HOSPITAL ENGINEERING

October 1979

International Federation Issue

The Journal of the Institute of Hospital Engineering

I.F.H.E.

Energy Conservation in the NHS

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HOSPITAL ENGINEERING

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Contents

Institute News

Eduardo Caetano

It is with pleasure that we congratulate Doctor Caetano on his appointment as Secretary General of the Portuguese Ministry of Social Affairs, which was announced recently. It is only regretted that this new task meant that Doctor Caetano could not attend the international seminar reported below, which was very much his inspiration.

First International Seminar

An idea proposed by the International Federation of Hospital Engineering came to fruition at the Hospital Engineering Centre, Falfield from August 28–September 14, 1979. For three weeks delegates from as far apart as Indonesia, Pakistan, Sweden, Nigeria, Denmark and Iraq attended the first International Seminar for Senior Engineers. The seminar, which was jointly organised by the Department of Health and Social Security and the Institute of Hospital Engineering, had the title *Focus on Appropriate Technology*. This highly successful seminar emphasised the need to determine the most appropriate solution in the planning, design and operation of health care facilities.

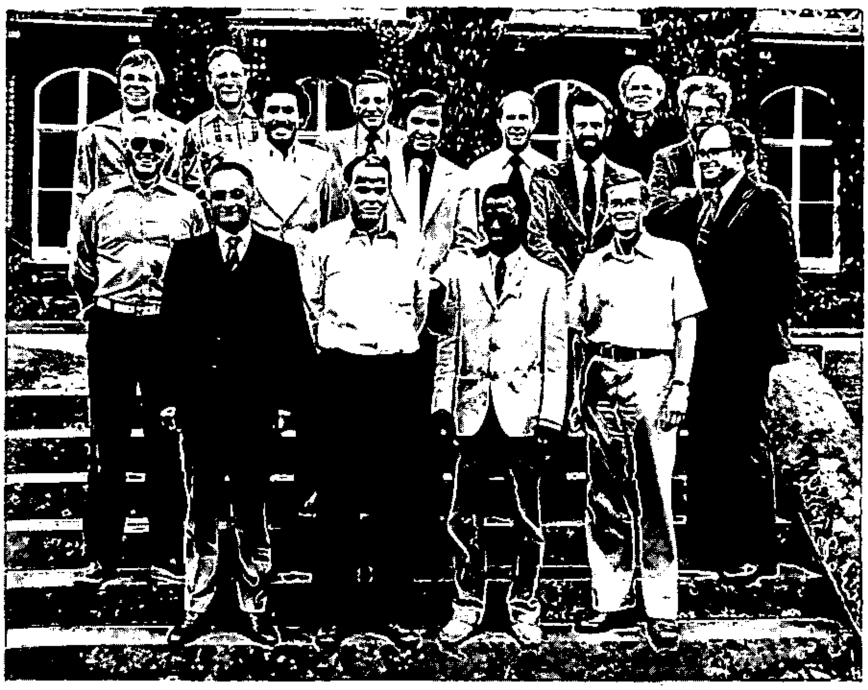
The seminar was opened by the President of the Institute, Mr Lawrence Turner. The British health service was used as an initial model. However, once the problems associated with geographical, sociological, cultural and economic factors were considered, it was readily seen that there was not one universal solution. The delegates undertook a project in separate groups which engendered a healthy spirit of competition. Each group gave a very high standard of presentation and the ensuing discussion showed a high degree of understanding and mutual co-operation between delegates from so many different and varied backgrounds. The project developed the theme of 'Appropriateness' by planning, designing and preparing operational policies for two large hospital complexes located in two different cultures and climates.

This project paralleled the subjects presented by the invited speakers by progressing from the more general issues of planning to the more precise issues of technique. The seminar commenced with a very broad view of the organisation and planning processes involved in health services. This led to five sessions on the problems of meeting the needs of real health services. Particular attention was given to the place and value of standardised design data.

Thoughts were gradually focused onto specific functions of the works staff, as part of the whole health care team. The appropriate technology approach to building and engineering, and the interaction of the two, was considered in detail. The three weeks concluded with a series of technical updating sessions which included the topics of patient-connected equipment safety, the production of sterile goods, and the development of electronics in the hospital field.

A dinner to which all the participating speakers were invited, was held on the last evening. The guest of honour was Mr Vincent Oviatt, Vice-President of the IFHE. All those involved with the seminar, especially the delegates, gained much from the mutual exchange of experiences. The success of this seminar bodes well for the second seminar in two years' time.

Above, members work on a hospital plan. Below, some members and Course Directors looking reasonably cheerful during a break.



IV National Hospital Congress in Spain

The IV National Hospital Congress in Spain will take place on November 19-23 at Barcelona and will as theme 'The Hospital of 100-300 Beds'.

The organisation of the congress will be the responsibility of the Asociacion para el Desarrollo Hospitalario del Distrito Universitario de Barcelona; the Asociación Española de Ingeniería y Arquitectura Hospitalaria; and the Asociación Española de Administradores de Hospitales. These organisations will co-operate to see that the Congress achieves maximum interest and a high scientific level.

As part of the IV Congress, the European Association of Hospital Administrators will celebrate their III Congress under the theme 'Hospital Personnel'.

At the same time 'Hospitalex-79', a photographic exhibition devoted to all aspects of the hospital world, will take place.

IV Congreso Nacional de Hospitales

Durante los días 19 al 23 de noviembre, se celebrará en Barcelona el IV Congreso Nacional de Hospitales, bajo el tema monográfico 'El Hospital de 100 a 300 camas'.

La organización del Congreso corre a cargo de la Asociación para el Desarrollo Hospitalario de Distrito Universitario de Barcelona; la Asociación Española de Ingeniería y Arquitectura Hospitalaria; y la Asociación Española de Administradores de Hospitales, las cuales colaboran para que el Congreso alcance el mayor interés y un elevado nivel científico.

Dentro del IV Congreso, la Asociación Europea de Administradores de Hospitales, celebrará su IIIer. Congreso, bajo el tema 'El Personal en los Hospitales'.

Paralelamente y durante las mismas fechas, tendrá lugar 'Hospitalex-79', feria monográfica dedicada al mundo hospitalario en todos sus aspectos.

Energy Efficiency

A special exhibition on energy efficiency is being held at the Commercial Gas Centre, 139 Tottenham Court Road, London W1 until October 31, 1979 as part of British Gas support of International Energy Conservation Month.

Displays and several case histories illustrate heat recovery methods. Energy saving techniques, together with equipment researched and developed by British Gas are also illustrated.

Even though there is sufficient natural gas to meet the demands of existing customers to the end of the century or beyond, it is obviously foolish to use energy wastefully; therefore the efficient and effective use of energy is a prime concern of British Gas. Each Gas Region has a Technical Consultancy Service (TCS) for industrial and commercial gas users which offers a first class engineering service to help ensure that gas is used effectively. Each TCS is linked to the resources of the British Gas research stations.

In addition there is the British Gas School of Fuel Management which has helped train thousands of managers from industry, commerce and local authorities to save fuel. Details of both these services are available at the exhibition.

The exhibition is open between 9.00 am and 5.00 pm Monday to Friday. The Commercial Gas Centre is situated opposite Warren Street Underground Station.

Whole City Heating — Combined Heat and Power

A Conference on this subject is being held at the Kensington Conference Centre, London W8 on Wednesday 21 and Thursday 22 November 1979. The Conference is being arranged by the Construction Industry Conference Centre Ltd and the Organising Committee includes representatives from the Department of Energy, the Chartered Institution of Building Services, the Institute of Energy, the Institution of Electrical Engineers, the Institution of Municipal Engineers and the Society of Local Government, Chief Mechanical and Electrical Engineers.

Further details are available from: Conference Secretary (WCH), Construction Industry Conference Centre Ltd, PO Box 31, Welwyn AL6 0XA. Tel: Welwyn (043 871) 6772.

Stafford District General Hospital Phase 4 — Hospital and Service Complex

The fourth phase of development of the Coton Hill site on Weston Road, Stafford is the 300 bed district general hospital, which is due to be completed in 1982.

Clearance and preparation of the site started in 1977 and a residential contract for housing medical and nursing staff has already been completed. Major remodelling of the site and planting to the perimeter has been completed and this work will be extended during the fourth phase.

Phase 4 is based on the 'Harness' design method, developed by the Department of Health and Social Security. The Stafford solution makes use of some of the standard data but modified to comply with the requirements of the West Midlands Regional Health Authority, as well as some departments specifically designed for this project.

The hospital departments have been designed to link onto a purpose designed central street which accommodates the primary circulation routes, administrative offices and engineering plant rooms. The first phase is to provide five operating theatres, accident and emergency and outpatients facilities together with approximately 140 acute beds. In addition a large maternity delivery unit, special care baby unit and maternity ward accommodation are located at second floor level.

The hospital is to be a three-storey building cladd in brickwork, the chequerboard plan being broken up with Courtyards which will provide natural light and ventilation to the ward areas. Some of the courts will be accessible for patients during convalescence.

Internally the hospital is a complex plan, a careful study is being made in the use of colour and graphics to help patients and visitors find their way around the development. The building has been designed to allow for extension and alteration as the medical need develops.

A second residential development will be starting on site in 1981 and completed to enable staff to be accommodated and trained prior to the opening of the hospital for patients in 1983.

Architects, Structural, Mechanical and Plumbing Engineers, and Quantity Surveyors are Building Design Partnership, Manchester in association with West Midlands Regional Health Authority.

North East Branch 1979 Programme

Tuesday October 9 1979

Presentation by the National President, Lawrence Turner, who is visiting to stimulate an interest in the 1980 Annual Conference and talk on his specialist subject — Static switching and silica chips. The meeting is to commence at 7 pm and will be held in the large Lecture Theatre of the Post-Graduate Teaching Centre at the Freeman Hospital, Newcastle.

Tuesday, November 13 1979
Paper presented by Mr Hinde of Gestra (UK) Limited, on the subject of Heat Recovery from Steam Boiler Blow Down. This meeting will commence at 7 pm in the Lecture Theatre of the Post-Graduate Medical Centre at the North Tees General Hospital.

Tuesday December 11 1979
'Fire Safety in Health Buildings' is the theme for the evening. This is a continuation of the highly successful paper presented last session by Mr C. Davies of the DHSS and up-dates the work currently being undertaken by Study Group No. 14. This meeting will commence at 7 pm in the Lecture Theatre of the Post-Graduate Medical Centre at the North Tees General Hospital.

Tuesday, February 12 1980
Paper presented by Mr G C Fawcett of Robert Jenkins Systems Limited who will talk to us on the subject of 'Incineration and Waste Heat Recovery'. This meeting will commence at 7 pm in the Lecture Theatre of the Post-Graduate Medical Centre at the Queen Elizabeth Hospital, Gateshead.

Obituary — John Robert Fletcher

It is with deep regret that we have to report the sudden death of one of our authors, Mr Jack Fletcher, Area Engineer for Cleveland Area Health Authority, who died in a holiday tragedy on August 30.

Jack joined the Health Service twenty years ago as engineer and clerk of works for the first of the new district general hospitals in the country, which was the new West Cumberland Hospital. He had formerly been a chief engineer with the P and O Shipping Line.

He moved to Cleveland as resident Engineer for the North Tees Hospital scheme (1,004 beds), and supervised work through all its stages between 1964 and 1974. In 1975 he was appointed Area Engineer for the Cleveland Authority.

He was a fully professional and dedicated man, committed to enhancing the roll of the engineer in the service. Jack was Chairman of the Association of Area Engineers (Northern Branch) and an active member of this Institute, being author of many articles on hospital engineering for the journal, with particular interest in training more junior engineers. He was also involved and made a very positive contribution to many national Working Parties. His expertise and experience in running the vehicle maintenance organisation, made him a major contributor to the DHSS Working Party on this subject.

Jack will be greatly missed by his many friends and colleagues throughout the service. He leaves a widow, Mary, and three sons, Kevin, Mark and Stephen, to whom we extend our deepest sympathy.

The Institute of Hospital Engineering is delighted to publish their special international issue devoted entirely to Energy Conservation.

The following papers have been assembled by the Department of Health and Social Security, whose considerable assistance is gratefully acknowledged.

The author of this foreword is Chief Engineer, Department of Health and Social Security.

Energy Conservation in the National Health Service

Foreword

T. A. NICHOLLS BSc(Eng) CEng MIEE HonFIHospE

Need for Energy Savings

The average age of the Health Service Estate is some 65 years, much greater than is generally realised. Thus to a large extent the buildings and their major engineering works reflect the attitudes and economic practices of an age of indigenous cheap fuel, when the plentiful supply of hot water and warmth was possible at costs which were barely significant to hospital accounts.

These days have gone, possibly for ever. Not only are the costs of energy and possible economies of ever increasing importance but the very availability of the energy, be it primary as gas, oil or coal, or secondary as electricity or SNG, is at risk nationally.

The following papers and case histories are not only interesting in themselves technologically but they also demonstrate very clearly that many cases exist where a radical reappraisal of installations is more than warranted in the interests of energy conservation. I hope these papers will be widely read by Works Officers and others who will realise that it is no longer good enough to maintain and review heating and hot water systems to the thermal performance standards of bygone years. It is necessary to stand back from the day to day operational activities and review perhaps by some of the methods outlined in these papers, the thermal efficiencies of the buildings and their energy consuming installations to see whether they satisfy today's criteria. The technology of heat generation and distribution is largely the province of the engineer but the elimination of waste and prodigal usage of energy is the duty of all. These papers demonstrate how significant savings can be made and will, I hope, stimulate further interest and work to save the increasingly expensive and scarce energy resources.

Mr Skegg is a Superintending Engineer with the Department of Health and Social Security

The Progress of Energy Conservation within The National Health Service since 1974

V. E. SKEGG CEng MIMechE MIMarE MCIBS MInstR

The Energy Problem

Much has been written about energy consumption and the finite nature of the world's energy resources since the initial OPEC action to raise the market price of oil was undertaken in the autumn of 1973. In recent months we have seen both a repetition of this action and also a concurrent oil shortage due to the political events in Iran. These events have provided both an increased stimulus to effect a reduction in world oil consumption and also a somewhat unwelcome backcloth to the International Energy Conservation month of October 1979 which is being sponsored by the twenty member nations of the International Energy Agency to promote international co-operation within the energy field and to boost conservation activities within each member nation. The intention of this article is to review the progress which has been made within the NHS on energy conservation since 1974 and to highlight the particular areas where significant savings can be achieved at moderate cost. It also serves as an introduction to a number of case studies which have been contributed by NHS Works Staff who have been active in various aspects of energy conservation.

