are coordinated by the Department, and well illustrated in the monthly publication of *Energy Management.*

That the United Kingdom has been a leader in this field is illustrated by the choice of Birmingham by the International Energy Agency for the first International Conference on Energy Management. Incidentally, the Watt Committee has been asked to sponsor the second dinner at this three-day conference October 9-11.

More important, it has been asked and agreed to do a survey of the extent to which energy matters are included in the teaching at universities and polytechnics and *in addition,* the probable demand by industry for fully or partly trained energy staff. To meet this request, the Education Sub-Committee will have the status of a permanent Watt Committee on Energy section continuing under the same chairmanship. To ease their task two working groups: a University Working Group chaired by Professor Weinberg and an Industrial Working Group under Mr B. Lubert have been formed.

On September 5, the Department of Energy issued a press release on how 'Energy Conservation should be taught in Schools'. They suggest that all children should be taught about energy and energy conservation for, as they say 'Those who are in school now will, as adults, have to face a much more difficult energy situation towards the end of the century'. This will mean special in-service training for teachers and the possible inclusion of energy in GCE and CSE examination syllabuses.

The numerous meetings associated with Energy Month will doubtless have a *major education impact, but what must* follow is a continuing effort based not on London or Birmingham alone, but on numerous provincial centres.

Many of our individual members are already associated with such local activities, and fairly recently the Royal Institute of British Architects set up regional centres for the training of architects in energy matters. The Watt Committee is keen to support such efforts, and indeed suggested in 1976 the formation of 'mini-watts' to assist in the application of its recommendations.

We believe that we could help such local centres considerably by finding:

Professional lecturers for professional audiences;

Speakers to address more general meetings;

Speakers to give talks, take the chair or open or close meetings or conferences organised by less technical organisations such as evening classes, women's institutes or factory groups.

If members of our constituent bodies are willing to help the energy problem in this way, we should be grateful if they *would inform their secretary and* provide the following information:

Name, address and telephone number;

Aspects of energy they would be prepared to present, eg generation, process utilisation, space heating, heat recovery, new sources (domestic or commercial) or other topics of their own choice.

If, as we hope, there is a good response to this appeal, we can collect at the *Watt Committee lists of people ready to* help with particular subjects in given areas of the country.

The Watt Committee already has considerable impact within the UK, mainly via the professions. It was in response to appeals for wider education that we published the relatively cheap supplement of energy maps for use in schools and our first paperback 'A Warmer House at Lower Cost'. Our impact could however be far greater if extended to different regions in the country which only seems possible by the use of voluntary lecturers of assured quality, backed by the visual aids which the Committee hopes shortly to supply.

Time is not on our side, we must save now or be cold later. We hope that you can help us and do so soon.

H. BROWN

Chairman — Education Committee,
The Watt Committee on Energy,
1 Birdcage Walk,
London SW1H 9JJ.
Telephone 01-222 7899.

The author, Assistant Chief Engineer, Department of Health and Social Security, delivered this paper at the Institute's one-day seminar on 'Electricity and Health Buildings in the 21st Century' in London in June.

Hospital Design Philosophy for the 21st Century

R. MANSER BSc(Eng)(Hons) CEng MIMechE FIEE PPIHospE

Use of Electricity

Let us look very quickly at the current use of electricity in health buildings and from this make intelligent forecasts of future use and perhaps foreseeably improved technologies.

Major uses are currently for lighting, communications, small power, large power including lifts and fans, diagnostic and treatment apparatus. For all these uses electricity is likely to remain the supreme choice.

What changes can we reasonably foresee? I suggest within a decade much of the electrical apparatus will be sold integral with its own solid state switching devices. Even motors will I think include suitable solid state starting devices. It is more difficult to foretell the type of trigger circuit, although clearly the power of such circuitry will be very small indeed. Possibly, control will either be directly by microprocessor type circuits, by remote control telemetry devices, or even by light current devices with hard wiring. The essential change I foresee is that the main wiring will not drop down into controlled devices and back again, but will be switched at the point of use.

To remind you of the difficulties of being a prophet *The Observer* recently included an article by Sue Arnold on a voice-printed car named George. This is a model car on which you 'print' your own voice and which will then obey your spoken commands. Apparently in West Coast homes in America curtains can already be drawn, and hi-fi switched on, by spoken command.

It is already accepted, I think, that supervisory control in the widest sense will be both possible and normal. This will, I think, inevitably include environmental control. If such controls are to suffer the reduction in cost which we have seen in computing devices, one might foretell controllers on a room-by-room basis, which would provide not only environmental control but also automatic lighting control as required. There would be no difficulty even with today's technology in sensing a presence in a room and switching on accordingly. Even as a halfway stage in office accommodation a small bleeper could ask at 5.30 whether lighting and heating should remain on, and the occupant can reply whether he wishes it to remain, for a further period or until cancelled.

The light current role of electricity in communications is a potentially vast field. The communication and record-keeping in hospitals is in general extremely primitive compared with what is already feasible. Almost inevitably one feels the future will include on-line medical records, drug prescription, drug issue and automatic stock control.

I need hardly tell you of the nurse-call, radio and more straightforward telecommunications services.

But these predictions are the easy part. Much more fascinating is the potential use of energy in the major environmental control of whole buildings, not merely in the sense of controls but in the sense of heating and cooling. I believe electricity has a tremendous part to play in the future, and I believe we must not be over-influenced by considering electricity in the context of the present generation of buildings, particularly office buildings. Many of these, I suggest to you, have been designed with minimum capital costs in mind and with inherently poor internal climatic control, made acceptable by the brute use of energy for heating, cooling and ventilation. Such an approach will be out of the question in the future with rising energy costs, and I would like to look at some features of building construction before examining the technology of possible future electric hospitals.

Building Construction

In our climate for a large part of the year we will wish to hold a temperature differential inside/outside, so we require the inevitable structural carcass to include insulation to reduce the energy needs of this artificial environment to a minimum, especially in buildings occupied 24 hours a day, 7 days a week. The mass of the structure should clearly be where it helps the environmental thermal stability.

The Department has embarked on a study of a low energy hospital, intended among other things to determine the levels of insulation etc for various building lives and predicted energy costs. When all the figuring has been done and the computers have churned out their paper, I believe the answer for the outer shell or carcass of our hospitals — probable life of 100 years — will be near enough equivalent to a good solid Victorian brick type shell, cased externally in about 12 inches of insulation, together with a well-proven tiled or slate roof with about 18 inches of insulation. In case you think this is extreme it is of the same order as the current Swedish Northern Latitude Building Regulation.

Windows

Windows fascinate me. They are superficially so simple, and yet so complex in action, and so interactive with our conscious and subconscious needs. I once wrote down the various seperate functions of ordinary household windows and listed 14.

Let us talk about radiation and reflection on glass surfaces. That is radiation proper, not ordinary thermal conduction, which we are all aware of, and which double and triple glazing can reduce almost as much as we may wish. I want to talk about radiation.

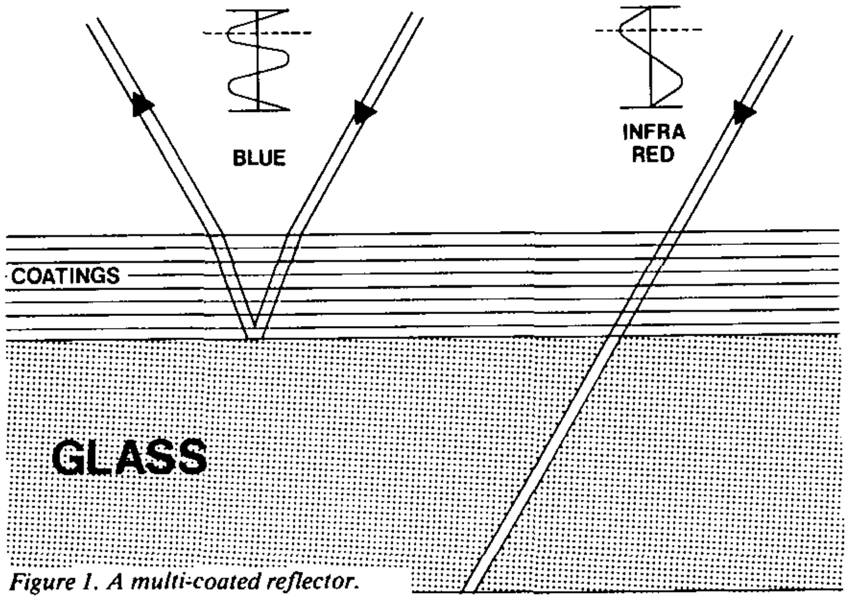


Figure 1. A multi-coated reflector.

All of you who have an interest in photography are aware that modern camera lenses are coated. Basically this consists of a ¼ wavelength transparent layer of a different refractive index. The basic idea is that the reflected light is bounced back into the required direction, reducing both flare and reducing transmission losses.

With a coating having a refractive index lying between that of air and of the glass concerned, reflection is reduced. With a refractive index greater than the glass it is increased — for that wavelength.

Now may I turn to an uncompleted modern reflector as in *Figure 1*. This is not a silvered reflector. It is multi-coated with a number of transparent layers. It is clearly a reflector, but now look at it as a transmitter.

What is the significance of this? Multicoating with transparent layers enables us to make filters which transmit, with a very high efficiency indeed, light of the selected wavelength, whilst other wavelengths are reflected virtually without loss.

Here we have a tool all ready to increase, if we so wish, the greenhouse effect by bouncing back into the room from the window all the low temperature radiation from the surfaces, whilst transmitting into the room the higher temperature, shorter wavelength, radiation from the sun and sky.

It is too much to expect that within some 10 to 15 years this multi-film effect will be electrically controllable. Windows could be made which, driven by suitable micro-computer control, would alter their characteristics to accept or reject solar gain as required? When this happens architects might properly go back to the all-glazed building, which could then both utilise and control simple solar heating without any moving mechanical device.

Thus I predict that in the short-term, perhaps for 25 years, windows and the fenestration ratio of window to wall area will change to viewing apertures to provide the visual link to the outside. They will no longer relate to mechanistic daylight factors, since artificial lighting will clearly be more than capable of covering this role.

After 25 years I suggest that windows will be electrically controllable that is to say by electric charge effects on surface films in respect of radiation transmission in both directions. By the use of what will then be the inevitable chip environmental controller, we may have a significant degree of solar heating control by large windows (and will probably have obscuration as required for privacy as an additional independent control.

Technology, Heating, Ventilating and Air Conditioning

There is not enough time for a full discussion of all types of air conditioning and I am going to consider only:—

Natural ventilation plus a heating system;

Full air conditioning;

Opening windows plus background ventilation and heating.

In all cases there will, of course, be individual fully air conditioned areas — for example, operating suites.

There is surprisingly strong objection both by medical and nursing staff to full air conditioning with its inevitable locked or sealed windows. It seems likely that the naturally ventilated hospital will be with us for a long time, due largely to first, its general acceptability, second its low capital cost, and third its low running cost.

Full air conditioning can generally only be justified at the moment in a city, with noise and dust pollution problems. A major item of plant and running cost is the need for refrigeration plant and the year round cost of fan power for say six to eight air changes throughout.

The third choice is very interesting and perhaps the long-term solution most likely to be accepted in this country. It is background or minimum mechanical ventilation, allied to a heating system, and with windows which can be opened.

Let us examine each of these in turn, in the light of the need for greatly increased energy economy in future.

The first is the animal we know well. The techniques for energy economy are clearly, first, improved insulation and winter draught-proofing, second the building mass must be inside the main insulation, third, reasonable fenestration ratios and 'architectural' control of summer solar gain, and fouth, heat reclaim wherever feasible, as from the kitchen etc.

Where a decision is taken to include full air conditioning, energy reclaim should clearly include:—

First, Maximum acceptable recirculation and/or energy recovery;

Second, architectural control of summer solar gain to reduce the refrigeration air conditioning load;

Third, heat reclaim from drains etc where possible.

But it is the third choice which is perhaps the most technically interesting; consisting of heating, openable windows and background ventilation.