Fuel Consumption of Hospitals

Firstly, it is appropriate to look at the statistics of annual fuel consumption relating to all hospitals (and associated laundries) in England and Wales which have been compiled from the annual Costing Returns (Form 19). The relevant figures are illustrated graphically at *Figure 1*. This graphical picture shows that energy consumption was on a rising trend up to 1972/3 due to a combination of new hospitals coming 'on stream' and the progressive upgrading which was then in progress in many of the older hospitals. In the crisis years of 1973/4 there was a dramatic fall in consumption followed by an upsurge in the following year when fuel became more freely available albeit at increased price levels. Subsequently up to 1977/8 — the latest year for which figures are available — there has been a slight but progressive decline.

The saving against the previous trend line is 15.9% (or 18.4% if electricity is excluded) but this assessment includes for estate growth at a constant rate which may not be applicable due to the closures and other cut-backs which the NHS has suffered during the recent years of inflation and financial restriction. The absolute saving uncorrected for any of these extraneous factors is however 6.8% (or 9.7% excluding electricity) which is still a creditable achievement.

The calculations on which the above performance levels are based treat electricity consumption as 'primary fuel', so that due allowance is made for the generation and distribution losses associated with this form of energy. In addition, all fossil fuel consumption has been expressed in terms of 'tons of oil equivalent' so that a fair and consistent basis for comparison is used.

Since 1972/3, the fuel supply situation and associated economics have resulted in a dramatic increase in gas consumption with offsetting declines in the amount of coal and oil consumed. The relevant figures are as in the table below.

	1972/3	1977/8	% Increase or decrease on 1972/3
Oil — (tons × 10^3)	1,056	907	-14.1
Coal — (tons × 10^3)	917	598	-34.8
Gas — (therms × 10^4)	7,766	15,453	+99.0
Electricity (kWh × 10^6)	1,433	1,501	+ 4.7

Electricity consumption shows a small increase over the review period. The reduction in oil consumption constitutes a particularly welcome contribution to the overall world oil supply problems and is illustrative of a long term trend which accords with the recent national undertaking to reduce dependence on this particular fossil fuel.

Potential for Further Savings

Although the NHS has made useful energy conservation savings since 1972/3, the achievement must be considered against the potential savings

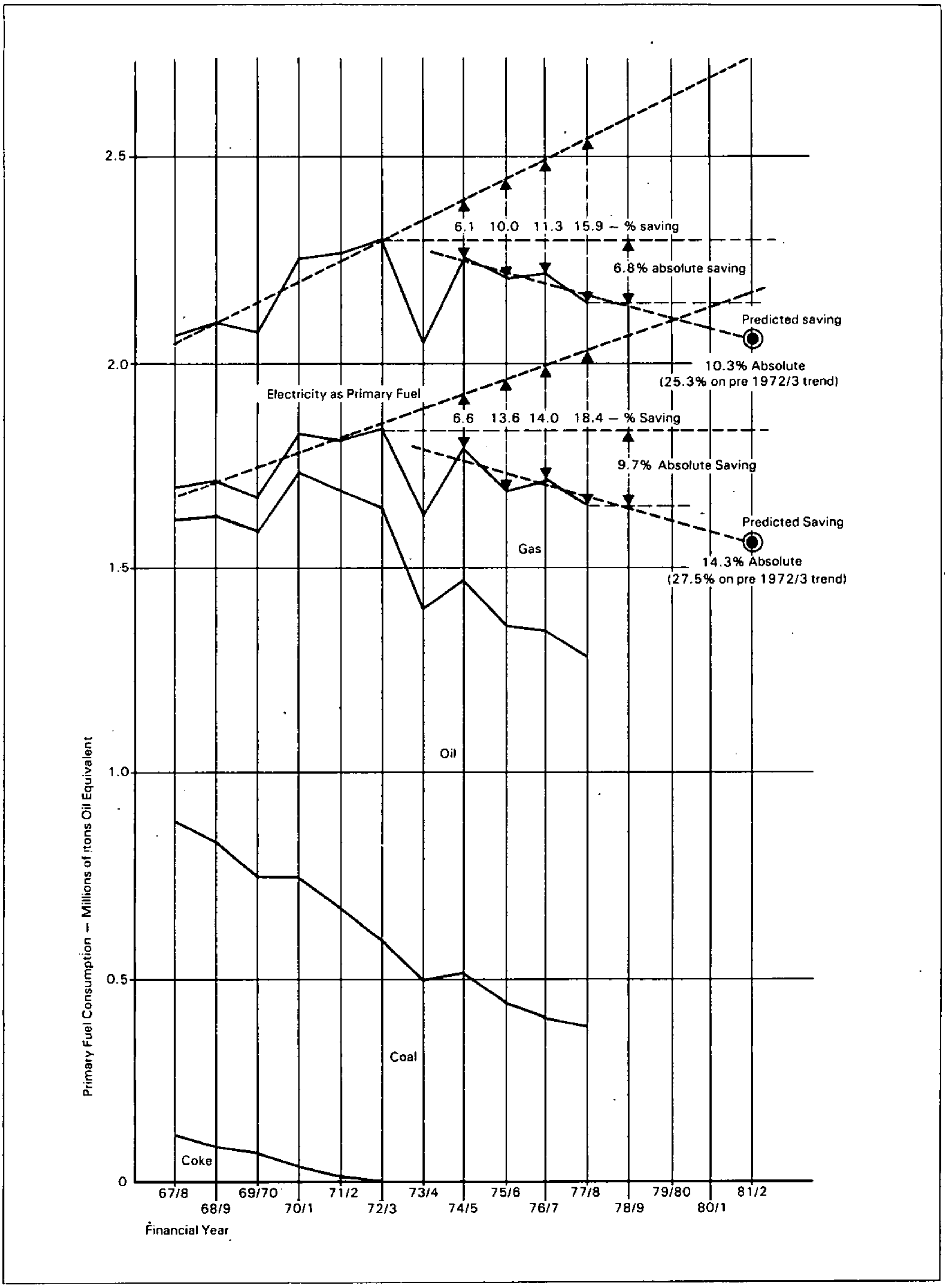
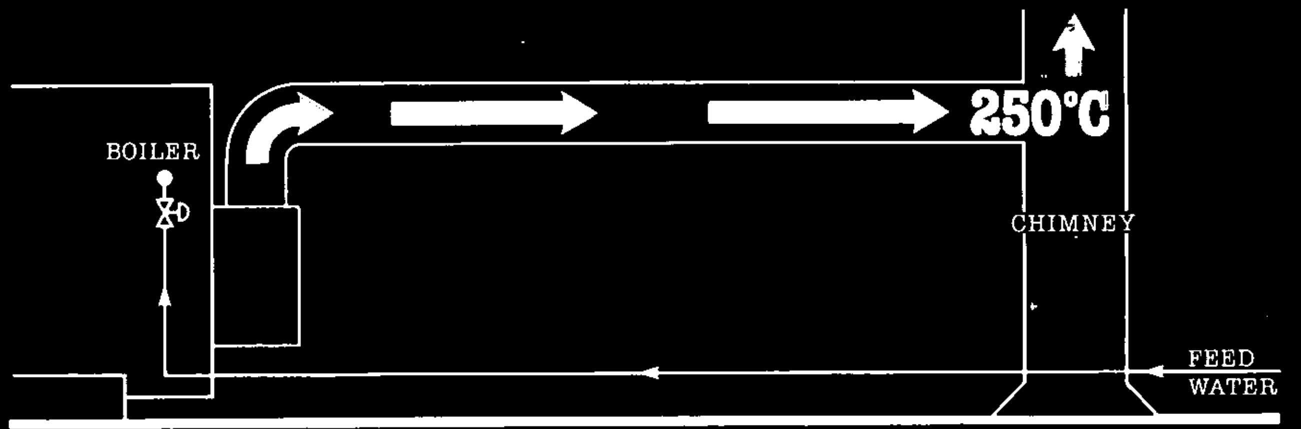


Figure 1. Hospital Energy Savings — Actual and Future Predicted.



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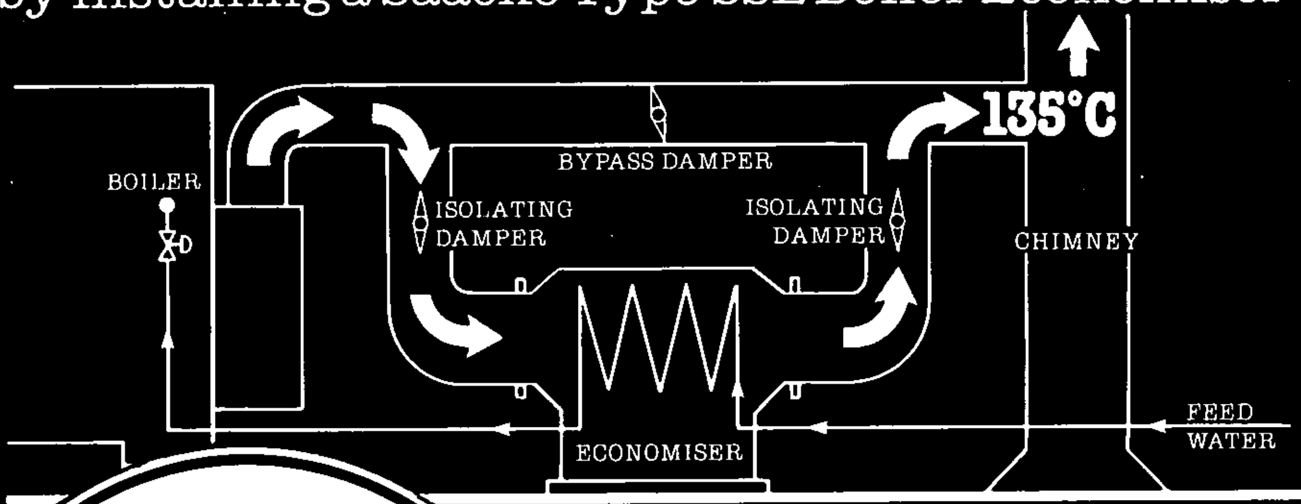

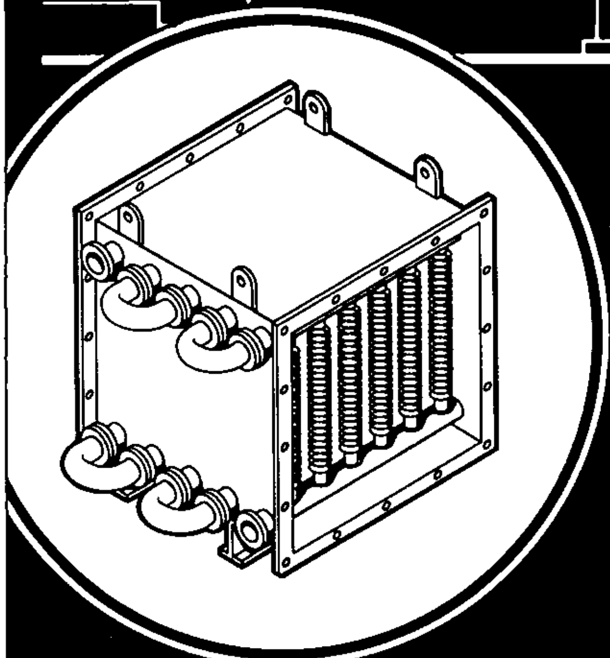

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available, bearing in mind that energy usage in the NHS during the post-war years has tended to be wasteful and, in some instances, almost profligate. During the development of the 'Energy Management — Monitoring and Targeting System' in 1978, field trials were conducted in about 300 hospitals. These investigations in conjunction with independent surveys carried out under the Department of Energy's short survey scheme in a further 180 hospitals, indicate that there remains a great potential for further savings — the suggestion being that on many sites very little has been achieved. The cumulative findings of these investigations are summarised in the following paragraphs.

Thermal Efficiency of Buildings

A large proportion of existing NHS buildings are thermally inefficient — in particular the narrow span single storey structures of wartime origin (1914/18 as well as 1939/45), the former TB sanatoria and isolation hospitals all generally possess thermal characteristics which are way below current requirements. In addition, much of the post-war construction consists of prefabricated lightweight and/or system built buildings (often with excessive glazing areas) of almost equally low thermal standards. At the other extreme, a large amount of the lofty Victorian buildings still have roof spaces which have not been insulated to acceptable levels and ill-fitting sash-type windows. Since structures of these generic types constitute the majority of our hospital buildings, it is apparent that a programme of extensive improvement is necessary to raise the thermal characteristics to currently acceptable levels. This, however, is really only a palliative since the end result will be structures, which in many cases are thermally little better than high quality garden sheds, whereas the requirements for those hospital buildings which are continuously heated on a 24 hour/day basis to hospital temperature levels is a thermal performance considerably better than the average UK building structure.

Engineering Services

In general, and particularly in the older hospitals, the engineering services are woefully out of date and incompatible with contemporary requirements for the efficient use of fuel. The following recurrent defects and shortcomings were identified in the services installed in many of the 300 hospitals studied:

Heating Systems

Inability to shut down non-key zones either at night or during the summer months due to inadequate sub-circuit arrangements. In many cases this was exacerbated by the absence of radiator valves and/or the continued use of gravity flow systems. Additionally there was a surprising number of virtually uncontrollable direct steam heating systems still in service (particularly in Mental Illness hospitals).

DHWS Systems

A high proportion of the existing DHWS systems were based on centrally located calorifiers. In some cases utilisation of energy at the draw-off points was below 30% of heat supplied to the calorifier. This sorry state of affairs arises from over-centralised calorifiers with their excessively long circulation mains (often poorly insulated), totally uninsulated distribution runs within building curtilages and the calorifiers' standing losses.

Space Heating Controls

In a high proportion of hospital buildings the only method of control was the manual adjustment of boiler thermostat or calorifier steam valve.

Where automatic controls existed these were often of the insensitive direct acting type and/or of an obsolescent pattern. The mechanical condition of three-way control valves was often poor — fluid 'let by' in the nominally closed position being very high. This situation was compounded by the absence of local trimming/night shut-off controls and inadequate zoning arrangements. As a consequence of these defects mild weather overheating was a widespread problem resulting in an average overconsumption of space heating energy in the sample hospitals of approx 18%.