Background ventilation is usually though of as plenum or fresh air supply, but it can easily be arranged as mechanical extract. Windows can now incorporate arrangements for minimum ventilation when closed, and there are constant volume flow devices which can also be incorporated.

The particular advantage of using the background ventilation system as extract is that heat recovery can easily be incorporated in the extract air duct and, taken in conjunction with the special windows, minimum ventilation standards are maintained with the windows tightly shut in mid-winter. Thus we have a building with the general acceptability of opening windows, minimum ventilation in winter, and a ducted extract system which may be used either with run around coils or heat pumps, to provide a general heat source which is amenable to heat reclaim at reasonable operating temperatures.

Now let us consider the technology of heat and energy reclaim.

The Technology of Heat Reclaim

I should like to run through the various available methods very quickly with you. This will not be a laborious review with the efficiencies and other factors, but just a reminder of the techniques and limitations of the various methods.

Among the simple devices is the plate type heat exchanger, which can be used for air to air transfer; the heat pipe which can be similarly used; the thermal wheel which requires a small driving motor; all these three when used for air to air transfer require the ducting to be brought into fairly close proximity. Then there is the run around coil which requires a pump, but allows the two air flows to be widely spaced; and the heat pump which may similarly be used.

The heat pump, or refrigerator in reverse, is unique in that the amount of heat transferred from a low temperature to a higher working temperature can exceed the amount of power used for heating achieving ratios or coefficients of performance between some 2.5 and 5. A high coefficient of performance is associated with a low temperature differential.

Dealing for the moment with building heating it is, I think, immediately clear that the use of heat reclaim, and the use of heat pumps at high COP requires that the heating system can use heat at the lowest possible temperature. Supposing for instance we were continuously discharging some process water at 50°C then it would be comparatively easy to reclaim a portion of this heat if we had a building heating system with a flow temperature of 40°C or less. If, however, the building was heated with low pressure steam at over 100°C then the process of reclamation would obviously be much more complex and less efficient.

Thus it is a prime necessity that if we are to reclaim heat in the future we shall be reclaiming at moderate temperatures. The building heating system must also operate at moderate temperatures to enable efficient heat transfer to be effective. This rule applies whether the heat is to be transferred directly into air for ventilation or whether it is transferred into or another medium for building carcass heating.

Heat Source

I should like you to look at *Figure 2*, which is a bit odd because it does not compare like with like.

Figure 2 **Approximate Capital Costs per kW Output 1979**

Nuclear Power Station	£500
Coal Fired Power Station	£300
Diesel Generator	£200
Boiler	£15

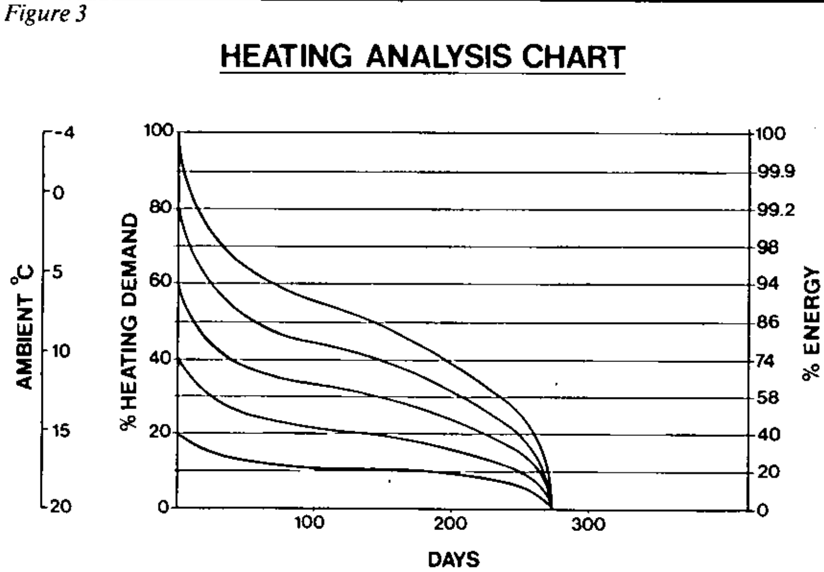
But the message is that, if you want nationally power 365 days a year, 24 hours a day, it should come from a Nuclear Power Station. High capital cost, high efficiency.

If you want to dance round a heat source, starkers, for half an hour once a year on Walpurgis night you should light a bonfire — low capital cost, low efficiency.

The Heating Curve and and its Implications

I should now like to discuss a heating curve or analysis chart (see *Figure 3*) that many of you will have seen in a recent article in the CIBS Journal by Derek Brahan. It is a curve of infinite subtlety, and I do not intend to talk about it since the variations on this theme could well take three hours or more. I merely wish to use the curve to illustrate a few points and the direction in which I think some building developments must move.

Figure 3



Forget all the other ordinates and scales for the moment, and simply examine the *ambient temperature* vertical scale and the *days per annum* horizontal scale. This is a curve drawn for a building requiring no artificial heating when the ambient is 20°C or above. Incidentally, the *days per annum* curve has been cut short at the number of days for the recommended heating season. You will see that essentially there was probably one day with an ambient temperature of minus 4°C, perhaps two days at minus 2°C and so on down the curve. It is of course the area under the curve which represents the annual energy requirement which we must strive to reduce.

The first thing it is very easy to demonstrate on this particular curve or chart is the tremendous energy saving we make if, by improving building insulation and draught control, we achieve, by the effect of the internal gains, a shift in the ambient temperature above which heating is not required. Any gain of even one or two degrees achieves an energy saving across the entire heating season. In fact you can see this curve roughly aligns with the rule, which should be more generally recognised, that every one degree centigrade reduction in over-heating produces a 10% saving in the annual energy bill for heating.

Hence the first rule, that the architectural design and construction of the building must be vastly improved and this will produce marked improvement in the annual energy heating bill.

The next thing the curve demonstrates is the way the major part of the annual energy account occurs at the medium ambient temperatures. For instance this horizontal line cuts off 75% of the annual amount and it equates approximately to an outside temperature between 10 and 11°C. Perhaps more surprisingly 94% of the annual energy occurs below the horizontal line, equivalent to 5 or 6°C ambient.

These facts are very relevant to the use of heat pumps for building heating. A heat pump is clearly a moderately expensive piece of equipment, that is to say, if purchased it should be used with a good load factor to justify the capital cost. But secondly, heat pump co-efficients of performance improve markedly as the temperature differential across which they are required to operate gets less. Thus for instance the 75% line, or thereabouts, might well represent the optimum design level for a high COP heat pump (perhaps 4), with a good utilisation throughout the heating year. The remaining 25% of the annual heating energy requirement, and which also necessitates a peak demand of $1\frac{1}{2}$ times the heat pump capacity, could well be supplied by a fossil fuel boiler which is very low in capital cost and should therefore have a proper role to play in a high peak demand, low energy, situation.

The diagram makes it abundantly clear that once we consider novel and mixed heating systems we must think separately about how to meet the peak demands and about how to fulfil the bulk of the heating season load.

I would rather leave this very simple concept with you rather than deal with the complexities of series or alternative working of various energy sources. May I then draw some simple conclusions on building heating by electricity:-

If buildings are constructed to really high levels of insulation and ventilation control, then the cost of heating by the direct use of electricity can already be competitive with other, ostensibly lower cost, heating mediums. The very high degree of controllability and the absence of planning constraints are an additional bonus.

In large and sophisticated buildings, and against universally rising energy costs, the use of heat pumps with their achievable coefficients of performance of three, four or five must be seriously considered. The efficient use of these more elaborate heat convectors requires that they shall be used with a good load factor ie for a high proportion of the heating season, and secondly, at the lowest possible temperature differential. Both these factors indicate using the heat pump for the base load of the heating season.

The topping and peaky heat requirement remaining can best be served by some sort of storable fuel and boiler or converter.

Drawing together and Conclusion

Now may I begin to draw together these various arguments to show what I think will be the pattern of future health building in the first part of the second millenium.

Before doing this may I turn to the rather quaint *Figure 4* dealing with the cost of fossil fuel, coal or oil.

Figure 4

The Cost of Fossil Fuel is:

The mineral rights of extraction

The Labour to extract it

The Cost of Transport to the point of use

$$E = mc$$

Energy = manpower cost

FOR NUCLEAR POWER

$$E = mC^2$$

Where m the mass converted is very small

C^2 is very large

What we are pleased to call the cost of oil or coal is not the cost as seen by the Almighty. For coal in this country the price includes the mining rights, the cost of reclaiming from the ground, the cost of transport to the point of use, with some profit on the way. It does not include the intrinsic value of the coal as made by nature over millions of years. Similarly with oil.

I happen to believe that we must eventually come to the use of renewable sources of energy. While experiments with wind and tidal power are very interesting I regard nuclear energy, which is not merely fission but potentially fusion, as a renewable source because basically it represents the production of energy by the destruction of very small amounts of matter. Hence in *Figure 4* what is now the formula for graffiti on lavatory walls $e = mc^2$ where c is very large and m is usually very small. The amount of matter required to provide man's needs is so trivial, compared with the earth's mass and the radiation falling upon it, that it can, I think, legitimately be neglected.

But whatever views you may have on Nuclear Power, for health buildings renewable power means Electricity — with someone else looking after primary renewable source. I suggest Solar heating in this country can only be a topping up or bonus source for health buildings. I refuse to tilt at windmills. Therefore I deduce that we must learn to design buildings which can utilise primarily this Electrical Power and use it with the efficiency which its future cost and value must warrant.

Thus I believe that health service buildings and other advanced buildings must, first, incorporate very much better inherent climatic control by their architectural design, and their residual needs should next be met by highly efficient electrical devices which in the heating field probably means heat pumps, with co-efficients of performance hopefully in the region of four, capable of supplying the majority (say $\frac{3}{4}$) of the building climatic energy requirements for the year. The exceptional climatic energy requirements should be met by the comparatively cheap technique of boilers, and either fossil or synthetic storable fuel.

I believe the window sizes will gradually decrease for perhaps 15 or 20 years and then, as we achieve the window capable of full radiation control in both directions, windows will increase in size dramatically, becoming both more interesting architecturally, as well as making a contribution to the direct solar heating, or radiation cooling, of the building.

Energy reclamation from extracted air, drainage, kitchens etc is virtually a sine qua non, as is the use of heating systems with low flow temperature of say 40°C or thereabouts.

With the achievement of co-efficients of performance of three and over the old gibe that more power is wasted at the power station that is utilised at the point of use is largely nullified.

Finally may I say that, although I may be sounding an advocate for both nuclear power, and for certain views which are also held by the Electricity Council, these views are in fact my own independent assessment of the situation. I would like to pay tribute to the considerable political bravery of the Council in recognising that the long-term future may in fact properly lie with a dual fuel concept for this particular application. I happen to think that they are correct in this assessment.

The author is managing director of Armca Specialties Ltd, sole UK distributors of Armstrong Dry Steam Humidifiers, which are made in Belgium and the USA. He has worked with Armstrong for ten years.

Steam Humidifiers — their Use and Application

RAYMOND CARR

Why Humidify?

Humidification is a subject often discussed through clenched teeth, as though to mention it alone could create problems. Mostly this is due to misunderstanding or even fear. The requirement for humidification is plain common sense, so let's get a few facts straight to start with.

Relative Humidity is a common term used to express how much moisture is in the air compared with the amount of moisture the air can hold in total, *at a given temperature*. This is the key. Because hot air can hold more moisture than cold air, 0.235 cu.metres of air at 0°C, the winter outside air, when saturated, can hold about 1 kg of water. If the same volume of air is heated to 21°C, inside temperature, the air can hold about 4.6 kg of water, so the relative humidity falls below 25% after heating. If this is true then, during the heating season, the heated air will try to take moisture from any source. This fact is borne out in many ways, some of which become very obvious to us all, although the cause may not be common knowledge.

So, what happens in the winter, without any addition of moisture to the air? Well, dry air is very thirsty, and its ability to remove moisture from people and articles can be uncomfortable, troublesome, potentially dangerous and costly. Problems of dry skin can increase during the heating season. A number of clinical observations have shown the benefit of adding moisture to the air in this respect, especially for infants and geriatrics. Other investigations indicate positive help from humidification in respiratory problems which are also aggravated by the air. Many theories have been advanced, for and against humidification for medical benefit.