Distribution and System Losses

Many hospitals have triple thermal distribution systems of Steam, LPHW and DHWS on sites with relatively dispersed buildings resulting in total distribution losses exceeding 20% of the annual raw fuel intake. In most hospitals the thickness and condition of thermal insulation on distribution mains was well below current economic thicknesses. In extreme cases lengthy totally uninsulated steam mains were found to be buried direct into the ground. All sample hospitals with external mains insulated with 'loose-fill' powder type insulants were found to have excessive distribution losses. Many small hospitals — below 200 beds in size — were found to be still using steam boiler plant although the need for steam for sterilizing or other processing purposes had long since disappeared.

Operational Policies

In many cases operational policies could be criticised as these resulted in excessive fuel consumption and/or lower than desirable boiler house efficiencies. In particular, the practice of having unnecessary boilers 'on line' or as 'stand-by' hot reserves appeared to be relatively widespread. On many sites these losses were compounded by a failure to shut the heating systems down during warm weather in case a cold snap occurred. The latter was particularly common in small hospitals or in off-sited buildings where there is no continuous engineering presence on the site.

Boiler Houses and Plant Rooms

The following shortcomings were observed in a high percentage of the hospitals studied:

Uninsulated bulk fuel oil storage tanks (3,500 sec and 950 sec grades).

Steam feed pumps or other steam driven ancillary equipment exhausting direct to atmosphere.

Flash steam at condensate receivers exhausting continually to atmosphere due either to faulty traps or the absence of condensate coolers on calorifiers.

Low rates of condensate return due to various system defects.

The above failings all constitute a grievous waste of energy and are contrary to the principles of good energy management.

Laundries

Many laundries were visited where steam consumption per article laundered was excessive. Contributory factors were excessive flash steam loss and/or part loading of batch production equipment plus, in some cases, steam mains left continuously 'on' during non-productive periods.

Hydrotherapy Pools

A number of installations were observed where the hydrotherapy pool was kept at the desired temperature level by the continuous injection of hot water from the hospitals' DHWS system and with the overflow passing directly to the drains.

Electricity

Excessive consumption arose in many hospitals not only from lighting being 'on' when not needed but from the use of tungsten lighting in areas where there could be no clinical objection to the use of fluorescent discharge tubes. In addition the use of electricity for space heating in 'temporary' structures and/or the colder areas in major building was prevalent. The use of electricity for continuous uncontrolled space heating cannot be condoned — if the radiator heating surface is inadequate or the circulation insufficient then these system defects should be corrected as priority commitments.

Inter-Relationship of Building and Engineering Services

Good thermal performance is only achievable where there is complete compatability between the thermal characteristics of the buildings and the system/control characteristics of the supporting engineering services. Most hospitals have evolved gradually over the last fifty years (or even longer) and as a result there are examples of practically every building form and construction applicable to this century. The thermal characteristics of the different styles are vastly different and it is not possible to achieve a satisfactory standard of control from a single centralised point which is the most common method in the older hospitals. As a result one finds that in order to achieve satisfactory temperature levels in one small part of the building, it is necessary to overheat the balance of the hospital. A reasonable thermal performance with mixed building types necessitates recourse either to local controls throughout the hospital or local trimming controls in areas likely to overheat. Almost invariably post-war additions and extensions have been built **without** the supporting engineering systems being adapted to suit the resultant mix of building types. The end product is a relatively cheap extension coupled with excessive fuel consumption and inflated running costs.

It will be appreciated from the foregoing summary of findings that there is a great scope for energy saving within the NHS and that the 6.8% absolute saving achieved up to the end of 1977/8 is only a small part of the available potential. This revelation immediately prompts the question, "What should we as responsible architects, engineers, surveyors and works' officers' be doing to rectify this situation?" The second half of this article is devoted to answering this question by reviewing proven methods of achieving energy reduction, mentioning any research and development in progress, and introducing the contributions from works staff in the field.

Building Improvements

Only one case study is known where a large scale attempt has been made to improve the thermal characteristics of a largely wartime temporary hutted hospital. At this establishment the insulation of both flat and pitched roofs plus allied works have reesulted in 27% saving in annual energy consumption over the last four years. The following article by Mr R. Edson is proof that building improvement work on substandard structures will reap high rewards. Many other cases have been identified where simple roofspace insulation in limited areas of the hospital have paid good dividends.

There are two ongoing research projects under DHSS auspices which should provide information on the best methods of improving existing buildings. One of these is at St Margaret's Hospital, Epping where heat consumption in two constructionally improved hutted wards will be monitored against an unimproved ward to ascertain the economics of the approach. The other project is at Bromley AHA where a whole range of building types ranging from lofty Victorian structures through to contemporary construction is being reviewed to identify the extent of building improvement which is economically justifiable.

Small Compact Hospitals (under 50 beds)

The boiler plant in most of these hospitals is heavy cast-iron sectional boilers (often conversions from solid fuel) which serve combined DHWS and heating circuits. Controls are usually minimal and often limited to manual adjustment of the boiler thermostat only. The combination of high standing losses (particularly during the milder months of the year) and relatively poor combustion efficiency (particularly at low fire) make these installations relatively inefficient. The modern trend is to install compact fully automated modular boiler plant for the heating services and a combination water heater/storage vessel for the DHWS. Several installations of this type are known to the writer and the results of these prototype installations are being monitored with a view to publication.

Time Clock Control for Intermittently Occupied Buildings

The use of optimum start or time clock control of heating/DHWS systems in intermittently occupied buildings has been given prominence in recent years. The savings which can be made from the provision of simple controls of this type are illustrated in the article by Mr Feasey relating to Hackwood Road Hospital, Basingstoke on page 29 of this issue. No additional editorial comment is required to supplement this real life case history.

Hospitals 100 to 200 Bed in Size with Central Steam Boiler Plant

The use of central steam plant to serve a number of dispersed buildings in which there is no prima facie requirement for steam for process commitments has already been criticised. The dramatic fuel savings which can be achieved by decentralising the boiler plant and dispensing with lengthy distribution mains and steam system losses is highlighted in the articles by Mr Cruickshank (Wandle Valley Hospital), on page 22, Mr K. Dale (Thistle Hill Hospital, Knaresborough), on page 34, and Mr M. Lees (Winford Orthopaedic Hospital) on page 23. It should be noted that approx 50% saving in raw fuel consumption is accompanied by a further saving of about £20,000 per annum as a result of dispensing with shift stokers. Editorial comment here would again be superfluous.

Improvements at a Hospital with Decentralised Boiler Plant

The act of boiler plant decentralisation as outlined in the previous paragraph does not in itself result in all potential savings being obtained. This will be evident from the article by Mr C. Aveyard (see page 25) dealing with building and engineering improvements at Monsall Hospital where the starting point was 47 relatively inefficient local boiler plants. Expenditure of £60,000 over a four-year period has resulted in a 20% drop in fuel consumption worth over £15,000 per annum at current price levels. The moral of this story is that the Nelson touch will not pay dividends in the battle against excessive fuel consumption.

Traditional Large Acute Hospitals

The article relating to Ormskirk General Hospital by Mr D. Nicholson and Mr A. Schaffel (see page 39) outlines the potential savings which can be obtained in hospitals of this type where both the engineering systems and the operational procedures reflect the long gone era of cheap fuel. Whilst this case study reflects the tremendous savings (23%) in fuel consumption which can be achieved, it also demonstrates the necessity of producing an overall plan before embarking on major conservation works.

Large Hospitals for the Mental Handicapped

These hospitals are usually composed of a relatively large number of villas/chalet type buildings which are widely dispersed in a rural setting. This category of hospital is particularly prone to excessive distribution losses and the case for decentralisation of boiler plant is particularly strong. Studies of the thermal performance of large mental handicap hospitals equipped with local LPHW boiler plants have shown that the concept of boiler plant decentralisation should be given serious consideration in view of the extremely heavy cost of raising the levels of thermal insulation on the distribution mains to currently acceptable standards. The performance of one recent conversion is now being monitored and the results will be made available in 1980/81.

Mental Illness Hospitals

This group of hospitals is perhaps the most difficult on which to make long term recommendations due to their uncertain future. Most of them have archaic, turn-of-the-century engineering installations which require replanning to modern concepts. A long term phased improvement plan at a typical hospital of this type has achieved a 43% saving in oil fuel consumption. The engineering work included replacement of Lancashire boilers by Economic type, provision of LPHW radiator heating and control systems in the central buildings and steam fan convectors (with inbuilt thermostats) in the peripheral structures. The replacement of the inefficient direct steam heating installations which are relatively common in this type of hospital should result in dramatic fuel savings particularly where automatic heating controls are non-existent.

Post-War District General Hospitals

The most significant problems inherent in this group of hospitals is inadequate control performance and mild weather overheating. In many cases the pipework circuiting arrangements do not permit the heating in non-sensitive areas of the hospital to be shut down readily during the summer months. There are also some installations where unsuitable and illogical embedded panel heating systems make fine control and quick response to changing ambient conditions impossible. Except where there are grievous faults of these or similar types, the emphasis should be on control and insulation improvements plus the provision of condensate coolers where these were not provided as part of the original design.

Heat Recovery

The other field which may prove fruitful is heat recovery and this is always worthy of exploration.

Heat Recovery by Thermal Wheel

Heat recovery from ventilation systems using a thermal wheel is an accepted form of energy saving. The earliest known installation in the NHS was on an operating theatre at the National Orthopaedic Hospital. This installation gave a heat recovery performance of over 60% and was the subject of articles in *Hospital Engineer* (May/June '77) and in *Heating and Ventilating Engineer* (October '77). The contribution by Mr Dalzell (see page 14) gives the full detail of this installation plus a chronological statement of its operational history. It will be noted that it is an item which requires routine inspection and a considerable amount of maintenance. The writer has been advised of a thermal wheel installation on a hydrotheraphy pool which causes 'fogging' conditions whenever it is run. Whilst superficially it appears that latent heat transfer via moisture condensation is the cause of this phenomenon, it would be premature to issue advice until the current in depth investigations are complete.

Heat Recovery by Plate Exchanger

An alternative heat recovery device to the thermal wheel is the static plate type heat exchanger. The contribution by Mr E. Davies (see page 20) outlines the performance tests which were carried out on a hydrotheraphy pool ventilation system at Leybourne Grange hospital. The indications are that an annual heat recovery rate of about 70% will be achieved. Moisture transfer by this type of equipment does not occur and both the space requirement and the subsequent maintenance are obviously less than required for the equivalent thermal wheel.

Heat Recovery by Run-Around Coils

There are no known installations of this type as yet in service in the NHS. Consultants are however working on two schemes in post-war hospitals and the test results will be promulgated in due course. The scheme at Norfolk and Norwich hospitals relates to an operating theatre ventilation plant and is comparatively small, whereas the similar project at Yeovil DHG is a more ambitious concept concerned with heat recovery from the mechanical ventilation plant serving the core of the hospital.

Heat Recovery by Heat Pipes

There are no known installations using this device within the NHS either in operation or planning. Undoubtedly this is an area which will receive attention in future.

Heat Recovery by Recuperator on Gas Fired Boiler Plant

The initial recuperator installation at Booth Hall Children's hospital was the subject of a report in the September 1978 issue of *Health Service Estate* (HSE). This installation has now completed over a year in service and the overall performance is in accordance with the initial expectations equivalent to a gain of approx 7% in boiler efficiency. A second installation has now been completed at the same hospital and others are under consideration at two hospitals in SW Thames RHA.

Economisers for Gas Fired LPHW Boilers

A fairly recent addition to available heat recovery equipment is an economiser for use in conjunction with gas fired LPHW boiler plant. The makers' claim that approx 4 to 5% improvement in combustion efficiency is achieved by passing a proportion of the primary return water through the equipment. One advantage of this device is that no additional fan or pumping head is required. This type of equipment may also be used on gas fired steam boiler plants and four trial installations are now in progress.

Continuous Boiler Blowdown and Heat Recovery

The increasing use of continuous blowdown systems in conjunction with fully automated boiler installations provide an ideal opportunity for recovering both the flash steam and sensible heat components from the blowdown discharge for feed water preheating. A number of installations incorporating heat recovery are now coming into service within the NHS — the pay back period is normally under one year. Heat recovery in this manner should be given serious consideration wherever boiler blowdown rates are high.

Other Aids to Improved Combustion Efficiency

The trend away from the use of central steam raising installations and towards the use of local LPHW modular type plants has previously been mentioned in this narrative. The latter, used in conjunction with high efficiency DHWS combination heaters/storage vessels, should provide cost effective savings even in small hospitals where the existing CI sectional boilers are of comparatively low efficiency.

The control of combustion in the larger gas and oil fired plants has always been an area where marginal improvement was possible but the unreliability of CO_2 recording instruments have always militated against the realisation of these possible savings. The recent introduction of oxygen monitoring equipment as a trimming control has yielded useful results in prototype trials. Whilst there are theoretical and practical constraints on the extent to which excess air can be reduced particularly under low load conditions, the initial experiments are encouraging. The contribution by Mr R. Stokes (see page 3) outlines the results achieved at four hospitals in SW Thames RHA.

Other similar prototype installations and tests are in progress at seven hospitals in SE Thames RHA.

Boiler and/or fuel additives have been the subject of many recent claims in respect of improved combustion efficiency. Field trials at a number of installations have however proved inconclusive mainly due to instrumentation difficulties. Testing however continues and the results will be made available in due course.

Waste Heat Recovery from Incinerators

Three prototype installations are in service — the installation at Peterborough hospital which operates in parallel with the main steam raising plant was the subject of an article in the March 1978 issue of *HSE*. The installation at the University Hospital of Wales, Cardiff is generally similar but provides a smaller proportion of the hospital's steam requirement. The following contribution by Mr R. Tucker (see page 13) refers to an installation which operates in parallel with LPHW boilers serving residential accommodation at Farleigh hospital. Whilst all three installations result in increased maintenance and a degree of operational complexity the magnitude of the amount of heat recovered more than compensates for these additional commitments.