The writer is not a doctor, but investigations made by Armstrong Machine Works into known facts show that the bacteria pneumococcus — type

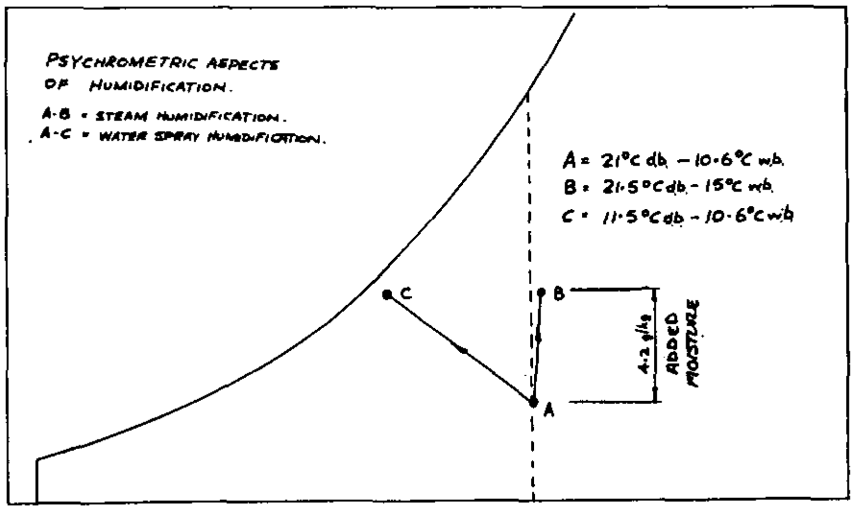


Figure 1. Psychrometric aspects of humidification.

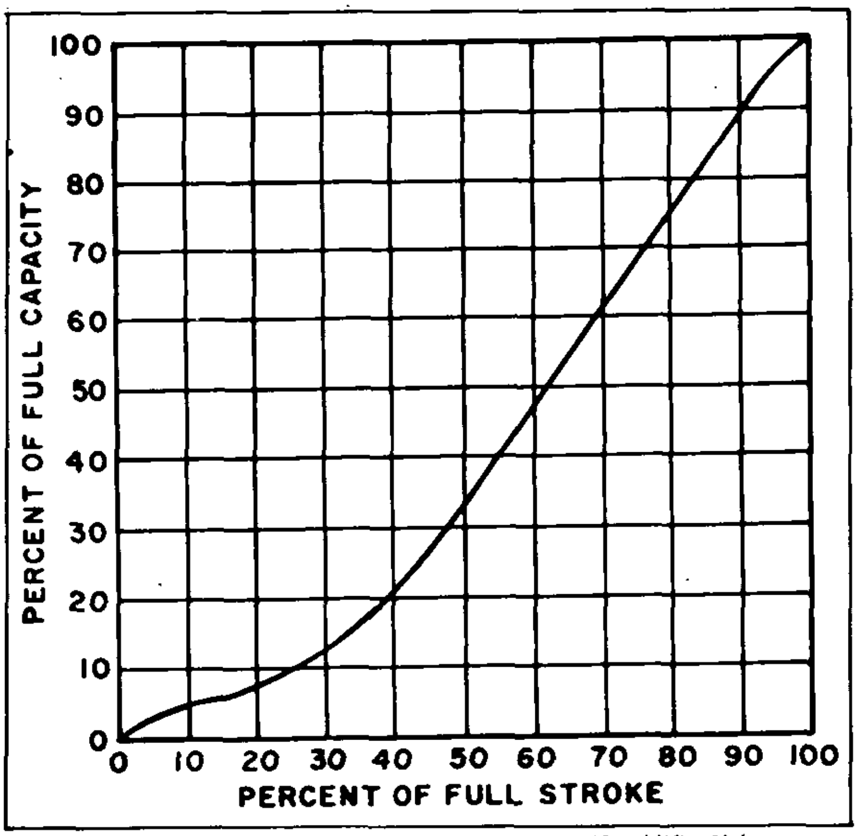


Figure 2. Modified Linear Characteristics for Armstrong Humidifier Valves.

1, haemolytic streptococcus, group C, die much more quickly in relative humidities of 45% to 55% than in dry or very humid air. Studies on some measles and influenza viruses show that they survive much longer in dry air than in the middle and high RH conditions.

Everyone has probably experienced the unpleasant effect of static electricity accumulation in low humidity air. Handling paper, plastics and material in film form and the use of man-made fibres in carpeting and clothing inevitably produce static build-up. Where explosive gases are used, an obvious danger exists. The personal discomfort is enough for some organisations to invest in full humidifications control for that reason alone.

Any material which absorbs and normally holds moisture, can suffer in a dry atmosphere. Paper, wood, textile materials, all change their dimensions as moisture is given up to the air. In computer rooms, for example, serious problems can develop if punched cards shrink even fractionally. Wooden furniture can crack or joints fail due to low humidity.

There is also a case to be made for humidification control in the cause of energy conservation. This idea generally raises an eyebrow or two, but the explanation is valid. Looking at a theoretical system and discussing the enthalpy of the air — on a winter day when the outside temperature is minus one degree C and RH is 75%, the enthalpy of the air is 5.5 kg/kg. If the air is heated to 21°C without any moisture addition the resulting enthalpy is 27.5 kg/kg thus the theoretical RH is 16%. From our experience we know that the actual RH will be 25-30% at 21°C and 30% RH, the actual enthalpy will be 33 kg/kg. The difference between actual and theoretical enthalpy being made up by hygroscopic loss from people and materials. Where does the energy come from to make up this differential? This 20% increase comes from the heating system.

If a humidification system is introduced to raise the RH to a basic comfort level of 35% the enthalpy is 35 kg/kg, only a 9% increase over the inevitable energy load of 27.5 kg/kg (less 5.5 kg/kg). Further, it has been proved often that if humidity is controlled to a comfort level, then dry bulb temperatures can be reduced around 1.5°C with a further reduction in energy cost. This is not to claim a case for humidification specifically for energy conservation, but that if humidity control is required, the running cost may be less than is first apparent.

What Choices Exist?

A good case exists for humidification, then, on a number of important counts. From this point the responsible designer has to choose the best method of adding humidity. He has a number of options. The moisture content of air can be increased by the addition of water in the 'wet' form, by sprays or by spinning discs. This method was regularly used a few years ago. The evaporation of the water requires the addition of heat, so a reheater is always necessary to replace the heat of evaporation. The psychrometric aspect of this method is shown in *Figure 1*.

As the main humidification load occurs in the winter for most institutional buildings the additional heat load is not very welcome. Another disadvantage with this method is the amount of maintenance required, this is mostly due to the precipitation of solids from the water as evaporation takes place. These solids can collect in the duct, on filters, or, in many cases, are discharged to the space as a fine dust. The duct condition has to be saturated as you will see from *Figure 1*, so a pool of water may be present in the duct which can be unhygienic. Evaporative pan humidifiers use an external heat source to create vapour, but again, the presence of a pool of water in the duct is far from desirable, also maintenance costs can be high, due to plating-out on the heating elements or coils.

Steam Humidifiers

The use of steam as a humidification medium has also been adopted over a long period. At one time it was not uncommon for steam to be injected into an air stream through an on-off valve and a perforated tube — not steam humidification in an engineer's sense. Modern steam humidifiers used in a very large number of hospitals in the UK offer very real advantages to the designer and to the user. As a principle the first advantage in using steam humidifiers rests in the fact that all evaporation is carried out in the most efficient vaporizer, the steam boiler. Most of the solids are removed there and mainly dry steam distributed. The task of the steam humidifier is to take the normal plant steam, clean, dry and meter the steam into the air supply, without spitting or carryover of condensate or particles of

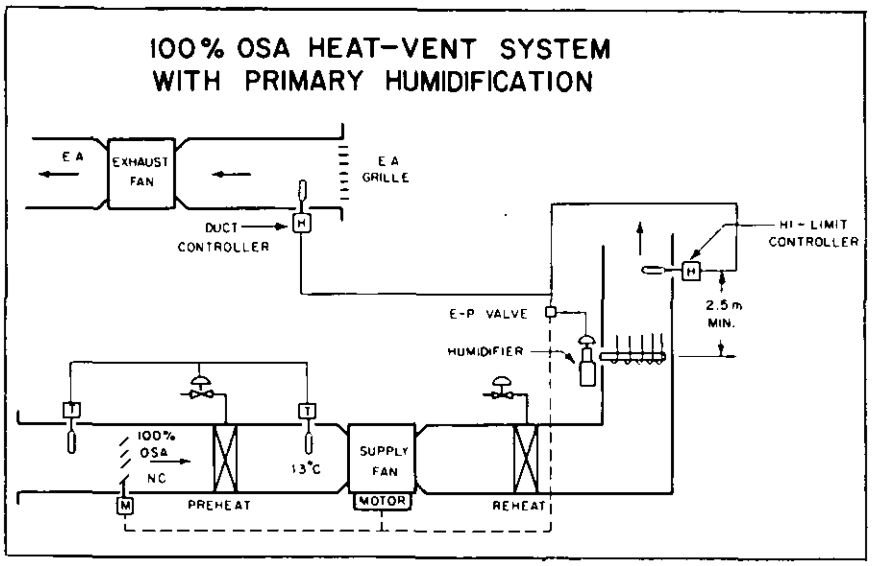


Figure 3. 100% OSA Heat-vent System with primary humidification.

This is a typical 100% outside air system with preheat and reheat coils. The preheat coil heats the air from outside design to a duct temperature controlled at say, 50 to 60°F. The reheat coil adds more sensible heat depending on the space heat requirement. Here the desirable location for the primary humidifier is downstream from the reheat coil so as to introduce moisture into the highest level of dry bulb air temperature.

Note the humidity controller location in the exhaust air duct. When a good pilot location for a humidity controller is not available in the space humidified, one placed in the exhaust air duct as close to the outlet grille as possible serves the purpose very well.

The high limit controller is optional but generally recommended.

boiler feedwater treatment additives.

Now, the use of steam humidifiers in hospitals has sometimes been challenged on the basis of the quality of the steam. Important tests have been carried out to realise the actual content of steam leaving the humidifier. An investigation carried out on Armstrong steam humidifiers at the Institute of Technology in Munich, Germany, set out to discover if dangerous concentrations of amines in room air could occur if vapour containing amines was used for humidification. The tests showed that: 'The theoretically occurring amine content in humidified room air would amount to approximately 1/100 of the MAK value (Federal Ministry Allowable Concentration), and, amine content in humidified air will practically no longer be detectable — at least it will be below the theoretical content by a tenth-power'.

Further testing carried out at the IIT Research Institute of Technology in Chicago, USA, used an Armstrong AMR-32-D humidifier to establish the following results:

Under test conditions, there was no significant carryover of water in liquid form by the humidifier. 'Significant' here would be an infinitesimally small amount by commercial standards.

The carryover of particles by steam discharged through the humidifier was very low, tests revealed the number of particles larger than 0.3 micron (about 1/200 the diameter of a human hair) ranged from 23 particles per cubic foot (PPCF) to 295 PPCF, normal atmospheric counts are well in the range of millions of PPCF.

Measurement of particle size, carried over by the humidifier, showed that well over half the particles were less than 0.6 microns in size and 83% to 94% of the particles were less than 1.5 microns. (medical authorities have stated that bacteria in air can travel on particles no smaller than 2 to 5 microns).

Half of the supply steam's content of a morpholine type volatile amine was removed by the humidifier before the steam was discharged to the subject air. The supply steam contained 10 parts per million (PPM) of morpholine, the steam discharged by the humidifier contained 5 PPM in 100% steam. When the steam added to air at the ratio of one kilogram of steam to every 133 kilograms of air, the resulting concentration of morpholine was a virtually undetectable 0.038 PPM.

Use of a properly engineered and tested steam humidifier means the addition of virtually no contaminants to the environment compared with the use of water humidifiers, and drip pans, eliminators etc are not required.