Heat Recovery in Laundries

Laundry installations are the principal industrial type process application in the NHS accounting for approx 7% of the overall total energy usage. A number of prototype energy conservation installations have been made including the fitting of a plate type heat exchanger to three tumbler driers at Ormskirk General Hospital. Subsequent testing indicated that a reduction of about 40% in steam consumption was achieved but some difficulties have been experienced due to fan noise. The provision of a lint chamber avoided excessive fouling of the heat transfer surfaces.

Trials including measurement of steam consumption using standard loads are shortly to commence at Groby Road hospital laundry on the following equipment:

Tumbler driers fitted with thermal wheels;
Calendar fitted with plastic hood;
Calendar fitted with shrouded rolls.

It is also hoped to field test a prototype tumbler drier with a closed 'cold dry' cycle incorporating a heat pump at this site. Reports on all tests will be made available in due course.

Research on the feasibility of applying humidity control for the automatic adjustment of the cycle time of tumbler driers is in progress. The initial tests on fully dried work gave encouraging results and the research has now moved to ascertaining whether this form of control is possible for 'conditioning' loads.

It is important to note that many hospital laundries have a flash steam problem and that elimination of this condition by using the flash steam to preheat laundry water supply must be the first priority and take precedence over improved cycle efficiency. The report by Mr D. Nicholson and Mr A. Schaffel (see page 39) indicates how this was achieved in the Ormskirk General Hospital laundry.

One potential area in laundries which, in theory, offers great rewards is a successful recovery system for reclaiming the waste heat in the effluent. No known successful installation exists within the NHS — the principal problems to be overcome are the fouling propensities of lint and cotton fibres combined with heavy deposition of fatty acids/grease/soap scums on the heat exchanger surfaces. It is hoped that serious research in these areas will be possible in the not too distant future.

Solar Heating

Solar heating systems in this country are not currently economic propositions but, nevertheless, there are two small experimental schemes in progress in hospitals for evaluation purposes. Both these schemes use solar heat for DHWS preheat. The Torbay hospital project is a kitchen installation where the times of maximum draw-off link closely with the hours of sunlight. The Department of Energy is contributing to this scheme on a purely research basis.

The other scheme relates to a Geriatric Block at Groby Road Hospital, Leicester — this is commercially sponsored with similar objectives.

Reports on these long term tests will be made available in the more distant future as the installations concerned have yet to be completed and the subsequent performance analysed over a full twelve-month period.

Improved Standards of Thermal Insulation on Pipework

Inter Authority Engineering Study Group 6 recently completed an evaluation of the economic thickness of thermal insulation on distribution pipework under hospital operational conditions — vide article in September 1979 issue of *HSE*. The recommended thicknesses generally align with the recommendations shown in BS 5422 (published 1977) but there are some applications where an increased insulation thickness is appropriate. Insulation to these levels should be employed in all new works and on all upgradings (wherever physically possible), provided the forseeable life of the pipeline is not less than the twenty-year term used in the amortisation calculation for the capital component of the total ownership and operating costs. In this context it is important to note that DHWS circulating mains within individual hospital buildings are often totally (or inadequately) insulated. It is however relevant to stress that the provision of increased insulation thicknesses on external distribution mains should not be undertaken where the proper long term solution is decentralisation of boiler plant and/or change of medium from steam to LPHW.

Energy Monitoring and Control Systems

The adaptation of TDM systems for energy monitoring and control purposes offers potentially great rewards. A number of evaluation studies are in progress and one scheme at Bristol Royal Infirmary has progressed to the point where the control computer is now being commissioned. The application of the technique is as yet in its infancy and early field experience with pilot installations is needed before the full potential of micro electronics becomes generally available. This control concept will probably become the future standard for large hospitals provided the initial capital outlay can be held down to reasonable limits. Development work in this sphere is expected to increase in the future.

The Cost

The instant reaction of Works Officers of all levels will be that improvements and changes of the magnitude indicated in this article require the injection of considerable amount of money. The Department of Energy has made a special allocation of funds to the NHS for energy conservation work over the four year period from April 1978 to April 1982. This sum of £32m (unadjusted for inflation) amounts to approx £80 per bed and constitutes a yardstick for the planning of such works. Well thought-out schemes at sites where energy utilisation is low can achieve a great deal for expenditures of this general order. The expenditure levels at the specific hospitals mentioned in this article are tabulated below:

Hospital	No. of Beds	Overall Expenditure (C+R)	Overall Expenditure Per Bed (C+R)	% Saving in Annual Fuel Consumption %
		£	£	
Newmarket	300	40,000	135	27
Wandle Valley	140	50,000	360	53
Thistle Hill	50	65,000	1,300	53
Winford Orthopaedic	230	40,000	175	46
Monsall	400	60,000	150	20
Ormskirk	440	74,450	169	23

At all the above hospitals a considerable proportion of the work carried out was overdue plant/services replacement and building maintenance. The inference is that the proper deployment of the Department of Energy special allocation supplemented by an equivalent injection of funds from AHA/District resources will go a long way to achieve the energy savings.

Conclusions

To save energy two fundamental precepts must be assiduously followed:

the conversion of raw fuel to heat energy must be improved above existing combustion efficiency levels; and

the useful heat generated therefrom must be used with less waste. To achieve this the distribution and system losses, mild weather overheating, unnecessary space heating and building heat losses must be reduced.

Reliance on 'good housekeeping' is not sufficient although this aspect of energy management is of prime importance. Hospital staff of all disciplines have other important duties to carry out and consequently the opening of a window to remedy a constantly recurring overheating situation will become the accepted course of action when there is no external motivation or direct pressure on the user to do otherwise.

The inescapable conclusion is that hospital buildings and the associated engineering services and controls need to be raised to, and maintained at, standards which are consistent with the present day costs and availability of fuel. *This is an urgent and pressing* requirement if the NHS is to play its full part in the national effort to conserve energy and it is hoped that the following contributions and reports will spur others to even greater achievements.

The author is District Engineer, Bristol and Western Health District.

Waste Heat Recovery System at Farleigh Hospital

R. TUCKER BSc(Eng) MCIBS

Location

Farleigh Hospital is a 250-bed hospital for the mentally handicapped with a main multi-storey block and several single storey ward blocks on the perimeter of the grounds. There is also a continuing development plan for the construction of extra wards.

Background

Originally the decision was taken to build a district based incinerator located at Farleigh Hospital. This requires a system of waste collection from other hospitals in the district. The waste is conveyed in skips with a purpose built vehicle and delivered to Farleigh Hospital where it is burned and thus produces an amount of waste heat. With the continuing programme of development at Farleigh Hospital a twin block, known as 'A' and 'B' blocks, was built. These blocks were constructed within close proximity of the incinerator house and, therefore, the idea of utilising waste heat became a more practical proposition, because a suitable user of the available waste energy was now located within a reasonable distance of the incinerator house.

System

Equipment

The incinerator house contains two Universal 4B incinerators see *Figure 1* which are hand-fired. The waste heat is recovered by the use of a heat exchanger which allows flue gas from either or both incinerators to pass through it subject to certain control conditions. The outline of these control conditions is indicated below. These should be read in conjunction with the schematic layout drawing.

Control Dampers (MD1 & MD2)
Dampers are opened when incinerators are burning. Dampers automatically open and close when induced draught fan is running and stopped consecutively.

Induced Draught Fan
Fan automatically stops and starts on rise and fall of water temperature in heat exchanger. This temperature is detected by thermostat T1 which is mounted in the heat exchanger shell. T1 has a high level manual reset facility which prevents the fan from running when the temperature reaches an excessive level.

Fresh Air Inlet Damper (MD3)
Damper remains stationary in a slightly open position, unless adjacent thermostat T3 detects an excessive temperature in which case the damper will open to allow more air into duct to cool the fan blades.

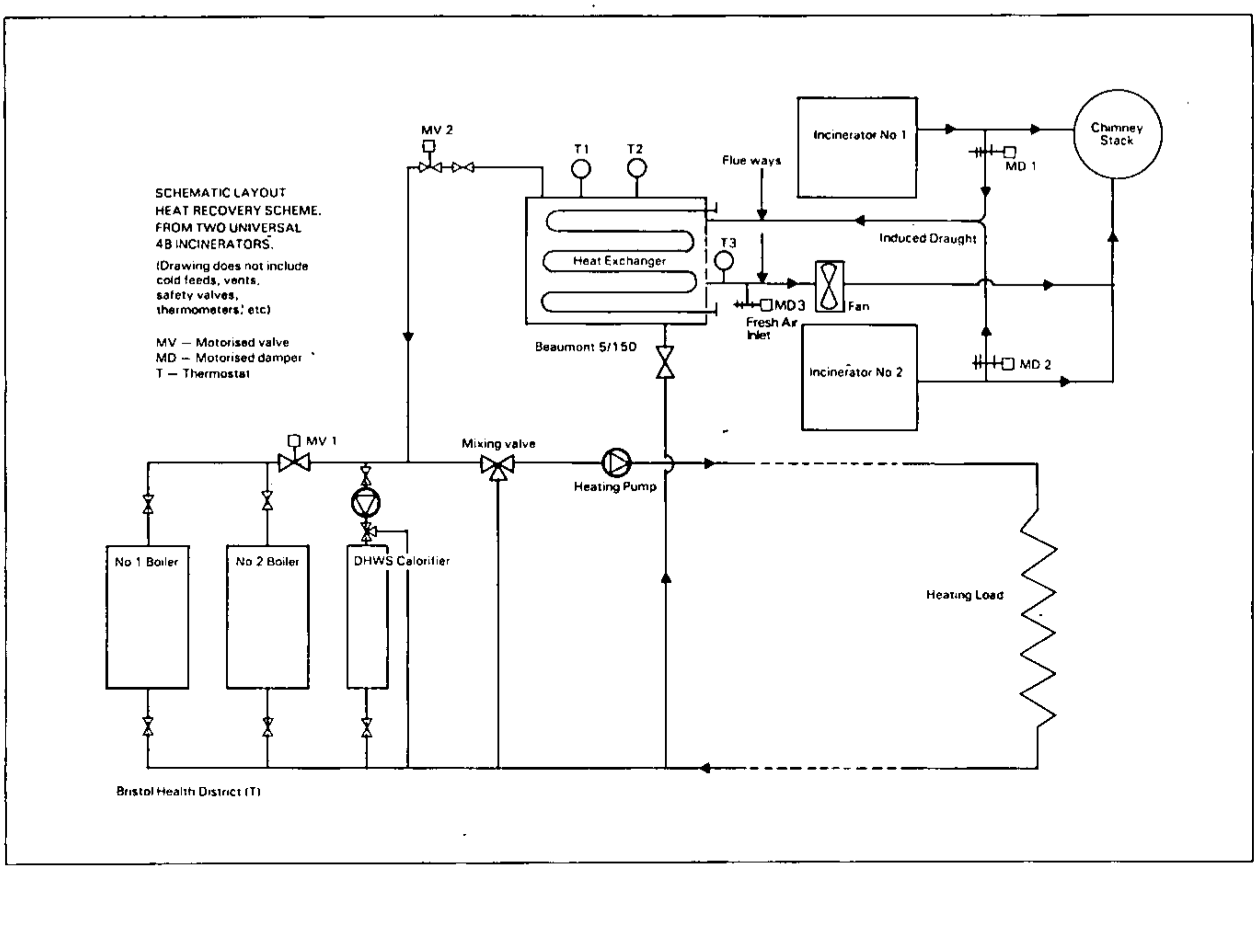
Motorised Valves (MV1 & MV2)
MV2 opens on temperature rise and closes on temperature drop. Temperature is detected by thermostat T2 which is mounted in shell of heat exchanger. When MV2 is open MV1 closes and at the same time the LPHW oil fired boiler is electrically isolated and vice versa.

Thermostat Settings (approximate)
T1 Control thermostat for induced draught fan stops at 160°F (71°C);
High limit manual reset 190°F (88°C);
T2 Control thermostat for MV2 water flow valve opens at 120°F (49°C);
T3 Control thermostat for fresh air inlet damper opens at 550°F (288°C).

Flow Circuits

The medium for exchanging the waste heat is water which is pumped through the heat exchanger and circulated to the domestic hot water and calorifiers in both 'A' and 'B' blocks as a primary circuit. When the incinerator is shut down at night or at weekends the primary heat is supplied by two 35 sec oil fired low pressure hot water boilers which are sited in a plant room integral with 'A' and 'B' blocks. The incinerator is normally operated for nine hours per day on a six day/week basis.

Figure 1.



Future Development

Expenditure on the waste heat recovery installation inclusive of interconnecting flow and return mains to the twin ward blocks totalled approx £12,000. The estimated amount of the recovered heat usefully utilised in these buildings is equivalent to a boiler consumption of 18,000 litres having a value at current price levels of approximately £1,250 per annum. The payback rate is thus 9.6 years but this will fall dramatically when future residential blocks are built in this area of the hospital and are interconnected with the waste heat recovery system.

The initial control difficulties associated with the parallel operation of the heat recovery system with the LPHW boiler plant have now been overcome and we have a viable heat source of proven capacity to support the proposed future developments.

The only remaining problem is a relatively minor one concerned with the need to replace certain sections of the flue gas transfer ducting which are subject to 'burning-out' at fairly frequent intervals.

Mr Dalzell is Group Engineer, Royal National Orthopaedic Hospital

An Operating Theatre Air Conditioning Installation Incorporating Heat Recovery and User Experience of it

I. C. DALZELL CEng FIMechE

Introduction and Background

The operating theatre suite concerned is on fifth (top) floor of the Royal National Orthopaedic Hospital in Central London. Prior to 1976 the theatres were mechanically ventilated, about fifteen air changes per hour, with controlled heating using room thermostats. There was no provision for cooling or humidity control. Nevertheless, this gave satisfactory conditions for most of the year but inevitably, at the height of the occasional hot summer's day it became uncomfortably hot in the two theatres due largely to solar heat gain, particularly through roof lights, windows and also the roof structure.

Various measures to improve these conditions were taken over the years including white paint on roof lights, increasing fan speeds, the application of solar control film on all windows facing South and West and even the use of a lawn sprinkler on the roof. Each and all of these produced a noticeable improvement particularly the latter two.