For a steam humidifier to perform satisfactorily in the foregoing tests its basic design has to meet a number of important criteria, including steam jacketing of the control valve and the distribution manifold at supply pressure, full separation of the steam ahead of the control valve, inverted bucket steam trap to drain the separator of condensate and solids. For practical use, to prevent spitting when steam is first turned on and in the event of a condensate system failure, a temperature switch must be used to automatically fail the control valve to a closed position, The total design of the unit and its accessories is vital to satisfactory performance of the humidifier.

Control

A steam humidifier should have an integral control valve with a characteristic to match the requirements of the system. *Figure 2* shows the valve characteristic of an Armstrong Control Valve, modified linear to provide good control when the valve is metering on the lower half of its capacity. These valves are specifically

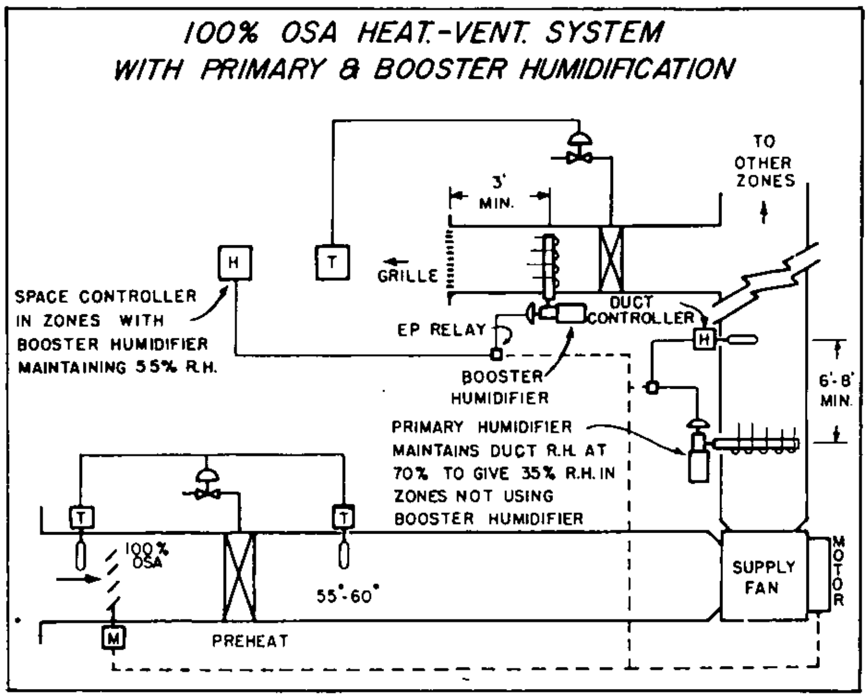


Figure 4. 100% OSA Heat-vent System with primary and booster humidification.

Here is another 100% outside air system. In this case, the air leaving the preheat coil is held at a constant dry bulb temperature in the 55 to 60°F range. This system indicates the use of two humidifiers — one as a primary humidifier and the second as a booster or secondary humidifier.

This system allows a primary humidifier to be controlled directly from a duct humidity controller at a level high enough to maintain a space condition of about 35% relative humidity at a space temperature of 75°F. The booster unit, located downstream from a reheat coil and fan, can then be sized and controlled to produce the necessary moisture to raise the space RH from 35% to some higher condition, say 55%, where and when desired. This allows individual humidity control for each zone at a higher level than otherwise possible.

This is an important combination because the use of the primary unit allows the capacity of the booster unit to be small enough so that super-saturation and visible moisture will not occur, even when the units are located as close as three feet from the discharge grille. Tests indicate that with capacities in the 8 to 10 pounds per hour range, three feet minimum distance will not produce visible vapour.

In this typical air handling system, it would not be psychrometrically possible to introduce enough humidity into the air temperature downstream from the preheat coil to give the maximum required condition in excess of 35% RH in the space. The use of both primary and booster humidifiers is the only method for controlling the relative humidity in space at any level above approximately 35%.

designed for the purpose of adding steam to air, they are parabolic plug valves which allow a longer stroke than normal industrial valves with the plug in the orifice even when the valve is 'full open'. The design provides rangeability figures from 10:1 on small sizes and up to 120:1 on some larger valves. The majority are greater than 30:1. A number of companies make and supply good quality control equipment. Where controls are electric or electronic, it is important for the humidifier valve to accept any make of actuator to enable standardisation per project. In the case of pneumatic controls, the actuator should be matched to the valve performance and have various spring ranges available for compatibility with the various systems in use.

For humidity control to be accurate, the correct controllers must be selected and properly sited, and the humidifier valve and operator must be correctly sized and be compatible with each other and the rest of the system.

A high limit humidity control should be used particularly where high duct humidity is predicted. In hospitals it can also be useful to use a separate high/low humidity sensor for visual or audible alarm purposes, particularly for burns units, geriatrics or delivery suites.

Location of Humidifiers

Correct locations are very important to the overall installation performance. Ideally, the following guidelines should be applied:

Install the humidifier at the point of highest duct temperature, steam is a vapour and a virtually gas to gas mixture will result.

The volume and temperature of the subject air must be able to absorb the applied steam with a safety margin (special care must be taken with VAV systems).

Ensure that any air temperature controls are located either upstream of the humidifier or **at least** 2-3 metres downstream of the humidifier.

Air filters should be 3-4 metres downstream of the humidifier (or upstream if possible).

Any other in duct plant item or change of direction of the duct should be **at least** one metre downstream of the humidifiers.

The humidifier should always fail closed when the fan stops.

Steam pressure should be relatively constant.

Figures 3 to 5 show some typical systems. The 100% fresh air heat and vent system is very typical and usually poses little problems. However when we come to a central air handling unit supplying several zones, the system shown in *Figure 4* is quite often not used. Usually, for reasons of economy, the primary humidifier supplies the moisture for all the zones averaging controls or with one important zone having ultimate control. Consequently the duct humidity, before the after heaters, will be high, plus considerable care must be taken to avoid duct wetting. Thought must be given to how much difference exists in each space in terms of heat gains and humidity gains external to the plant. Sometimes it is far better to use extra humidifiers.

A number of other factors have to be taken into account in some systems; large ducts, high velocity, high duct humidity, wide range of required humidities, (eg ITU application) and others. It is impossible to make a book of rules for all the variations, or to generalise in such situations, therefore advice should be sought from the specialists, or experienced supplier.

We have discussed the various reasons why steam humidifiers are recommended in today's engineering and the testing that has been carried out on certain equipment. The biggest endorsement of steam humidifiers is their use in hundreds of hospitals up and down the UK and throughout the world. The reasons for their continued and expanding use, are we think:

Moisture is added in the vapour form.
Steam is sterile and odourless (when conditioned properly).
Steam is easy to control.
Maintenance on ducts and humidifiers is very low.
Capital cost is low.
Small plant room space requirement.

For new hospitals, steam humidifiers can be specified more easily than any other types; on old schemes to be updated, they often represent the only method of replacing out-of-date equipment or of adding efficient humidity control to the system.

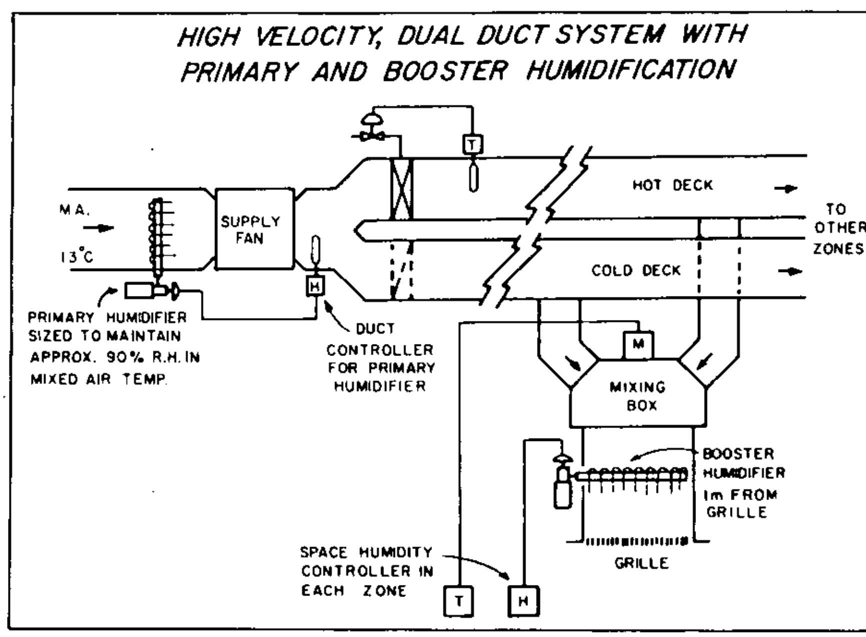


Figure 5. High Velocity, dual duct system with primary and booster humidification.

Like Figure 4, above, the primary humidifier is capable of providing 'comfort humidification' only — 30 to 35% RH. Because of space limitations, the primary humidifier, sized to maintain a duct condition of, say, 90% RH in the mixed air temperature, can be located as shown ahead of the fan. The humidifier should be located as far as possible upstream — no closer than three feet from the face of the supply fan — to ensure good air mixing and to allow the duct controller ample time to sense the condition short of saturation. The use of multiple manifolds will help provide good air mixing.

Note that the primary humidifier in this case should not be controlled from a space controller or an exhaust air duct controller, but rather from the supply duct controller as indicated. Since each zone has its own temperature-controlled mixing box, a location of the primary humidifier controller in the space or exhaust duct could not provide accurate control. Further, the distance between the humidifier and the controller could cause delayed response or override.

The paper describes the BSc level course option in Biomedical Electronics at the Lanchester Polytechnic in Coventry and discusses the requirements it was designed to fulfil. It was first published in the Journal of Medical Engineering and Technology *in January 1979.*

A BSc Level Option in Biomedical Electronics

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Introduction

It is a truism nowadays to talk about the spread of electronics into virtually every area of human endeavour. Readers of any Medical Engineering Journal will be particularly aware that the fields of medical diagnosis and therapy are no exception from this trend.

It is well known how the wide use of x-rays for medical diagnosis led to the employment of physicists in hospitals in the early part of this century. As more and more advanced techniques based on physical phenomena were introduced the work load of physicists increased and Departments of Medical Physics were established. It was therefore a quite natural development for many of these departments to accept responsibility for the new electronic equipment as this was introduced. The rapid development of electronics resulted in the increasing sophistication of equipment in existing applications as well as the invention of entirely new ones. Consequently, a new area of specialisation evolved called Medical Electronics, and to reflect the growth of this and other areas, many of the old Departments of Medical Physics now include the word 'Bio Engineering' in their new title.

The expansion in the use of electronic equipment of course necessitates an expansion in its supply. Increasing numbers of specialist engineers who are employed mainly for the purposes of Research, Development and Liaison, are also required by the manufacturers of medical electronic equipment.

Bio-engineering includes much more than just electronic engineering, but numerically this is its most important component. The precise definition of a Bio Engineer, Bio Medical Engineer and Clinical Engineer has been the subject of debate for some years[1, 2]. Words apart, there is little doubt, however, that someone working in the field of bio-medical electronics has to be a good electronic engineer first and foremost, and not someone with an insufficient knowledge of two or more subjects who is unable to do useful work in any one. An understanding of the basic processes of biology and physiology and of the elements of anatomy is also important. An appreciation of the language, methodology and thought processes of doctors and biologists is a similarly important aid in the establishment of the good communications between the two groups, which is so necessary for their successful co-operation[2].

Courses for Bio-Engineers

The traditional route to biomedical engineering throughout the world was via a conventional first degree course in the relevant branch of engineering or physics. The necessary knowledge of the life sciences and other inter-disciplinary subjects would then be 'acquired' informally in the first few years of employment or research studentship.

Courses in the United Kingdom

In the UK there are a number of first degree courses in Physics and some in Mechanical Engineering where a bio-physics, a medical physics or an engineering option is offered[3, 4]. These are usually single final year options of between twenty and thirty lectures duration. No introductory education in the life sciences is offered in these courses, so they cannot be considered as 'self-contained' for work in the medical physics-bio-engineering field.

Alternatively, the necessary knowledge could be obtained by formal postgraduate education. A number of full time or part time MSc programmes are offered[3, 4]. A considerable portion of the material in such programmes is essentially undergraduate work which may be life science for engineers or engineering for the life scientists. Part time attendance is limited to those living within reasonable travelling distance of the few centres where these courses operate. Full time students face the prospect of entering the rather restricted postgraduate employment market. Both groups tend to become research oriented and may expect to be rewarded for their additional qualifications and expertise.

There are, however, many tasks both in the medical electronics industry and in the Health Service that require specialist bio-medical engineering knowledge, but not necessarily of a postgraduate nature.

One often stated requirement of applicants is a thorough appreciation of the realities of biomedical engineering. This section of the employment market appeared to be somewhat neglected in Britain in the earlier part of this decade, with only one full time course being offered at Salford University which started in 1972. This paper describes a biomedical electronics option of the BSc sandwich course in Electrical and Electronic Engineering at the Lanchester Polytechnic which started in 1977. This course was designed to educate students who would be well qualified by their academic education and practical training to compete in this sector of the employment market on graduation. The holders of Honours degrees would also be well qualified to enter truly postgraduate programmes if they so wished. At the time of writing, there is, therefore, one full time and one sandwich course in the UK teaching Biomedical Electronics at first degree level. In view of the importance of practical experience in biomedical electronics as discussed in a later section, the author may be forgiven for his preference of the sandwich structure. Before a detailed description of this course it is instructive to examine briefly the state of biomedical engineering education on the Continent and in the USA.

Courses Abroad

The education of biomedical engineers on the Continent was discussed in two recent papers[5, 6]. Direct comparison with education in the UK is rather difficult because of the differences in the educational system, but a number of courses do exist abroad in the field of biomedical electronics which are comparable to those in the UK. Continental graduates face many of the problems so well known to their UK colleagues. Although the Continental education system differs from that in the UK, the system of health care is similar. The opposite applies in the United States, where the system of higher education is comparable to that in the UK, but health care is provided on a very different basis. Many BSc courses have been developed in biomedical engineering in the USA. Specific degrees in biomedical engineering were awarded by 25 universities in 1975. There were 49 others with biomedical engineering programmes giving first degrees in electrical engineering. Hospital internship was a required component of only five courses out of the 187 BSc courses listed as having a biomedical element. It is interesting to note that many students take a BSc course in bioengineering as their undergraduate requirement for entry into Medical School and these students constitute the majority on some courses. There are also a large number of MSc and PhD programmes. It is recognised now that the rapid development of such a large number of courses was far too optimistic. The demand from the employment market did not expand to absorb the supply of graduates. This resulted in a re-examination of many of these programmes. Many were criticised for not giving their graduates an undiluted expertise in engineering, and thus giving rise to some justified resistance on the part of industry to the employment of these graduates. The decentralised nature of the health care delivery system makes it difficult to establish a satisfactory career structure for engineers and physicists in this sector and there are fears that engineers will be prevented by the powerful doctors from attaining positions of substantive authority and responsibility.

The Course at the Lanchester Polytechnic

The Lanchester Polytechnic runs well established and successful sandwich degree courses in electrical and electronic engineering and in biology. These courses, together with the research and other educational activities, resulted in close links with industry and the Health Service and provided the springboard for the development of the biomedical electronics course option.

As a result of discussions with scientists and engineers working both in industry and in the Health Service and the considerations outlined already, the following set of requirements were drawn up for the design of a biomedical electronics course option.

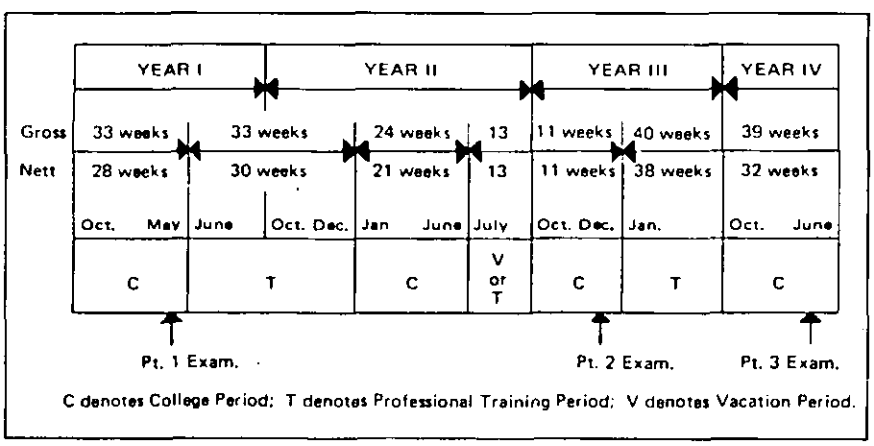
1. It should provide a full education in the relevant aspects of (a) electronic engineering and (b) of the principles of its applications in the fields of medicine and biology.
2. It should provide an introductory education in biology, anatomy and physiology.
3. It should enable students to gain first hand practical experience of biomedical electronics both in industry and the NHS.
4. The course should be structured to allow students to leave the specialist option at any stage and continue their education towards a conventional BSc in electrical and electronic engineering. This ensures that no penalty is incurred as a result of the early specialisation and when students complete the course they will be able to seek employment on the basis of a well informed decision founded on practical experience.

It was decided that the biomedical electronics course should not stand entirely on its own, but it should be a fully integrated option within the existing electrical and electronic engineering course. The sharing of as much of the teaching as possible has a number of benefits. It helps to emphasise to the students and to employers our commitment to the maintenance of the standard of the engineering content of the course. It promotes the exchange of ideas between the two groups of students and highlights the common foundations of electrical and electronic engineering regardless of the area of eventual application. This arrangement also minimises the difficulty of implementing the transfer of students from one group to the other. Lastly this is the most economical scheme for the estimated number of between ten and twenty biomedical electronics students in each year of intake. The biomedical electronics option, called B stream or group, was thus designed to fit within the framework of the already existing electrical and electronic engineering course, called A stream.

The Course Structure

The common structure of the A and B stream courses is best explained by reference to *Figure 1*. This shows that

Figure 1. The course structure showing the arrangement of the academic and training periods.



two periods of practical training (totalling 68 weeks) are sandwiched between three 3-term academic periods at the Polytechnic (totalling 92 weeks). The whole course can be completed in four academic years. This structure enables the student to spend two conventional (September–June) academic years at the Polytechnic. The academic and training periods are made long enough for the development of a coherent programme, arranged and supervised jointly by the Polytechnic and the training company or hospital, in each. The students are thus able to correlate their knowledge of theory and practice. The only disadvantage of the above scheme is the 13-week summer break mid-way through the second academic period. This price is considered to be well worth paying to obtain the many benefits resulting from this particular structure.

The Academic Periods

The first academic year is used to lay the foundations of the whole course and to bring the students who entered with different backgrounds and experience up to a common level in each subject by the end of the year. The results of the examinations at the end of the first year are used to advise students whether to follow the more analytical Honours Degree course or the more descriptive and less analytical Degree course.

Each technical subject area is treated at both the Honours and Degree levels in the second and third years of the course. *Figure 2* shows the Honours level subjects offered in each of the three years of the course, together with a brief summary of the syllabus content. Each of the subjects listed is allocated approximately 90 hours of class contact per year for lectures, tutorials and seminars. A further forty three-hour long periods are available in each academic year for supervised practical work in the various laboratories. In the final year these practicals are additional to the project carried out by each student. Students must take all of the subjects in their group in the first two years of the course. In the third and final academic year they can select the ones most appropriate to their particular area of interest. Each Honours student is required to take five of the subjects offered, one of which must be Mathematics.

It can be seen from *Figure 2* that students taking the biomedical electronics (group B) course study mathematics, electronics, circuits and systems together with those students who take the mainstream electrical and electronic engineering course (group A). Group B students also take a life science subject in each of the three periods as well as a specialist instrumentation subject in the second and third years.

The designer of any course is faced with numerous excellent arguments for the inclusion of many topics in the course. There is, however, only one argument for excluding topics. This is the one created by the necessarily finite amount of time available in any programme. Thus, many painful decisions have to be taken during the process of course design about the relative importance of topics for the purposes of the particular course in question. For example, the exclusion of engineering drawing from the first year group B syllabus was one of these difficult decisions. It is hoped that some experience of this subject can be obtained during the first training period.

The three life science subjects provide an introductory education in this field throughout the course. A-level standard knowledge of these subjects is not assumed as a prerequisite for taking the course which is structured to provide a fundamental knowledge (*Figure 2*).

The second year Group B specialist subject, biomedical equipment technology, includes under this title a number of distinct themes. One of these themes is an introduction to instrumentation systems and components with special reference to physiological measurement. The constituent parts of a general instrumentation system (transducers, signal conditioners, recorders and displays) are outlined and then discussed in detail. Another theme covers the topic of imaging. The principles of image construction are described together with the factors that limit resolution. This is introduced by emphasising the principles common to all imaging systems. The process of image formation is discussed together with the limits placed on resolution by diffraction and other effects. The description of particular imaging systems used in medical diagnosis is based on these common fundamentals, pointing out the influence of practical considerations, such as the state of the art of source, sensor, processor and display technology. Electrical, microbiological and other safety considerations are dealt with in a further section. The relevant user-orientated aspects of electrical power supply are also discussed as one of the themes of this subject, since B group students do not take the designer-orientated second year power engineering subject.

The final year specialist subject, physiological measurement, is concerned with the measurement of bioelectric potentials, body fluid pressure, flow, volume and composition and sensory measurements. The techniques for carrying out these measurements are explained and the knowledge of system components gained in the second year biomedical equipment technology subject is used to describe the instruments employed and their characteristic specifications. Techniques using ultrasonic and ionising radiations are also included emphasising the instrumentation aspects. It is envisaged that the typical B group student will take the following subjects in the final year: mathematics, physiological measurement, environmental physiology, electronics and one other from those listed in Table 2. The choice of the extra subject enables the student to orient his studies either towards computer systems or control systems, including systems analysis, or the communication of signals and their analysis. All the students carry out an individual project in the third year. This work is presented as a series of project talks and a formal bound report. The project marks carry a considerable weight in the final degree assessment.

Transfer from group A to group B is possible only at the end of the first year. The student is required to study the life science subject according to a directed programme during the first practical training period and to show the prerequisite ability to study Systemic Anatomy and Physiology at the start of the second year. Transfer from group B to group A is possible at the end of the first and second years. The former requires a directed study of mechanical engineering similar to the above. The latter is by the appropriate choice of five final year subjects out of six available to both groups. Since the B option was designed with the guidelines governing the criteria for acceptability by the Professional Institutions in mind[8, 9], the transfer between groups is not affected by this consideration.