Study of Energy Saving Measures

Meanwhile, and in view of other shortcomings in connection with size and layout of the suite, feasibility and cost studies were carried out on complete redevelopment of the suite including provision of full air conditioning. Costs proved prohibitive so that in the event a much smaller scheme was adopted involving provision of full air conditioning for the existing suite with a new plant room on the roof. As a keen protagonist of energy-saving measures in our hospital group, I had adopted these over the years wherever practicable and cost-effective. Apart from the obvious first priority here of attaining maximum efficiencies from boiler plants and steam and heating distribution systems, thermal insulation etc, measures had been taken in other directions, e.g.

Recirculatory air conditioning in hospital staff refectory which includes heat recovery from lighting fittings.
Staff lounge heated by waste heat from vending machines and cool cabinets.
Fitting of automatic doors at entrances to Outpatients Departments.
Using warm air extract from autoclave plant room to heat an otherwise unheated corridor in winter.
Time switch control of operating theatre cooling — off at nights and at weekends but with manual over-ride provision.
Provision and correct setting of compensated heating systems and/or thermostatic radiator valves, and night set-back.
Addition of optimum start heating controls in all buildings where this is appropriate.

Heat Regenerator

Consequently, the Consulting Engineers for the operating theatre scheme were instructed that installation design should incorporate energy-saving features so far as these were practicable and likely to be cost-effective while keeping to a 100% fresh air rather than recirculatory system as was accepted practice for operating theatres at the time and probably still is. Accordingly the specification included provision of a heat regenerator of the thermal wheel type. This is basically an enclosed rotor or wheel arranged so that supply air passes axially between the spokes of one half of the wheel while exhaust air passes in the opposite direction through the other half. The spaces between the spokes are packed with a heat transfer material so that as the wheel slowly revolves it transfers heat from one air stream to the other according to their difference in temperature. In theory it is also self-cleaning by virtue of the reversal of air flow through the wheel as it rotates.

The regenerator actually specified was of Swedish manufacture having a heat transfer medium of inert and bacteriostatic dessicant material to recover both sensible and latent heat. However, the possible risk of bacteriological cross-infection of supply air by exhaust air when using this type of material led to second thoughts about advisability of its use; this factor, together with delivery difficulties encountered with the Swedish regenerator led to adoption of a British model designed to recover sensible heat only and using for this purpose a matrix consisting of knitted aluminium mesh.

The Project

Everything about this project was tight — finance, space, time and contract programme and control of it. Contractors came to site on June 7, 1976, theatrès were to re-open on September 7, 1976 and during this 13-week period at least one of the two theatres was to be operational for an aggregate of seven weeks. These aims were achieved although on the targeted re-opening date the regenerator was not yet operational, the cooling plant installation was incomplete as was plant instrumentation and some automatic controls, while a final adjustment programme remained to be carried out. The latter was eventually programmed for and completed over a three-day period in the following December.

This installation was unique in being the first ventilation system with heat regeneration to be commissioned in any hospital in the U.K. and also the only such one fitted or even contemplated for an operating theatre system. A further point of note is that these are orthopaedic theatres where operations of about two hours duration are common. Patients are therefore exposed for relatively long periods to whatever level of bacterial presence there may be in the neighbourhood of their wound and this includes that in the air delivered by the ventilation system. The installation was outlined in an article in *Hospital Development*, May-June 1978. The heat regenerator was the subject of site tests in March 1977 by Mr P. Robertson,BSc, CEng, Building Services Research Unit, University of Glasgow. These tests were aimed at obtaining information on efficiency of this regenerator in practical use and the results were presented in a paper published in *Heating and Ventilating Engineer*, October 1977.

The Installation

Figure 1. Schematic of Plant Layout
A schematic diagram of plant layout is shown in Figure 1 and some salient design features are given below.

Airflows

Air Changes per hour: 25
Supply fan duty — Main: 3.3 m^3/sec against 450 N/m^2 external pressure
Standby: 1.9 m^3/sec against 150 N/m^2 static pressure
Exhaust fan duty: Main: 2.1 m^3/sec against 380 N/m^2 static pressure
Standby: 1.2 m^3/sec against 130 N/m^2 static pressure
Secondary extract fan: 0.5 m^3/sec
(ie window fan in autoclave room extracting from theatre via grilles in partition).

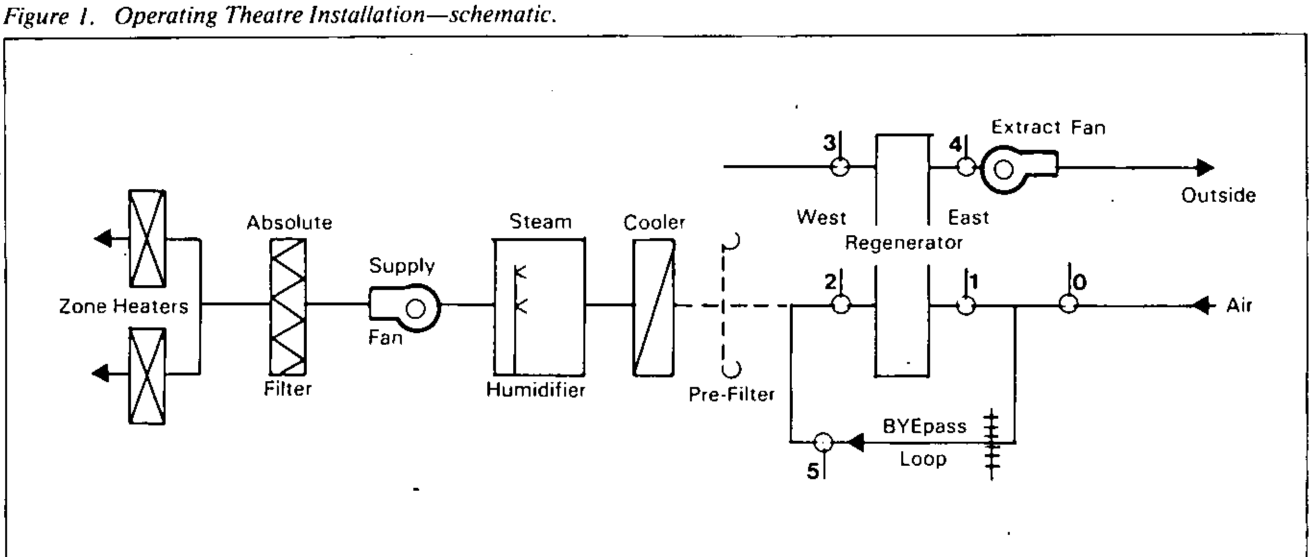
Heat Regenerator

Dimensions:
Rotor 1,300 mm dia × 200 mm wide
Casing 1,700 mm square × 500 mm wide
Heat transfer material — knitted aluminium wire mesh
Design efficiency — 62½%
Speed of rotation — 20 rpm
Drive arrangements — electric motor geared down with toothed belt drive to spring-loaded cross-shaft carrying rubber tyred wheels bearing on the outer periphery of the rotor. Single phase motor with running current of 2.5 amps.
Control: By two ambient thermostats to start the regenerator when outside temperature is either:
below 17°C for heating ingoing air in winter; or
above 21°C* for cooling ingoing air in summer.
The rotor is stationary between these temperatures because calculated energy recovery is less than to drive it.

Fresh air bye-pass: provided to reduce pressure drop across rotor and also has the effect of allowing less fan power,

*This was subsequently reset to 23°C when it was found that best comfort conditions in theatres, as set by users, produced a combined air exhaust temperature of 22°C.

Figure 1. Operating Theatre Installation—schematic.



noise etc. Measurements indicate this carries about 40% of total fresh air supply.

Air Handling Unit

Packaged Unit incorporating cooling battery, direct steam humidifier, supply fans, final filters and heater batteries.

Heater Batteries: modulating valve control of steam at normal maximum operating pressure of 55 kN/m^2 (8 psig).

Filtration

Pre-filter — Trox autoroll. Efficiency of 94% on Test Dust No 2 as BS 2831 when handling designed flow.

Final Filters — Cartridge type bag filters of rectangular section having efficiency of 95% to NBS discoloration test when handling designed flow. (*Note.* This is a U.S. standard representing better than 95% efficiency to BS 3928, sodium flame test).

Cooling Plant

Dual circuit, air cooled, packaged chilled water unit mounted on roof outside plant room.

Particular Features

There is no air filtration upstream of the regenerator on either the supply or the exhaust air side. The probable desirability of this on the fresh air side was recognised at design stage but space was not available for it. The need for it on the exhaust air side was not anticipated and is commented on later.

Cost and space considerations dictated a packaged air handling unit with the supply fans downstream of the regenerator instead of upstream of it as recommended by the makers. It was accepted that pressure distribution with this arrangement did nothing to encourage any air leakage past the regenerator seals being in the direction of fresh air to exhaust air rather than the other way round. Hence one reason for the bye-pass duct and high degree of filtration specified.

Performance Tests of Regenerator

Mr Robertson's paper indicates that the maker's designed efficiency of 62½% is being achieved and probably exceeded. His paper tabulates air temperatures on each side of the regenerator (ie, positions 1, 2, 3 and 4 in *Figure 1*) during the two days of his tests in March 1977 — some three months after the regenerator was put into commission.

TABLE I

	Supply Temperature °C		*Exhaust Temperature °C*		
Date	*t1*	*t2*	*t3*	*t4*	*Remarks*
22.12.76	9	15	20	12	Regenerator in use
26.12.76	7	14.5	21.5	11.5	Regenerator in use
28.1.77	4	12	19.5	8.5	Regenerator in use
19.12.78	5.5	13	Not Recorded		Regenerator in use
19.12.78	5.5	8.5	Not Recorded		Regenerator stopped manually*
1.1.79	-6.5	5.5	Not Recorded		Regenerator in use
24.1.79	0	10.5	23	9.5	Regenerator in use
14.5.79	28.5	17	22.5	24.5	Regenerator in use Chiller in use
18.6.79	19.5	20	22.5	22.5	Regenerator stopped Chiller in use
18.6.79	23.5	22.2	22	23.3	Regenerator in use Chiller in use
19.6.79	26.5	23	22	25.5	Regenerator in use Chiller in use
20.6.79	26.5	24.2	23.5	26.2	Regenerator in use Chiller in use

*These figures are thought to be more symptomatic of air leakage across seals from exhaust to supply side rather than of conduction within the rotor and indicate an element of recirculation.

TABLE II

	Supply Air						*Exhaust Air*					
	Position 1			*Position 2*			*Position 3*			*Position 4*		
Date	*Temp*	*RH*	*DP*	*TEMP*	*RH*	*DP*	*Temp*	*RH*	*DP*	*Temp*	*RH*	*DP*
8.1.77	4	42	-7	12	39	-5	19.5	33	3	8.5	38	-7
31.1.77	5	34	-12	13.5	29.5	-6	20.5	33	2	9.5	31.5	-8.5
2.2.77	5.5	40	-9	13.5	33	-4	21	33	3	9.5	35	-6.5
10.2.77	9	37	-10	16	32	-4	21	34	3.5	9.5	34	-5.5

Table I gives further examples of these temperatures as taken from thermometers with bulbs about four inches inside the ducts.

Table II gives further examples of temperatures together with relative humidity and equivalent dew point, all taken with a thermohygrometer with probe inserted in the same positions as the thermometers for *Table I*. Temperature and dewpoints (DP) are in °C, RH is %. The regenerator was in use, as was the humidifier, which is downstream of position 2.

The figures in *Table II* indicate that some latent heat is being recovered as well as sensible heat. A contributory factor to this could be the presence of lint on the regenerator rotor which is referred to later.

Operational Experience from January 1977 to June 1979

Early January 1977 — Final Filters

These were made up of six cartridges

each containing eight bags on a rectangular frame. Inspection showed uneven dust loading and evidence of uneven face velocities and of mechanical stress on filter bags with the fabric severely thinned and about to rupture in places. New set of filters fitted and manufacturers and plant designers called in to investigate the problem.

Mid January 1977

Inspection revealed a more alarming development: a long narrow and flimsy horizontal infill plate across the filter face above the cartridges had become unfastened at one end and air pressure had forced it to bend downstream leaving a gap allowing unfiltered air to by-pass the cartridge filters. No provision was apparent for fastening the plate to the casing along its top edge. Repairs consisted of fixing an angle strip to the inside of the casing as a buttress for the plate which was then fastened to it and all joints sealed with tape. A number of surgical operations must have taken place in the theatres in conditions where some of the ventilating air had not passed through the final filters but fortunately and somewhat surprisingly with no detectable ill effects whatever.

February 1977

The result of investigations into the filter problem were: incorrect design of the filter box had led to the cartridges being loaded into it with the long transverse axis of the bags disposed horizontally instead of vertically. The bags thus tended to lie on top of each other, giving uneven dust-loading and uneven face velocities which in turn were unduly stressing some bags. Corrective action consisted of modifying the cartridge mounts inside the filter box to accommodate four larger cartridges of another standard size in lieu of the six originals. In addition a perforated plate was fitted across the box upstream of the filters to distribute air flow more evenly across the filter face and reduce the turbulence there.

Late March 1977 — Regenerator

This was examined in association with the maker's local agents. The east face was relatively clean and clear of foreign material apart from dustiness but the west face was covered with a thin layer of very fine lint, some of which had passed into the interstices of the aluminium mesh. This was an unexpected development, the more so since the regenerator has an inherent self-cleaning feature by virtue of the cyclic reversal of air flow through it as it rotates. However, the rotor is not always in motion since this is dependent on outside air temperature. Furthermore, the speed of impact of lint fibres against the mesh probably causes many of them to curl round the mesh wires and lock themselves on so that they are not easily dislodged. The surface lint was easily removed with a suction cleaner fitted with a dusting brush but the embedded fibres resisted efforts to remove them by ordinary means in the limited period available at the time. The regenerator seals (along the horizontal diameter separating supply air from exhaust air) were found to have excessive gaps and were reset.

Chiller Plant

Summer conditions did not occur until some eight months after initial commissioning of the whole installation, so the chiller plant performance in these conditions were as yet unknown. The water side had been deliberately drained and left empty over the winter as a safeguard against freezing. The acceptability of an anti-freeze solution in relation to the materials of the various elements of the installation was explored and found to be positive. But a strength above 30% (giving protection down to -7°C) was not advised because of reduction in thermal capacity. I was not altogether happy about the use of anti-freeze (whose cost is not insignificant) and decided to fill with softened, alkaline boiler feed water and accept draining the system in winter. This has been the practice ever since and the plant has given splendid and trouble-free service to date.