The Practical Training

The aims of the practical training periods can be divided into two broad groups. The student is expected to acquire firstly technical knowledge and skill, and secondly information regarding the administrative, social and career structure and methods of working of industry and/or the Health Service. Although the training programmes tend to be written in terms of the technical content, both aspects are equally impor-

	First Period	Second Period	Third Period
Subjects for Group A and B	**Electronics** Device physics, device models, circuit models and calculations, switching circuits	**Electronics** Small signal models and circuit applications, feedback, analogue and digital circuits	**Electronics** Devices and models, analogue and digital circuits and their analysis, fabrication and packaging methods, electronics in instrumentation
	Mathematics Determinants, vector algebra, complex numbers, hyperbolic functions, co-ordinate geometry, differentiation, integration, differential equations	**Mathematics** Matrices, surface and volume integrals, vector analysis, partial differential equations, Fourier series, Laplace transforms, complex variables, computer methods	**Mathematics** Complex variables, Laplace and Fourier transforms, differential equations, statistics
	Electrical Circuits Component models, resistive circuits, time response, sinusoidal response	**Circuit Analysis** Reactance one port networks, two port networks and their parameters, introduction to computer aided circuit analysis, modulation, transmission lines	**Computer Aided Circuit Design** Component and device models, linear and non-linear circuits, sensitivity analysis, optimisation, layout design
	Electromagnetism Electrostatics, steady currents, magnetostatics, E-M induction, Maxwell's equations		**Telecommunications and Signal Processing** Signals, signal analysis, noise, information theory, coding analogue and digital modulation, typical systems
		Linear Systems Introduction to systems and signals, system models, response and analysis. Engineering systems Group A only Biological systems Group B only	**Control Systems** System representation and identification, sampled data, adaptive and optional control, system design
	Physical Science Waves, acoustics, kinetic theory, thermodynamics, magnetism Materials science Group A only Atomic and Nuclear physics, ionising radiations, safety Group B only		**Computer Systems** History and development, principles of operation, configurations, software, considerations, analogue and hybrid computers
Subjects for Group B only	**Life Science** Biomolecular science, basic anatomy and physiology, genetics	**Systemic Anatomy and Physiology** Bioelectrical phenomena and physiological control, body fluids and their circulation, respiration, digestion	**Environmental Physiology** Physiological effects of external temperature, fluid pressure and gravity resisted forces, biomechanics, the work environment
		Biomedical Equipment Technology Instrumentation systems, transducers, signals, signal conditioning displays, imaging, diffraction, image formation, holography, system examples Electrical power systems, supply components, networks. Safety	**Physiological Measurement** Measurement of bioelectric potentials, fluid pressure, flow and volume body fluid composition, sensory measurements, radiation techniques
Subjects for Group A only		**Electromagnetic Theory** Vector analysis, general solution of Maxwell's equations, time dependent fields, circuit laws and component models, transmission lines, fields and moving systems	**Electromagnetic Waves** Guided waves, distributed circuits, radiation, propagation, reception transmission
	Mechanical Science Statics, kinematics, kinetics, vibrations, strength of materials, fluid mechanics	**Power Engineering** Applied mechanics, heat engines, properties of materials, circuit theory, transformers, electrical machines, supply systems	**Electrical Power Supply** System requirements, components, operation, stability protection system examples
	Engineering Drawing Perspective, isometric, first and third angle projections, standards		**Electrical Machines** Design, thermal effects, generalised theory, static converters, applications

Figure 2. Honours level subjects studied during college periods, together with a brief summary of their content.
Group A. Existing electrical and electronic engineering course.
Group B. Biomedical electronics course.

tant for the student in making subsequent career decisions.

The decision whether to enter industry or the Health Service, and which one of the areas of activity of these organisations to choose can be made on the basis of some seventy weeks' first hand experience. Some students may decide that even though they completed the B option of the course, they would prefer to work in a different branch of the electronics industry (for which they are qualified without necessarily having to undertake further academic work), or indeed to make a complete change of career. This decision, too, is based on experience and it can be made at a time when such a change is relatively easy to accomplish.

The training element of the sandwich course, therefore, enables the student to acquire technical skills and to see the practical applications and implications of his academic studies and also to make an informed choice of career on graduation. The training organisation also benefits by having the opportunity to employ someone who may be known personally and who can do useful work with relatively little extra training and someone who is unlikely to have based the decision about his career on a misapprehension. The subject of biomedical engineering is particularly prone to the generation of mistaken impressions and one often hears employers say "we want people who really understand what this subject is all about in all of its aspects".

It is not possible to prescribe a set course of training to be followed by all students, since their needs, abilities and the circumstances of their training vary considerably. It is, however, possible to outline the elements that make up a successful training programme[7]. Ideally all students should get experience of both industry and the Health Service. College based students can do this by seeking employment in industry for one of their training periods and in the Health Service for the other. Sponsored students can be seconded from their sponsoring organisation to spend some time 'on the other side of the fence'. Manufacturers of medical electronic equipment usually have close research and development ties with some hospital departments which are useful for the establishment of such secondments.

The first period of training is suitable for the development of the practical skills relevant to the work of an electronic engineer and for providing an opportunity for the student to gain experience of the many different functions and departments of the training organisation, and thus to develop a more general appreciation of the way these parts inter-relate to form the whole of a company or a hospital. The technical competence of students is not generally sufficient at this stage for the satisfactory completion of development projects.

The second period of training is when students are able to undertake sometimes quite extended development projects. At best, such a project should be a wide-ranging one enabling the student to gain correspondingly wide-ranging experience. As an example this sort of project may involve the investigation of a particular feature of a range of equipment and the development of apparatus for its checking and calibration. Such a feature may be the power supply or the input amplifier which require periodic safety checks. Another project may involve the investigation of the compatibility and interfacing of a group of instruments that are to be used together in a novel way.

The process for the arrangement of practical training usually starts soon after the prospective student is interviewed at the polytechnic. This interview enables the staff to discuss with the student the many aspects of the course and of the practical training. One can assemble a picture based upon these discussions and information from the students's application form about his/her interests, personality, geographical and other preferences and constraints. The student is then introduced to a company, or to a particular hospital or Health Authority which is known to be interested in providing training for students taking the biomedical electronics option and the work of which is known to be of suitable depth and breadth for the satisfactory completion of the training. This introduction is normally followed by an interview by the training organisation. Some of the more enterprising students apply for training places themselves to companies or hospitals not familiar with this particular course and the training arrangements. In these cases a member of the Polytechnic staff visits the prospective training organisation to discuss these matters and to assess its suitability. If these discussions are successful, a scheme of training is drawn up in due course. It is Polytechnic policy to have agreed training placements for all but a very few students before the start of the first academic period.

Liaison between the training organisation and the Polytechnic is maintained by regular visits by the Polytechnic tutor and students are visited by their tutor approximately three times in each period of training. The prime purpose of these visits is to assess the student's progress and to discuss this progress and possible changes in the programme with the training supervisor. The visits also emphasise to the student the link between the academic and training elements of the course and the continued interest of the tutor in the student's progress.

A record of the training undertaken is kept for each student for the purposes of approval by the CNAA, although no formal grading procedure is applied.

Summary

1. The application of electronic instruments in medical-diagnosis and therapy is well established.
2. There is a demand for electronic engineers both in industry and in the Health Service at all ranges of educational attainment.
3. It is possible to identify a set of objectives for a first degree course in Biomedical Electronics. An important element of this course should be the provision of practical experience in industry and in hospitals.
4. Such courses are available both in Europe and in the United States. Although the postgraduate course provision was satisfactory in the UK in the early 'seventies, only one full time undergraduate course was in operation.
5. A sandwich course can be designed in Biomedical Electronics as a major option of an existing BSc course in Electrical and Electronic Engineering. Provision can be made for entering and leaving the option. The option can be arranged to follow the guidelines laid down by the IEE for exemption from its educational requirements.
6. The option described started at the Lanchester Polytechnic in Coventry in September 1977.

Acknowledgements

This course development is the result of the co-operative effort of very many of the staff of the Polytechnic. The author wishes to express his gratitude to all these colleagues, far too many to mention individually here, and to the many people in industry and the Health Service without whose help, ideas, encouragement and enthusiasm the development of this option could not possibly have taken place.

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The author holds a commission to lecture within the National Health Service on 'Planned Maintenance in Drainage and Sanitation'.

Planned Preventive Maintenance

Drainage and Sanitation for Hospitals and other Buildings

ROLF PAYNE HNDip TEng(CEI) LIOB FIOP FIHospE

Introduction

Drainage and sanitation is the one fundamental service required to sustain our way of life. We take it for granted, but in many parts of the world it is either non-existent or, at best, crude and defective.

The lack of proper sanitation — or a system which fails to function correctly — can quickly lead to outbreaks of infection which will re-occur.

Because most systems of sanitation rely upon gravity as the motive force they should function indefinitely once installed correctly, providing they do not suffer from misuse or environmental change.

In a perfect world, therefore, maintenance would be unnecessary and there are many systems that have been installed for decades that do come into this category. However, experience suggests that in the majority of cases maintenance is required even if only to counteract the effect of time and weather.

Very rarely are the designs of various systems perfect; it is usually a compromise, as sanitation systems are only part of a number of building elements and cannot dictate special requirements to the other members of the design team.[1]

Because sanitation is a gravity service taking mixed waste, it is liable to suffer from blockage occurring within the appliances and/or pipework systems. Within hospitals the provision of adequate sanitation is crucial to medical care, as well as for the back-up services such as pathology, pharmacy, X-ray, etc.

Faulty surface water pipework systems may not have an immediate and dramatic effect upon the health of the occupants, but can affect the fabric or structure of the building. If unattended repairs can prove very costly, and the building may even become unfit for habitation.

A leaking gutter may allow water to penetrate via the facia or eaves into the roof timbers, ceiling and wall finishes, causing extensive damage and even collapse of the ceiling. See *Figure 1*

Figure 1.

Sanitary Failure

A failure of the sanitary services within any building is always an emergency. It is very difficult to isolate quickly sanitary appliances connected to the blocked system. Spillage of effluent will usually occur together with the possible release of pathogenic bacteria into the environment, either directly as a result of the spillage or during the ensuing maintenance operation.

Those parts of the building away from the point of blockage may not be immediately affected, but, as the captive effluent backs up the pipework, it will reach appliances on the same level causing further spillage and cleaning problems.

Blockages are caused by a number of associated factors:

Poor design and installation.
Unsuitable pipework material.
Misuse of appliances.
Inappropriate or non-existent maintenance.

In this paper I concentrate on the maintenance of sanitary and surface water systems but by the nature of the problem the above factors must also be part of the overall planned maintenance study.

During the design stage of any project, it is essential to consider the life of the system and ensure adequate maintenance facilities. Manholes, cleaning eyes and rodding points should be built into the scheme in positions where they are easily accessible, and can be used successfully without disrupting the function of the building and creating a health risk during their use.

If the basic rules of good design are followed in the British Standard Codes of Practice CP301[2] and BS5572(1978)[3] many of the points that are known to cause maintenance problems will be eliminated. In hospitals, design information is limited, but the Building Research Station produced a useful Digest in 1967[4] and Marley Extrusions published a Technical Paper on the subject in 1977.[5]

It is particularly important that the correct pipework material is used to suit the effluents likely to be discharged, ie high temperature or corrosive. The pipes should be smooth bore with well radiused fittings and with jointing systems that do not cause protusions into the bore of the pipe.

Corrosion in 100mm cast iron

Figure 2.

The misuse of sanitary appliances can take place in the home, but as the user is directly affected it usually occurs infrequently. It is, however, prevalent in hospitals where all appliances, and particularly WCs are considered ideal disposal points for anything from scrubbing brushes to towel holders.

It is difficult to educate all concerned in the correct use of appliances and the effects of misuse. All initiation courses for new staff should include a talk by the maintenance supervisor on these problems and the risk to health misuse can cause.

In psychiatric hospitals the problem is accentuated and the watchful attitude of the nursing staff should include looking for signs of flooding caused by misuse of sanitary appliances.

In one particular case where blockages occurred at regular intervals due to the disposal of large numbers of paper hand towels in the WCs, the problem disappeared when hot-air hand driers were installed in place of the towels.

Planned Maintenance

The planned maintenance of drainage and sanitation pipework systems is required to prevent, where possible, any failure and to deal rapidly with those failures that do occur.

A failure occurs when the pipework systems will not remove quickly, quietly and without causing a nuisance waste matter deposited within the appliances. It also includes the problem of roof water penetrating the building.

To successfully carry out these tasks the following must be available:

Adequate up-to-date as installed record drawings and specifications of the various systems, catalogued and stored in such a way that the management and maintenance staff can quickly and easily identify the work involved.

An organisation and management control system with adequate funds, suitable to carry out effectively the work required.

A meaningful maintenance programme tailored to the estate and capable of being carried out in accordance with set procedures.

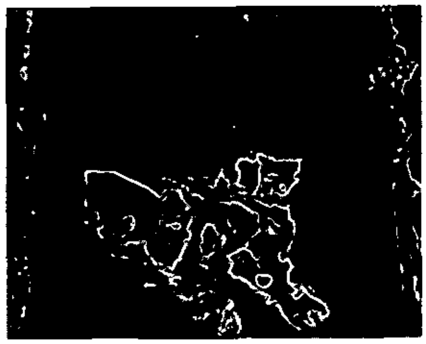
Sufficient trained staff with the correct stores and equipment to undertake the work in accordance with the programme and also the capacity to deal with emergency calls.

Remedial Work

It is preferable where possible to eliminate points of constant repetitive maintenance rather than clean up as and when required. During the survey necessary to assess the work load and create a planned maintenance scheme.

Certain defective points in the existing systems will be discovered from records, observations and staff discussions. Where possible they should be reinstated correctly, as in the long term the cost will be less than continuous planned maintenance.

Figure 3. Defective manhole blocked with towels.[6]



By carrying out such remedial works, a sanitary system can be created in which emergency maintenance will be reduced to a minimum, and the controlled planned maintenance programme can be methodically undertaken without the disruption caused by emergency calls.

To be able to undertake remedial works, the management must firstly be able to identify those sections of the systems where repetitive maintenance is being carried out. To diagnose the cause of the trouble and decide upon the appropriate remedial action.[7]

Infill Buildings

Additions to existing buildings, the erection of so-called temporary buildings and infill buildings in courtyards can create problems regarding the planned maintenance of existing services. The erection of a glazed, covered way can either prevent or make extremely costly the maintenance of the gutters and windows above it.

Most courtyards have existing drainage, as it is a convenient place to construct manholes and collect drainage from adjacent buildings. Too often when a new building is then erected little regard is taken of the existing services. This is particularly true when the new building is only 'temporary' as it may be placed directly over existing access covers. When this type of building work is being planned, it is essential that an accurate survey is made of those services likely to be affected and such access points that may become unuseable should be resited.

New Works

The maintenance of new works commences on the drawing board and should be minimal if the correct materials, fittings and gradients are used, so that there is enough documented information to assist and guide the

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cautious and well-informed designer of the public health services to carry out his task within the design team.[2, 3, 5]

The basic rules of good design for maintenance purposes are:

The use of smooth bore pipework material to suit the effluent type.

Fittings that are also smooth internally, well radiused and junctions that are oblique to the direction of flow.

The absolute minimum of bends and offsets.

Runs as short as possible and maximum flows.

Gradients to suit the discharge rate of the appliances — not the convenience of the service space.

Adequate access, both into and to the pipe networks; perferably above appliance flood level.

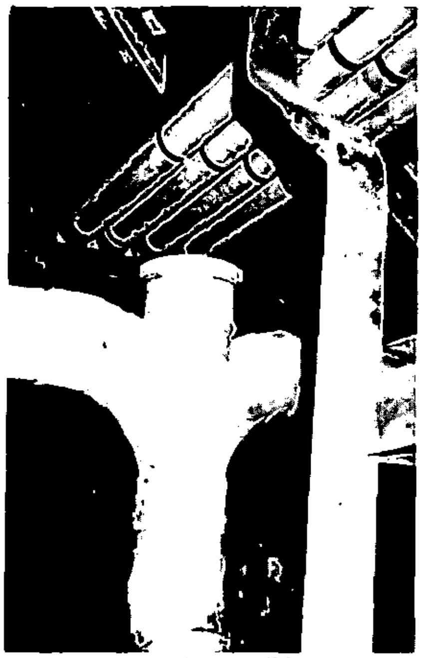

Figure 4. Access inaccessible.

There are some appliances, equipment and user processes that are known to cause maintenance problems. Kitchen drainage is possibly top of the list, as the waste is colloidal, of high solid content and often without the velocity to be self-cleansing. However during a recent survey of a number of kitchens, it was noted that a considerable proportion of blockages of the drainage system could have been prevented by better and stricter kitchen management.

In hospitals the use of bedpan macerators is recognised as an aid to good nursing, but the system is constantly failing due to the waste drain becoming blocked. Tests have proved that the equipment and systems can operate successfully if the basic rules of good design are followed and the staff do not misuse the equipment.

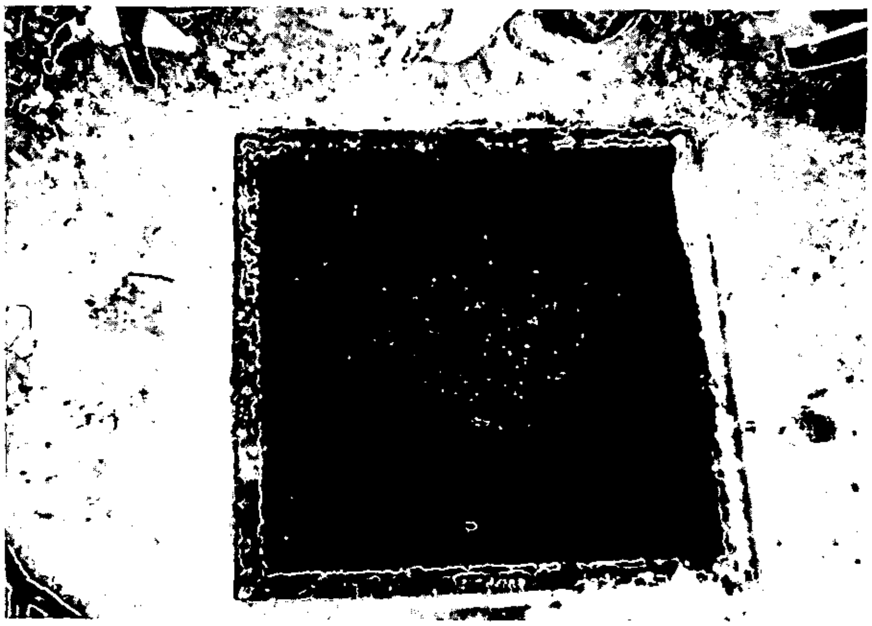

Figure 5. Old manhole blocked with waste from bedpan macerator.

During the planning of a new building complex, it is important to try to rationalise pipework materials and fittings, so that replacements or modifications can be carried out easily and quickly using standard items.

This is particularly important in laboratory design, where it is often necessary to rearrange the benching layouts.

Existing Estates

A considerable proportion of our existing building stocks have sanitary systems designed in accordance with rules formulated in the 19th century and are totally inadequate to carry 20th century effluents — particularly from such complex buildings as hospitals. These systems are often in a poor state of repair, especially the external underground systems, and planned maintenance coupled with remedial work is essential.

Roof drainage should not be neglected. As they are exposed to the weather, a continuous slow decline in standard can ultimately lead to a requirement for complete replacement of the gutters and down pipes. This can be very expensive and usually requires scaffolding for the work to be successfully undertaken. If left unattended, the break in the system will let water enter the fabric and structure of the building, necessitating additional expensive remedial work and possibly heating of the building to dry out the moisture.

The internal discharge pipework systems may be in cast iron with lead run joints, or external to the face of the building and consequently subjected to the affects of the environment.

Figure 6. Efflorescence and damp due to leaking down pipe.

The external systems will show the same signs of general decline as the rain water systems, but here maintenance is of greater importance as a break in the system will result in the release of effluent on to the face of the building. Remedial work will require that the stack is taken out of use during repair, with consequent disruption to the building's function.

If the internal system is trouble free, it will only require a general inspection at infrequent regular intervals to identify those areas that are showing signs of general decline.

Planned Maintenance

Planned maintenance is always necessary with all sanitary systems if the management of any organisation is to ensure the smooth and uninterrupted working of the building, to comply with the Public Health Act 1936, and the Safety, Health and Welfare Act 1974.

It may mean a general inspection every five years, or an elaborate programme, based upon a four week time interval extended to suit the individual requirements of each item of equipment and part of the system.

A programme that is devised for any building must be individual to the building and flexible in time and content. It is pointless and expensive to maintain at regular monthly intervals when only yearly inspection is necessary.

The programme devised should, therefore, include a monitoring and recording procedure, so that the frequency can be adjusted. The programme must be capable of dealing with emergency calls.

Conclusions

In this paper it has not been possible to deal adequately or thoroughly with all the aspects of planned maintenance for sanitary systems for all types of buildings. Every large building complex must have some form of planned maintenance programme, as the cost, health and safety implications of neglect could have serious implications on the smooth running of any establishment.

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Product News

Design Notes for the Middle East

The Chartered Institution of Building Services has published 'Technical Memorandum No. 4 — Design Notes for the Middle East' prepared for the Institution by a task group under the chairmanship of Mr J. P. G. Goldfinger.

The rapid development of the countries of the Middle East has involved Building Services Engineers from all over the world in the application of their specialist knowledge to an area with extreme climatic conditions, changing social patterns and technological expertise.

A great deal of experience has been gained, particularly in the last ten years. These CIBS Design Notes seek to provide designers of engineering services with all the basic information required to engineer building services to satisfactory standards in the Middle East. It seeks to direct the designer to the appropriate section of the CIBS Guide and other equivalent Guides and sources of information.

Technical Memorandum No. 4 is available from the CIBS Publications Department, 49 Cadogan Square, London SW1X 0JB. Tel: 01-235 7671 — price £10, including postage and handling. CIBS Members can obtain one copy at the special members' price of £7.

Three-Wheeled Fork Truck Range

Now available in the UK is a new range of three-wheeled battery electric lift trucks in capacities of 1,000, 1,200 and 1,500 kg. The trucks, manufactured by Allis Chalmers and marketed by ACR Lift Truck Ltd, are designed for simplicity of maintenance and ease of operation.

For further information please contact: Mrs V. Cockerell, ACR Lift Truck Ltd, Chalmers Way, North Feltham Trading Estate, Feltham, Middlesex. Tel: 01-751 0222.

Multistage Pumps

Europe's largest manufacturer of shell boilers, NEI Thompson Cochran Limited, has a contract with Grundfos Pumps Limited for the supply of boiler feed pumps.

The pumps are from Grundfos' CP and CR ranges. The multistage pumps are engineered specifically to meet the demanding operating conditions of today's sophisticated automatic steam raising plant. Grundfos make extensive use of stainless steel and diamond polished tungsten carbide for fabricated components, bearings and seal surfaces and the pumps have gained an enviable reputation for long, trouble-free life.

Grundfos also provide an excellent back-up service, and these two points played a major part in our decision to continue using Grundfos whenever possible.

For further information contact: Toby Oliver or Nick Hopewell-Smith on 01-486 8561.

Foam Insulation Development for Lofts and Roofs

Lofts and roofs can now be mechanically insulated with a foam that sets in situ. A new aminoplast foam has been specially developed for roof applications, and is now available under the name, Superoof, throughout Great Britain from John Baker (Insulation) Ltd.

Applications include occupied as well as vacant residential properties, hotels and restaurants, factories, offices, shops and showrooms, schools, hospitals and municipal premises and certain agricultural buildings, such as mushroom and chicken houses.

The product is applicable under the Government's energy conservation grants covering industry and commerce and public buildings (the latter to be applied for by local authorities), since it achieves the required calculated U-values.

Further information is available from John Baker (Insulation) Ltd, Superfoam House, High Street, Henfield, Sussex. Tel: 079-155 3561.

Consumat Incinerators

Havering Health District had been operating an incinerator for many years. It was smoking so badly, so they decided to replace it with a new unit. The new incinerator had to be reliable and be able to handle all the various types of waste on site — plastics included. The increasing use of plastics in hospitals creating many problems with conventional incinerators. The District Engineer wanted a machine that would be both safe to the operator in accordance with the Health and Safety at Work Act, and that would be smoke-free.

The Consumat covers the safety aspect with its automatic hydraulic loader. The operator is not in any way exposed to the hot fire bed of the machine. In addition, the loader takes away the need for operator judgement — he cannot overload the machine.

On the emissions side, the objective was to meet the standards of the Second Working Party on Dust and Grit Emissions. The Consumat unit meets these standards even when burning plastics — without having to fit costly wet scrubbers, cyclones, etc.

A Consumat Type C-150 loader was purchased. It was installed in a very confined space and connected up to an existing free standing stack. Commissioning engineers baked-in the refractory on site and trained the operator, and the incinerator comfortably handles 420 lb/hr of general hospital waste.

Of course, the unit can also be put out in the open. One such job was at Turner Village Hospital, Colchester. On a smaller scale they were looking for an incinerator to destroy 300 lb/hr of waste. The Consumat Model C-120 was chosen by the District Engineer for this job. In this example the incinerator was fitted with an 'air curtain'.

Robert Jenkins Systems' engineers installed the machine, it was enclosed with a simple screen as an 'aesthetically acceptable installation'. The only external access to the machine is the loading door of the air curtain loading extension.