Mid June 1977 Final Filters

Some bags of one cartridge found in weakened condition; this cartridge was renewed and the others inverted and replaced.

Early August 1977 External Control Thermostats

Following unsatisfactory control of relevant plant items these were discovered to be not as specified and were changed to correct type under the twelve months free maintenance and repair clause in the contract.

Early September 1977 — Final Filters

Inspection showed all was well with even dust loading; the cartridges were returned to use in their original positions.

Mid September 1977 — Regenerator

The west face was again founded coated with lint which was removed so far as possible as previously. More disturbing however was the discovery that the regenerator was inoperative due to complete failure of the self-aligning plain nylon bearings of the drive cross-shaft. It took some six weeks to get replacements supplied — a disappointing situation with winter coming on before the regenerator was again operational.

Mid December 1977 — Final Filters

No problems. Replaced as found.

Mid December 1977 — Regenerator

Surface lint removed. Attempts were made to dislodge embedded lint using jets of air, steam and water in turn with only partial success.

Late January 1978 — Regenerator

Internal squeaking warned of a repetition of drive-shaft bearing trouble which was confirmed on examination. Representations were made to the manufacturers who accepted return of the assembly for modification/repairs. The regenerator was out of use for a further six weeks. In the depths of winter at this time the consequent extra energy consumption was exemplified by the need to increase steam pressure to heater battery control valves from normal of about 0.6 bar (8 psig) to 2.5 bar (36 psig) to keep reasonable temperatures in the theatres with control valves wide open.

Early March 1978 — Final Filters

In generally good condition but part of one cartridge slightly suspect and was renewed.

Mid March 1978 — Regenerator

Manufacturers supplied and fitted replacement drive assembly incorporating, disappointingly, only minor modifications which did not apparently include any to the bearings. After only five days in use, inspection following recurrence of squeaking revealed a seized drive shaft bearing. Strong representations were made in writing to the manufacturers about the inadequacy of the design to stand up to service use. A re-design and the form that this should take was suggested to them and this included the use of ball instead of plain nylon bearings.

Early April 1978—Regenerator

A new drive assembly incorporating ball bearings was supplied and fitted by the manufacturers. At the same time it was arranged that they would clean the mesh in the rotor on site.

In preparing for this it was found that the mesh in that half of the rotor exposed continuously to incoming air during the weeks when it was stopped was showing clear evidence of wasting of the aluminium yarn which was beginning to crumble to powder. No doubt this was the result of oxidation aggravated by possible sulphurous pollution of the London atmosphere as well as erosion by dust particles and absence of the washing effect of exhaust air. The mesh in this half of the rotor was renewed and that in the other half was replaced after removal for thorough washing which cleared most of the embedded lint.

Since April 1978 the regenerator and filters have been examined at least once every three months and all has been found well up to the time of writing (late June 1979). However, there are signs that the original mesh in one half of the rotor will need to be renewed by about December 1979.

June 1979

It was interesting to find that over the last 15 months since new/cleaned mesh was fitted, the rate of lint accumulation on the rotor has been markedly less than previously. Also, and significantly, it lacks the slight greasiness noted previously. The source of this remains a mystery but its absence now is clearly aiding the self-cleaning features, ie, most lint fibres (which are presumably still present in the exhaust air) are passing right through the mesh to atmosphere instead of being caught by it.

Special Points

Two other points about this particular installation are perhaps worthy of mention, at the root of both of which are design constraints imposed by space and financial limitations.

The first concerns the humidifier. In spite of special measures to ensure injection of dry steam, injection into unheated or partially heated via the regenerator cold air in winter (when it is most needed) frequently gives rise to dew point problems in the ductwork and saturation of the final filters which fortunately have adequate wet strength to cope with this. The problem would be avoided by injection downstream of preheat or re-heat batteries. With concurrence of the theatre teams, the humidifier is not now used and RH is not often below 40%.

The second point concerns air flow switches operating 'flow' or 'no flow' indicating lights on the panels in the respective theatres. All efforts by the commissioning team to get these working properly came to nought — the lights either gave an erroneous indication of the true situation or kept flashing alternately. Having met this situation before in another installation and corrected it myself, I resolved to do the same here when the opportunity offered. The switch vane arms were lengthened and statically counterbalanced and the switches with their vanes were then repositioned in the ductwork in locations where air turbulence was judged to be at a minimum. This has been entirely successful.

A final point relevant to filtration standards in relation to degree of bacteriological infection is that, although the latter is not necessarily determined by the former, culture plates regularly placed at various locations in the theatres, including the floor, have never shown the growth after incubation of more than two colonies of non-pathogenic organisms such as *staph albus* or *micrococci diphtheroids*. No pathogenic organisms have ever been found.

Conclusions and Recommendations

The regenerator in this installation has demonstrated that it is recovering some 70% of heat energy which would otherwise go to waste; that it is recovering some latent heat although not designed to do so; and that, overall, it is more than paying for its initial extra cost. From the maintenance point of view, it does add to this load by virtue of being another piece of equipment with moving parts subject to wear and tear and requiring PPM. But, having got over the early difficulties with the drive arrangements, it has been reasonably trouble-free and quiet in operation. The normal useful life of the heat transfer material used in this instance and location would appear to be about three years before requiring renewal through oxidation etc. It is possible that this life could be longer in locations where the atmosphere is less polluted than in city centres. The lint pick-up by the rotor needs to be taken into account in plant design and layout and I would recommend filtration of air upstream of the rotor on the exhaust side but not necessarily on the supply air side. The provision of such filtration, which need not be of high efficiency, and could conveniently be auto-roll type, would not necessarily increase resistance to air flow beyond that otherwise caused by a clogged rotor. New rotors should be thoroughly de-greased before being put into use. Good access to both sides of the rotor should be provided by removable duct panels.

With the extract fan downstream of the regenerator the supply fan should, wherever possible, be upstream of it to give a pressure distribution which discourages fresh air 'pollution' by extract air across the rotor seals. Such pollution, nevertheless, is undoubtedly taking place in this installation. The filtration efficiency, however, is high enough to avoid any bacteriological problem as a result of it.

Bearing this experience in mind and also the findings of the Lidwell Committee, I would personally now be quite happy in my hospitals with a recirculatory system with say 10%-15% fresh air make up accompanied by the same standard of filtration, particularly since such a system would be inherently energy-efficient without need of a regenerator. In any other theatre ventilation scheme with which I might be involved in the future I would seriously consider re-circulation or alternatively a regenerator with a medium for total heat recovery, preferably one working on the heat pipe principal which has the attraction of no moving parts and ease of ensuring 100% sealing between supply air and exhaust air.

Finally, after over a decade of practical association, inter alia, with theatre ventilation systems, consultant surgeons and theatre staff, I have formed a hardening opinion that from the bacteriological point of view it is not necessary to go to extraordinary lengths to ensure super filtration of ingoing air. Once a reasonable standard of this is provided, the rest depends on sterilizing of equipment and appliances, surgical techniques, personal hygiene in the theatre and rigid enforcement of theatre discipline.

The author is Regional Engineer, SE Thames Regional Health Authority

Report on a Plate-Type Heat Exchanger Installed on a Hydrotheraphy Pool Ventilation System at Leybourne Grange Hospital

E. M. DAVIES, CEng FIMechE FCIBS FIHospE

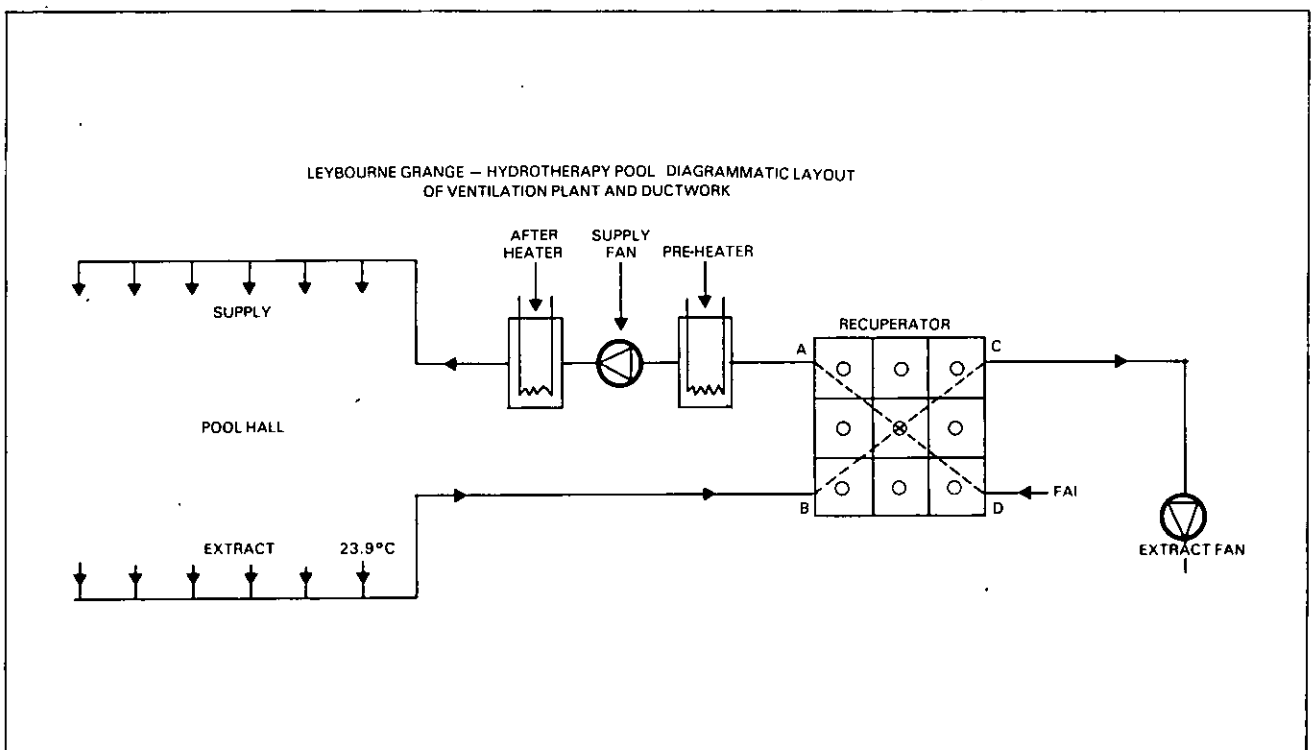
Introduction

In 1977 the DHSS sought a suitable location for the installation of an air-to-air recuperator and, on the recommendation of SETRHA, the Hydrotheraphy pool at Leybourne Grange Hospital was chosen. A recent upgrading at this pool included a new warmed air supply and extract ventilation system. Funds for the recuperator were made available by the DHSS, the design was carried out by the Region and the installation was funded by the District. Installation and commissioning were completed in 1978. To assess the economic benefits of the system test work was carried out by the RHA in February 1979.

Equipment

The recuperator is a plate-type, counter-flow heat exchanger in which the heating and the heated air streams are completely separated. Overall dimensions are 800 mm × 1,020 mm × 1,306 mm (31.5 in × 40.2 in × 51.4 in). Its location in the heating and ventilating system is shown diagrammatically in *Figure 1*.

Figure 1.



Most of the system is located in a plant-room roof adjacent to the pool hall.

The system operates on a 24-hour basis throughout the year. Supply air is initially heated in the recuperator by the exhaust air before being raised to its control temperature by steam coils in the air handling plant. It gains further heat in the pool hall as the water temperature is higher than that of the air over it. The air is then extracted and gives up heat in the recuperator to the incoming air.

Modifications to the system have included increased extract fan capacity. The air extraction rate is now about 10% greater than the air supply rate, the difference being made up by infiltration into the pool hall.

Test Results

Test work was carried out in February on a day of intermittent snow showers. The installed dial thermometers, a sling psychrometer and mercury-in-glass thermometers were utilised, while exhaust air discharge flow rate was measured by a Velometer. The test results are summarised in *Table 1*.

Table 1

	Average observed temperature °C			Derive Conditions	
Position	Dry Bulb	Wet Bulb	Wet Bulb °C	Moisture Content kg/kg	Heat Content kJ/kg Dry Air
Supply air at inlet	3.8	3.5		0.005	15.8
Supply air out of Recuperator	19.4		11.0	0.005	31.2
Discharge to pool hall	23.9		12.8	0.005	35.6
Vicinity of extract duct in pool hall	23.9	17.2		0.0096	48.1
Discharge from Recuperator to Atmosphere	11.9	11.8		0.0087	34.2

From *Table 1*, it can be seen that the heat loss per kg of exhaust air was 48.1 - 34.2 = 13.9 kJ. The heat gain per kg of supply air was 31.2 - 15.8 = 15.4 kJ. This difference is the result of the variation between supply and exhaust air flow rates.

There are a number of ways of calculating recuperator efficiency but, in this case, the manufacturers define the efficiency as supply air temperature change through the recuperator less the difference between exhaust and supply air inlet temperature.

This gives a figure of 77.9%, exceeding the manufacturers' predicted figure of 67.5%. However, the predicted efficiency is based on sensible heat transfer only. During the test period condensation from the exhaust air took place at the recuperator indicating a transfer of latent heat. This can raise efficiencies considerably. Moreover, the above formula takes no account of differing supply air and exhaust air quantities. Making allowance for these factors produces an efficiency figure of 70.6%.

Savings

Of the total supply air heat gain of 19.8 kJ/kg, 15.4 kJ/kg was provided by the recuperator. This represents a heat saving of 77.8%; such a saving is unlikely to be maintained in warmer weather as the beneficial effects of condensation from the exhaust air will not be achieved. An annual saving of about 70% is more probable.

Exhaust air flow was estimated to be 6,161 m^3/h. The corresponding total pressure drop through the recuperator is 67 mm WG and the equivalent fan power consumption, 2.06 HP.

The heat requirements of the pool hall are calculated to be about 9,100 therms/annum. Taking a boiler plus transmission efficiency of 75% and an oil price of 5.3 p/litre, these requirements would cost about £1,774 without the recuperator.

The recuperator can be expected to reduce direct heat requirements by 70% throughout the year, ie a saving of £1,242. The annual cost of extra fan power, however, is in the order of £245, leading to a net saving in running costs of £997.

The recuperator costs about £1,000; the installation being a further £2,600, so that a pay-back period of 3-4 years should be achieved. A recuperator included as original equipment in a new system should give greater benefits, as installation costs would be lower.

Maintenance

The casing of this type of recuperator is of galvanised steel. As such, it should prove reasonably durable, although protection from the weather would be beneficial in preventing accumulations of rain water on its horizontal surfaces.

The heat exchange surfaces are aluminium plates, accessible for cleaning by removing the casing. Adequate resistance to corrosion under condensing conditions is probable, although some caution in their use in salt-laden atmospheres may be necessary.

Under clean air conditions, and with suitable weather protection, this type of recuperator would have minimal maintenance requirements.

Conclusions

The test results indicate considerable potential for heat savings by the use of recuperators in ducted H & V systems. Such savings will be proportional to the period of operation so that continuously-operating systems provide the highest potential for recuperator use. High casual heat gains, eg from the pool surface in the case considered, can be largely recovered instead of being completely rejected.

The plate-type recuperator is particularly suitable for hospital use due to complete separation of the air streams. As it has no moving parts its maintenance requirements should be low when adequately protected and installed in a clean air situation.

Installation as original equipment will minimise costs, as will close proximity of supply and extract ducts to each other.

The author is District Works Officer, Sutton and West Merton Health District.

Energy Conservation at Wandle Valley Hospital

G. K. CRUICKSHANK FIHospE

The Hospital

This hospital which was originally built in 1920 as an isolation hospital is now a 60–70 bed geriatric unit. The buildings are of traditional 13½-in. solid wall brick construction with tiled roofs. The majority of the buildings are single storey.

Conversion of the Boilers

The change in use of the hospital meant a reduction in the amount of steam required for other than heating purposes. After a survey was carried out it was decided to replace the two 3,500 sec oil fired Lancashire type steam boilers for local gas fired boilers and to adapt the existing building services to suit this conversion. At the same time it was also decided to install 75 mm glass fibre quilting in all the roof spaces. Due to shortage of money it was not possible to change the whole system at once. A scheme was planned and the first local boilers, in Ward 5, came in service in January 1975. The other wards followed in reverse sequence until the steam boilers finally closed down in March 1977.

The boilers for the new installation were put into the existing calorifier rooms, pumps were fitted to the primary feeds to the calorifier and to the heating circuits. Controls were also fitted which could give night setback. Time controls have been fitted to the cyto-pathology laboratory which closes at the weekend. These changes have made energy savings of the order of 50%.

Cost of the Scheme

The cost of the scheme was in the order of £50,000 which included laying a new gas main around the site. Another saving, which in fact is hidden, is the reduction of the staff by four stokers, one of which remained at the hospital but in the grade of Hot Water Fitter's Mate. The other three were transferred.

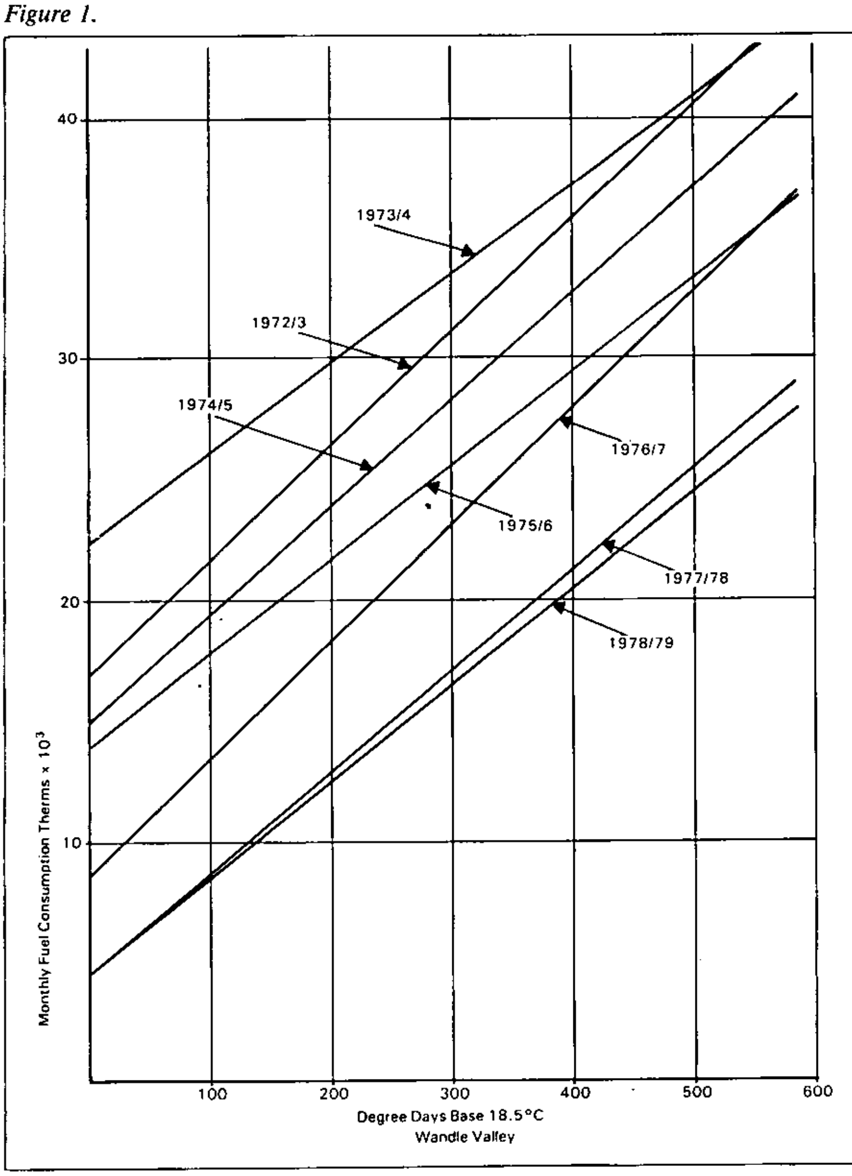
Energy Savings

The energy savings can be assessed in two ways, ie graphically and mathematically. In 1972/3, 371,074 therms of 3,500 sec oil covering 3,073 degree days giving 120.75 therms/degree day, whilst in 1978/79, 173,872 therms of gas at 3,189 degree days giving 54.52 therms/degree day.

The regression curves of fuel in therms/hospital degree days have been plotted for the periods from 1972/73 to 1978/79. The points on the earlier curves showed a great deal of scatter indicating that the controls then fitted were not very effective possibly giving a large degree of mild weather overheating. The new controls, however, are following the change in ambient temperature much more closely.

The graph in *Figure 1* shows the progressive annual fuel saving from commencement of the conversion until completion in March 1977. Fuel consumption during 1977/8 and 1978/9 has remained at a consistent level.

Figure 1.



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Energy Conservation at Winford Orthopaedic Hospital, Bristol

M. I. LEES CEng FIMarE FIHospE

Winford Orthopaedic Hospital

The hospital which was built in the 1920's is of traditional design and is situated on an elevated position to the SW of Bristol. In 1940, EMS hutted accommodation was added and later, in 1965, a physiotherapy building of cavity brick with flat roof was also added. Small short life buildings have also been added from time to time. The laundry was destroyed by fire in the early 1970's.

Energy Savings

Following a letter from the Chief Engineer, DHSS in January 1975, it was decided to survey the hospital to find out where energy savings could be made. A joint inspection by a team comprising Engineer's, Architect's, Treasurer's and Supplies' representatives was carried out in March 1975.

Roof Spaces

The Building Surveyor made recommendations that 75 mm glass fibre quilts should be laid in all roof spaces and, where possible, within the cavity walling of the temporary hutting. He suggested also that various doors and lobbies should be built to minimise heat losses through excess air infiltration eg the link corridor for the EMS hutting which was open at both ends and had one complete wall panel missing to give access to a calorifier room. An attempt was to be made to reduce the glazed area wherever possible.

The Boiler Plant

The mechanical Engineer's report covered the mains boiler plant, all calorifiers, associated pipework, and all the various wards and departments.

The original boiler plant consisted of two Lancashire type 3,500 sec oil fired boilers with Green's economisers rated at 7,000 lb/hr from and at 212°F. The boiler pressure of 150 psi was originally needed to run steam engines for driving the electric generators which supplied power to the laundry. After the laundry fire it was therefore possible to reduce this pressure to 60 psi and only raise it to 150 psi for the generators in the event of a power failure. Steam driven Weir pumps supplied the feed water to the boilers and the exhaust from these was fed into a low pressure steam line serving the LPHW calorifiers. Steam was provided for two main calorifiers by pipework which for the EMS accommodation was run overhead and in ducts for the other buildings. A boiler house calorifier provided heating and DHWS to the Ward Blocks, Nurses/Admin Block, Theatre/X-Ray Department and Chapel. The heating calorifier was provided with a Satchwell outside compensator and a modulating three-way valve control system. The EMS ward calorifier room provided heating to the six hutted wards, kitchen and dining room from one calorifier which had an external compensator of the direct acting type modulating steam flows at the inlet valve. A second calorifier provided LPHW at a constant temperature to the Physiotherapy building and Greenhouses. Some of the steam distribution mains were buried in the ground with service pits at trap sets and expansion joint positions. Corrosion was present on mild steel supports and three trap sets were faulty, either passing steam or condensate into the pits. From small sections of the steam mains the insulation had been removed and steam leaks were apparent. A single steam line was run just to serve one bed pan sterilizer in Ward 'A'.

From the foregoing it can be seen that there was a triple distribution of steam, LPHW and DHWS around a rather spread site, consequently the total circulation and distribution losses were, in all probability, very high.

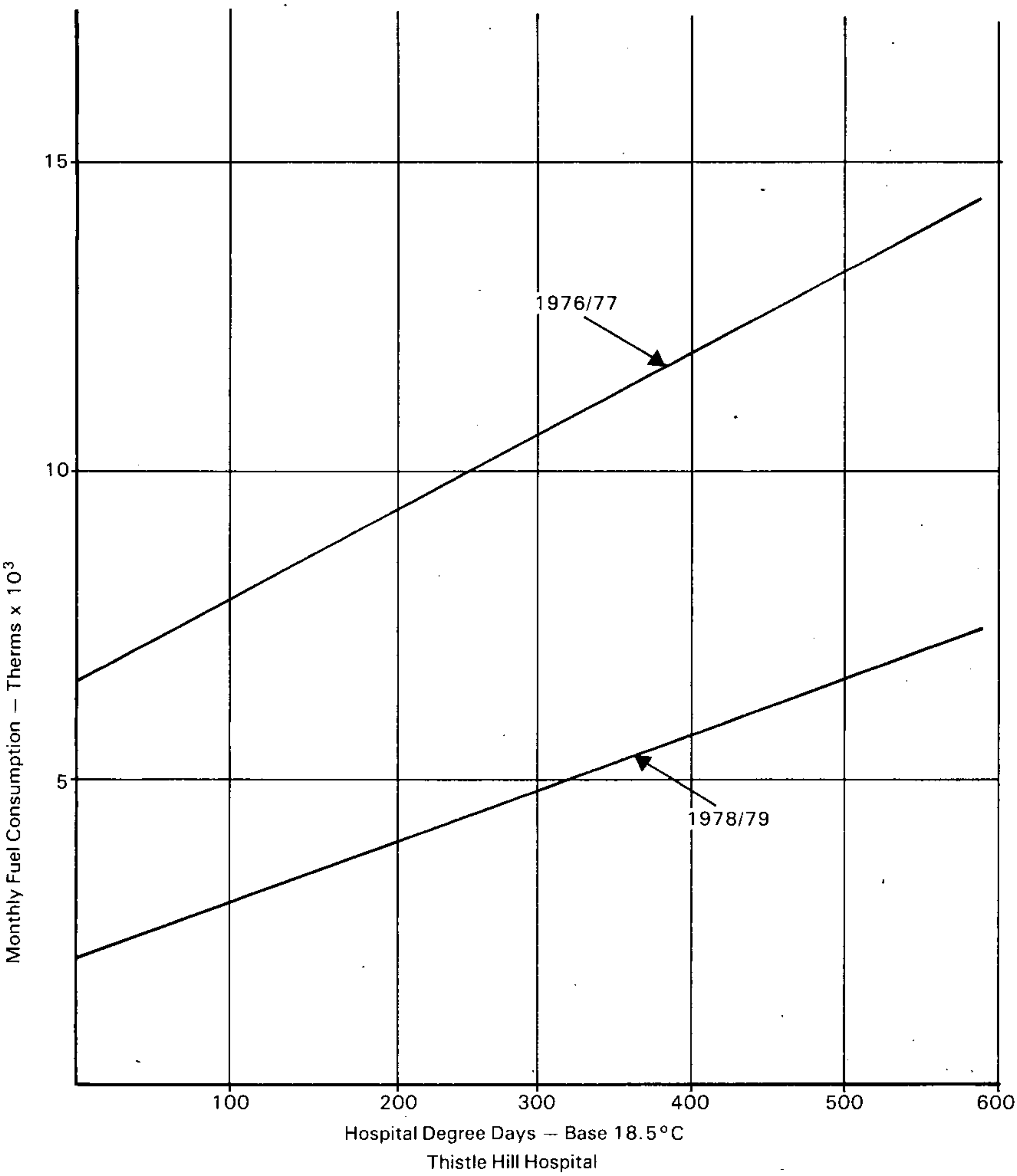
The Changes Made

It was decided to decentralise the boiler plant by the provision of four Allen Ygnis combination boilers in two locations — the EMS Calorifier room and the main boilerhouse. Simultaneously, arrangements were made for the replacement of sundry steam using apparatus in the kitchen, dining room, theatres and Ward 'A', thus permitting the removal of the entire steam distribution system. A small summer boiler was provided for the operating theatre block to allow the long LPHW heating mains to be shut down during the summer months. Sundry improvements were made to the heating controls including provision of time clock control in the physiotherapy building. The cost of the programme which enabled the existing LPHW and DHWS systems to continue in service with the minimum of disturbance and alterations was in the region of £40,000 including provision of ceiling insulation and other building improvements.

Other energy saving equipment installed was a solar panel to supplement the water heating facilities of the swimming pool. To show the savings, the consumption of oil has been brought to a common base of therms using 1.766 therms/gallon for heavy oil and 1.637 therms/gallon for the light oil used in the new boiler plant.

Fuel consumption see *Figure 1* in 1975/76 (3,081 degree days) was 292,702 therms and in 1978/79 (3,357 degree days) was 158,824 therms. A saving of approx 46% in fuel consumption has thus been achieved.