Robert Jenkins Systems offers a complete service in evaluation of the problem, site survey, fabrication to requirements, installation inside or outside existing buildings, hook up to existing stacks, supervised bake-in of refractory on site, training of operators to ensure smooth hand over, after-sales back-up.

Further details from: Robert Jenkins Systems Limited, Wortley Road, Rotherham, Yorks S61 1LT. Tel: Rotherham (0709) 76701, 64201.

Naidex Exhibition — Wembley

Nicholls & Clarke will again be exhibiting at the National Aids for the Disabled Exhibition to be held at the Wembley Conference Centre, November 21-23, 1979.

On Stand 111, their main exhibit will be the 'Phlexiplan' range of kitchen furniture. This was first introduced at Naidex in September 1978 and immediately became established as a very versatile range of kitchen equipment available to the disabled client.

Full information about the entire range of sanitary and ironmongery fixtures, supplied by Nicholls & Clarke, will be available at the Stand, and specifiers are invited to apply for the new catalogue PH2 which incorporates a full range of hospital sanitaryware.

Precise Temperature Controller

This instrument is ideal for controlling the temperature of such equipment as computer enclosures, constant temperature baths (water, oil, chemical) injection moulding equipment, etc.

Model 72A which minimises RFI generation, is a zero voltage firing, non-indicating proportional temperature controller which can maintain a resistive load, carrying from 1-15 amperes, to an accuracy of within $\pm 0.1°C$ of a specified set point temperature between -90 and $+450°C$. All the active elements are solid state with virtually unlimited lives. The overall size of model 72A is only $3 \times 3\frac{1}{2} \times 1$ inches and it weighs only 6 ounces, as the auto-transformers, magnetic amplifiers and relays are replaced by a triac.

The controls consist of coarse and fine adjustments for the set point and a gain control. An alternative optional external set point with a dial adjustment, calibrated in 0-100 reference marks only, can be mounted remotely.

The instrument requires a negative temperature co-efficient thermistor type resistance sensor with an operating range of 300 to 30,000 ohms. Standard RFL sensors can handle temperatures of -90 to $+450°C$ in six overlapping ranges.

The sensor actuates a bridge circuit causing a variable gain amplifier to supply a signal to the triac firing circuit. The value of the signal is proportional to the difference between the temperature registered by the sensor and that indicated by the set point. So long as a signal persists the triac is pulsed into conduction every time the AC cycle causes the supply voltage to pass through zero. The number of integral cycles supplied to the load is therefore proportional to the signal.

For further information please contact: Mr N. Macdonald, Ancom Ltd, Devonshire Street, Cheltenham GL50 3LT. Tel: 0242 53861 or 24690.

Clip-on Toilet Bowl Fragrance

An air-proof blister pack is used to preserve the strength and fragrance of the foam active toilet bowl cleaner, Ozi-Loo. It has been specially designed for easy-fit, economical and effective use in commercial and industrial toilets. Stated to be able to clean and freshen continually for over 500 flushes, Ozi-Loo contains a new formula of blended chemicals, but no acids. The foam cleans with hydro action detergents and has a pleasant lemon fragrance to overcome all odours.

A simple and unobtrusive clip-on unit, the manufacturers claim it will last up to two months on ten flushes a day.

Priced at £12.35 per box of 20 including packaging, postage and VAT, it can be purchased direct from G. H. Wood & Co Ltd at Wealdstone Road, Kimpton Industrial Estate, Sutton, Surrey SM3 9QN. Tel: 01-641 4719.

Range of Disinfectants

Established in 1903 and one of the first companies to manufacture household aromatic disinfectants, Newlands Bros & Mumford Ltd, London, announce plans to enter the commercial and industrial markets with their wide range of proven products.

Among the Newlands products being made available to the janitorial and other commercial markets are their scouring cream and lavender, pine, antiseptic and telephone disinfectants, the latter having the approval of the Post Office Telecommunications Quality Assurance Division.

For these markets too is the company's drinking glass sterilizer, which has powerful bactericidal and detergent properties, yet is odourless, tasteless and colourless. Also, their chewing gum solvent which is a light amber liquid mobile, equally efficient for removing lipstick, pencil marks, grease, tar, etc.

Further details are available from Newlands Bros and Mumford Ltd, 324 Harrow Road, London W9 2NP. Tel: 01-286 7231.

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Essex Area Health Authority comprises more than fifty hospitals plus health centres and ambulance stations divided into five geographic districts.

Further information from Mr D. Gray, Area Works Officer, Witham 516515 ext 238.

Salary: £5,328-£6,309 pa (increase pending) plus 5% bonus for involvement in incentive bonus schemes.

Application form and job description from Area Personnel Officer, Essex Area Health Authority, Collingwood Road, Witham, telephone Witham 516515 ext 226.

Closing date: November 26, 1979.

MANCHESTER AREA HEALTH AUTHORITY (TEACHING)

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Salary: £4,497-£5,718 per annum, plus 15% supervisory allowance for the Incentive Bonus Scheme. (Salary under review). New entrants to the Health Service normally commence at the minimum of the scale.

The successful candidate will be responsible for Mechanical Building Services and duties will include:

1. Compiling of working drawings and specifications for Minor Capital Projects and certain maintenance work.
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Opportunities for secondments, to ensure that experience is gained in all aspects of Estate Management, will be given.

Applicants must hold ONC in Mechanical Engineering or equivalent qualification and have completed an apprenticeship in Mechanical Engineering/Building Services. Candidates who have not undergone an apprenticeship but who have acquired fully practical training appropriate to the post will also be considered.

Application forms and job description available from the District Personnel Department, Withington Hospital, Nell Lane, Manchester M20 8LR. Tel: 061-445-8111 Ext 2125.

Closing date: November 16, 1979.

AVON AREA HEALTH AUTHORITY (TEACHING)

FRENCHAY HEALTH DISTRICT

WORKS DEPARTMENT

Applications are invited for the following posts:

ENGINEERING OFFICER

Glenside Hospital

ENGINEERING OFFICER

Stoke Park Hospital

Candidates should hold an Ordinary National Certificate in Engineering, a higher qualification or an alternative qualification acceptable to the Secretary of State.

The post holder will be required to assist the Senior Engineer over the whole range of his duties.

Salary scale £4,497 pa-£5,073 pa (increase pending) plus bonus.

For further information of a professional nature please contact Mr G. S. Thomas, District Engineer, telephone Bristol 565656 extension 517/518.

Application forms and job descriptions available from the Personnel Officer, Frenchay Hospital, Bristol BS16 1LE, telephone Bristol 565656 extension 566.

Closing date for completed applications November 19, 1979.

HUMBERSIDE AREA HEALTH AUTHORITY

SCUNTHORPE HEALTH DISTRICT

Engineer

Goole Sector, St John's Hospital

An Engineer is required to assist the Senior Engineer in the management and maintenance of Health Service electrical and mechanical equipment and services, together with minor new works, by direct or contract labour.

Qualifications – Minimum ONC Engineering or acceptable alternative; Apprenticeship in electrical or mechanical engineering and 5 years' relevant experience. Applicants should possess a current driving licence.

Salary – £4,494-£5,073 (increase pending) plus Bonus currently 5%.

This is a readvertisement; previous applicants will automatically be considered.

Application form and job description from: District Personnel Officer, Trent House, Hebden Road, Scunthorpe, DN15 8DT. Tel: 0724-64151 ext 24.

Closing date for completed applications November 30, 1979.

HEREFORD HEALTH DISTRICT

ENGINEER

(Operations and Maintenance)

Two posts. One for the Rural/Psychiatric Sector, the other for the Central Sector.

Salary £4,497 to £5,073 pa.

Apply to Mr C. W. Sheldrake, District Works Officer, District Works Department, 24 St James Road, Hereford by November 16.

GWYNEDD HEALTH AUTHORITY

SENIOR ENGINEER

required for the new District General Hospital, Bangor (Ysbyty Gwynedd) to control the maintenance and operation of the Engineering Services within a large hospital complex.

The annual salary will be within the range of £4,938 to £5,718 (under review).

The successful candidate will be in control of a staff of Engineers and Tradesmen for which he will share responsibility with others for their selection. Duties will include both operations and maintenance work and applicants should have a broad engineering background (both mechanical and electrical) and possess the following qualifications: HNC in Mechanical or Electrical Engineering or C & G 293, 255 Part 3 or Full Technological Certificate No 57 or 281 and an appropriate management qualification. Previous training must include an apprenticeship.

Application form and job description available from: Area Personnel Officer, Area Offices, Coed Mawr, Bangor. Tel: Bangor 51551. Further information may be obtained from: Area Works Officer, Tel: Caernarfon 4667/8.

Closing date: November 23, 1979.

ENGINEERS

That managerial role you've been waiting for. It's here.

An opportunity that combines the two sides of you.

Firstly, put your Mechanical/Electrical Engineering experience to good use working alongside Pharmacists/Managers in the factory environment of the Sterile Supply Unit, based in Wolverhampton.

As Assistant Engineer you'll be responsible for the smooth running of a wide range of modern plant and equipment, including technologically advanced pharmaceutical/sterilization and engineering machinery.

Secondly, exercise your managerial qualities leading a six-strong works team.

Duties include the recruitment of suitable tradesmen and maintaining good staff relations. Also, as a member of the Unit management team you'll be expected to liaise with other senior works and management personnel on various projects and developments. You will be professionally responsible to the Area Engineer.

Applicants should have an HNC or HND in Electrical or Mechanical Engineering, together with endorsements in electro-technology or applied heat/electrical engineering and a certificate in Industrial Administration.

Salary is currently in the range £5,328–£6,309, with a substantial increase pending. On top of this, earnings are considerably boosted by a successful well-established bonus scheme.

For a full job description and application form, contact Area Personnel Officer, Wolverhampton Area Health Authority, Administrative Offices, New Cross Hospital, Wolverhampton. Tel: 737221 Ext 35.

Closing date December 1, 1979.

WOLVERHAMPTON
Area Health Authority
Nobody needs you more than us.

LANARKSHIRE HEALTH BOARD

AREA ENGINEER

Applications are invited for the post of Area Engineer to the Lanarkshire Health Board.

Candidates must be corporate Members of one of the following Institutions: The Institution of Civil Engineers, The Institution of Electrical Engineers, the Institution of Mechanical Engineers, or The Institution of Electronic and Radio Engineers.

They should have a sound knowledge of engineering installations in buildings coupled with a knowledge of and a deep interest in maintenance of services and all equipment to be found in modern hospitals and other Health Service buildings. They should possess a good working knowledge of modern engineering techniques, all relevant regulations, Codes of Practice, and the Legislation (Health and Safety at Work Act etc) affecting them.

Managerial experience is essential together with the ability to act in close co-operation with the building department and to work in harmony with other disciplines at all levels.

Salary Scale: £7,566 rising to £9,006 (increase pending).

Application Forms and Job Description can be obtained from the Area Personnel Department, 14 Beckford Street, Hamilton ML3 0TA. Telephone Hamilton 281313.

Closing date: December 3, 1979.

SENIOR ENGINEER (2 posts)

Kirkcaldy & Levenmouth/North Fife

ENGINEER (2 posts)

Stratheden & Levenmouth/North Fife

Applicants must have completed an apprenticeship in Electrical or Mechanical Engineering, have a thorough practical training as appropriate to the duties and responsibilities of the post and have 5 years relevant experience.

Qualifications: For Senior Engineer, minimum of HNC Electrical with Mechanical Endorsement or HNC Mechanical with Electrical Endorsement. For Engineers post minimum of ONC in Engineering.

Conditions of service for all posts as per PTB Handbook. Salary for Senior Engineer £4,938–£5,718 per annum and for Engineer £4,497–£5,073 per annum. Both salaries are under review and there is a current bonus payment of 10%. All posts are open to men and women.

Further information, job description and application forms available from the District Personnel Officer, East Fife District, Forth House, Abbotshall Road, Kirkcaldy. Please state the post for which you wish to apply. Closing date for completed applications November 30, 1979.

Fife Health Board

HEALTH CARE FOR A KINGDOM