Figure 1.



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Engineering Improvements at Monsall Hospital, an infectious diseases hospital, with the objective of achieving a reduction in energy consumption

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Background

The hospital was built in 1871 and consists of approximately forty widely dispersed buildings of brick construction with pitched tiled roofs. The majority of these buildings are single storey with about five two storey units. The hospital is situated in a slightly elevated position, in a highly populated industrial part of a large northern city. The hospital was originally a 'Fever Hospital', accommodating about 400 infectious diseased patients. The establishment is now used for a variety of health care purposes and caters for about 300 patients having a variety of ailments. At present the distribution of patients is roughly:

15% Geriatric,
10% Orthopaedic,
30% TB and Chest,
30% Infectious Diseases,
15% Decanted for various reasons.

The infectious diseases section houses such diverse units as the Regional Lassa Fever unit, the Australian Antigen 'B' Dental Department, and a Hyperbaric Chamber Unit. There is also a Nurses' Home and a Regional Staff Training College on the site.

Practically all the engineering services which existed in the early 1970s were as installed during the years between the two world wars. The only significant work in the post 1945 period being the conversion of the 47 local LPHW boilers providing heating and/or domestic hot water from solid fuel to oil firing.

Although the building services were adequately maintained up to 1973 there was no engineer in charge of the engineering equipment and all engineering maintenance was carried out on a 'Jim'll fix it' basis. In 1973 the archaic engineering state was recognised by the 'new' engineer, not as a nubile young virgin, but more as the untouched old maid. With this in front of him a start was made on improving the engineering installations.

The following narrative is however concerned with the work carried out progressively since this date and the effect this has on energy consumption.

Original Installation

All of the original DHWS and heating systems were installed as gravity flow circuits, but accelerators had been added in a few instances. These were of inadequate capacity and were fitted without isolating valves. The radiators were generally connected direct into the single pipe systems without hand valve provision and in many buildings the installed heating surface was inadequate thus compounding the circulation problems. In severe weather complaints from the departments of underheating were frequent.

The boiler conversions were in general of poor quality and in most cases it was impossible to detect any CO_2 presence in the flue gases. The only controls provided on the installations were the boiler thermostats. If these thermostats were set below about 130°F during mild weather the circulating head was lost and the system ceased to function.

Constructionally, the buildings were sound but the large expanse of roof space on these mainly single storey structures was totally uninsulated, thus allowing most of what little heat the old girl was producing to go literally straight through the roof. There were also a number of clerestory roof lights in internal areas which are the cause of down draughts. Following a fire in one of the boiler houses, the Fire Officer recommended that all the individual oil storage tanks (many of which were located against an outer wall of the building they served) be re-sited away from the buildings.

Engineering Improvements

As the re-siting of the oil storage tanks had very high financial implications it became the trigger which fired off the decision to convert to gas. Gas firing would then meet the requirements of the Fire Officer and provide a much needed and more economic method of heating.

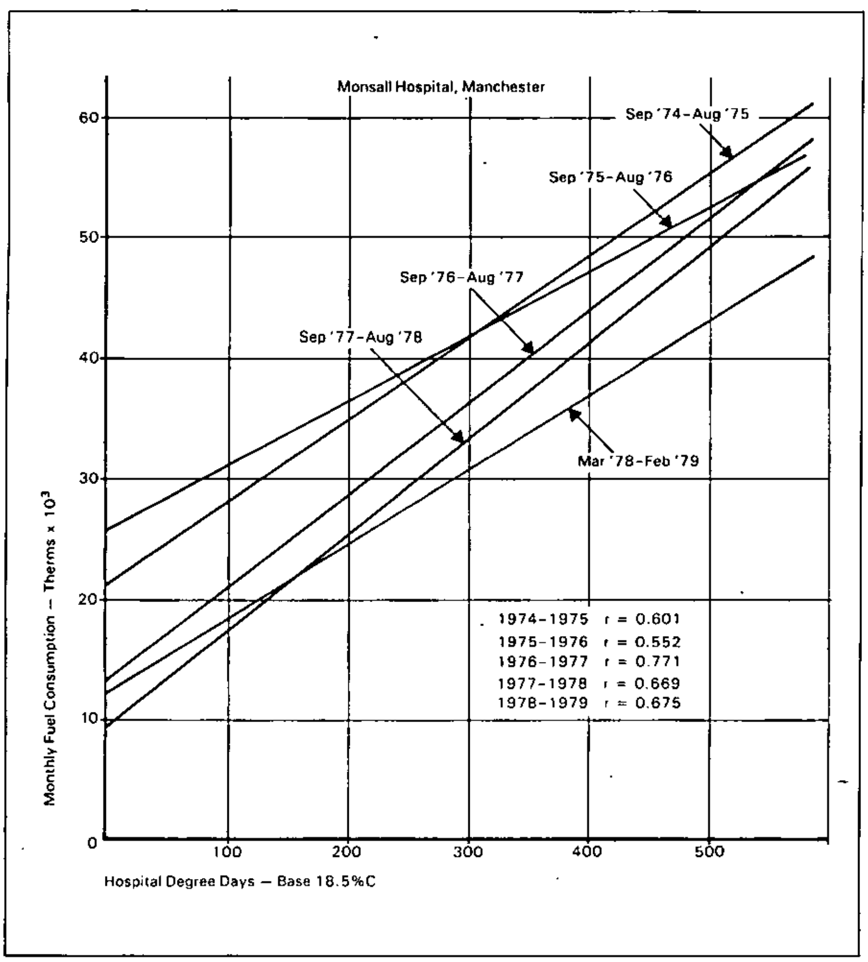
Major improvement work started during the period of September 1976 to July 1977. This involved the laying of gas mains around the extensive site at a cost of approximately £20,500, along with the renewal of 11 boilers and the conversion of 35 others from oil to gas firing at a cost of approximately £24,600. The new boilers were required because the previous plant was inadequately rated or in such a state as to make it unsuitable for conversion. In addition three new heating systems were installed, one in particular being in the pharmacy which had been heated entirely by electrical energy.

By August of 1977 all heating and DHW services were 'on gas' and approximately 85% of the heating systems had been provided with adequately sized circulating pumps.

During the 'gas conversion' the hospital incinerator was also changed to gas firing.

In the period following 'the big job' up to May of 1978, all remaining heating systems, with the exception of a small day nursery, were provided with circulating pumps. All the heating boilers are now controlled by Honeywell 'Aquatrol' outside compensating equipment which allows the ambient temperature to govern the boiler output. By the end of the period most of the wards and major buildings had been equipped with pumped DHWS leaving only a few very small gravity systems still in existence. Approximately 12 buildings, whose occupation is intermittent, were fitted with night time set-back and weekend shut-off facility timers. Sectional thermal insulation was fitted to all pipework not classed as part of the required heat output surface and some calorifiers were relagged.

Figure 1.



Building Improvements

During the period of time from 1976 to 1978 inclusive, improvements had also been taking place on the building side. New windows and frames had been installed in the wards. Progressively over this period all the roof spaces had been thermally insulated. In two of the buildings, the provisions store and the linen store, continuous ceilings were provided where draughts from roof lights were a particular problem.

Expenditure

The expenditure on all building and engineering work including the provision of site gas distribution, totalled approximately £60,000.

Energy Consumption

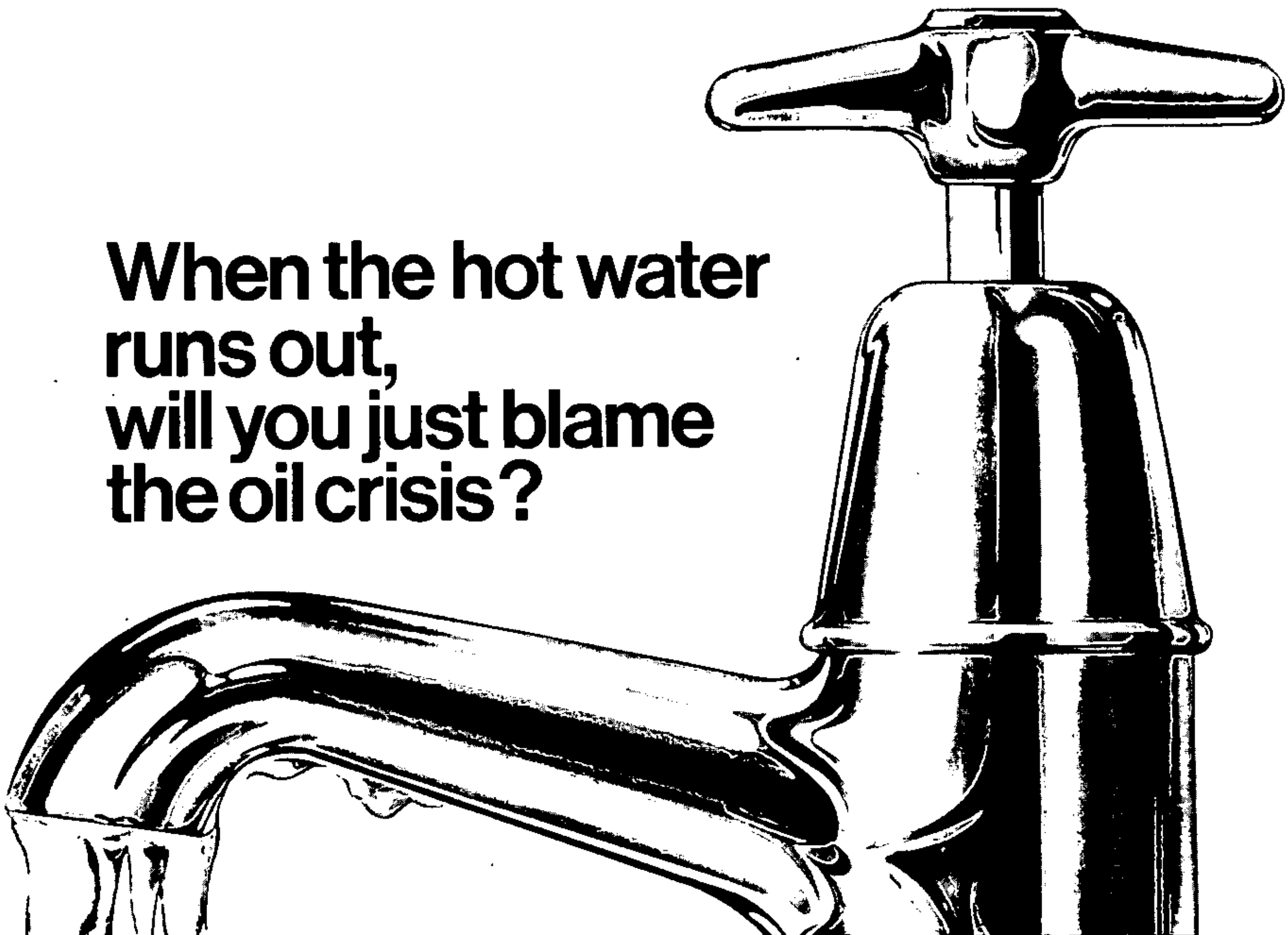
The operational policy followed at this hospital has been to shut all heating boilers down during the summer months due to the inability to achieve reduced heat input during warm weather. The annual mean performance lines for the individual years from 1974/5 to 1978/9 are shown on the graph in *Figure 1* — monthly fuel consumption being plotted against a datum of hospital degree days.

The apparent saving in raw fuel consumption achieved over this period is 20% equivalent to £15,000 at current gas prices. Actually the saving is greater than this value due to the fact that the 1977/78 and 1978/79 lines include kitchen gas and incinerator gas usage which are excluded from the data for the earlier years. It will be evident from the above information that the expenditure on energy conservation work, engineering improvements and arrears of maintenance will be recovered in four years. This outcome is encouraging and will act as an incentive to proceed with the multitude of major and minor works necessary to bring the heating installations up to date including the provision of manual control valves and sub-zones, so that unneeded radiators can be shut-off. In other words, we can't rest on our laurels, there's still more to be done yet.

Conclusion

Although the old lady may not be as fetching as she was in her youth, the improvements have given her a fresh lease of life and passion. She is no longer the expensive kept woman she was five years ago and with a few more improvements to her bustle we may no longer be 'not amused'.

When the hot water runs out, will you just blame the oil crisis?



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Mr Feasey is Senior Engineer, Park Prewett Hospital, Basingstoke.

Energy Conservation at Hackwood Road Hospital — time clock control of heating services in intermittently occupied buildings

E. W. FEASEY TEng(CEI) MIHospE AMISM

Introduction

This short article shows the results obtained from the provision of time-clock control in a Psychiatric Day-Hospital. The history of this establishment is that it was originally a busy thirty-bed Cottage Hospital. It had operating theatres and other medical supporting facilities and was situated in the centre of an expanding provincial town.

When the new Basingstoke District General Hospital came into use in 1975, the Hackwood Road Hospital was closed. It was re-opened in 1977 as a Psychiatric Day-Hospital, together with office accommodation for Community Health Services and Education.

At the present time a large proportion of the available space is unused, or only partially used during office hours, and the whole building is unoccupied at night.

Original Boiler Plant and Engineering Services

The original boiler plant consisted of two Beeston cast-iron sectional boilers burning 35 sec oil. These had been converted from solid fuel during the immediate post-war years. One boiler provided LPHW heating services and other domestic hot water. The only controls on these boilers were the boiler control thermostats; consequently heating control was limited to the periodic manual adjustment of the heating boiler thermostat. During the Summer months the heating boiler was shut down.

New Boiler Plant and Time Clock Controls

In late April 1978 the heating boiler failed. As an emergency measure the DHWS and heating circuits were interconnected, so that the DHWS boiler could fulfil both functions. Two Hamworthy gas fired boilers were installed as replacement units in September 1978, one boiler being operational and the other standby. At the same time a time clock and frost thermostat were fitted to the heating pump. The clock was set to shut down the circulation between 9.00 pm and 7.00 am. From October 1978 to May 1979 the duty boiler operated an 'as required' basis to maintain the domestic hot water at the required temperature since this was continuously circulated.

Comparative Performance

The monthly fuel consumption before and after the boiler replacement is shown on the graph in *Figure 1*. It is immediately apparent that the space heating fuel consumption has been reduced to approximately half of the previous level by the simple expedient of shutting down the heating circulation pump overnight.

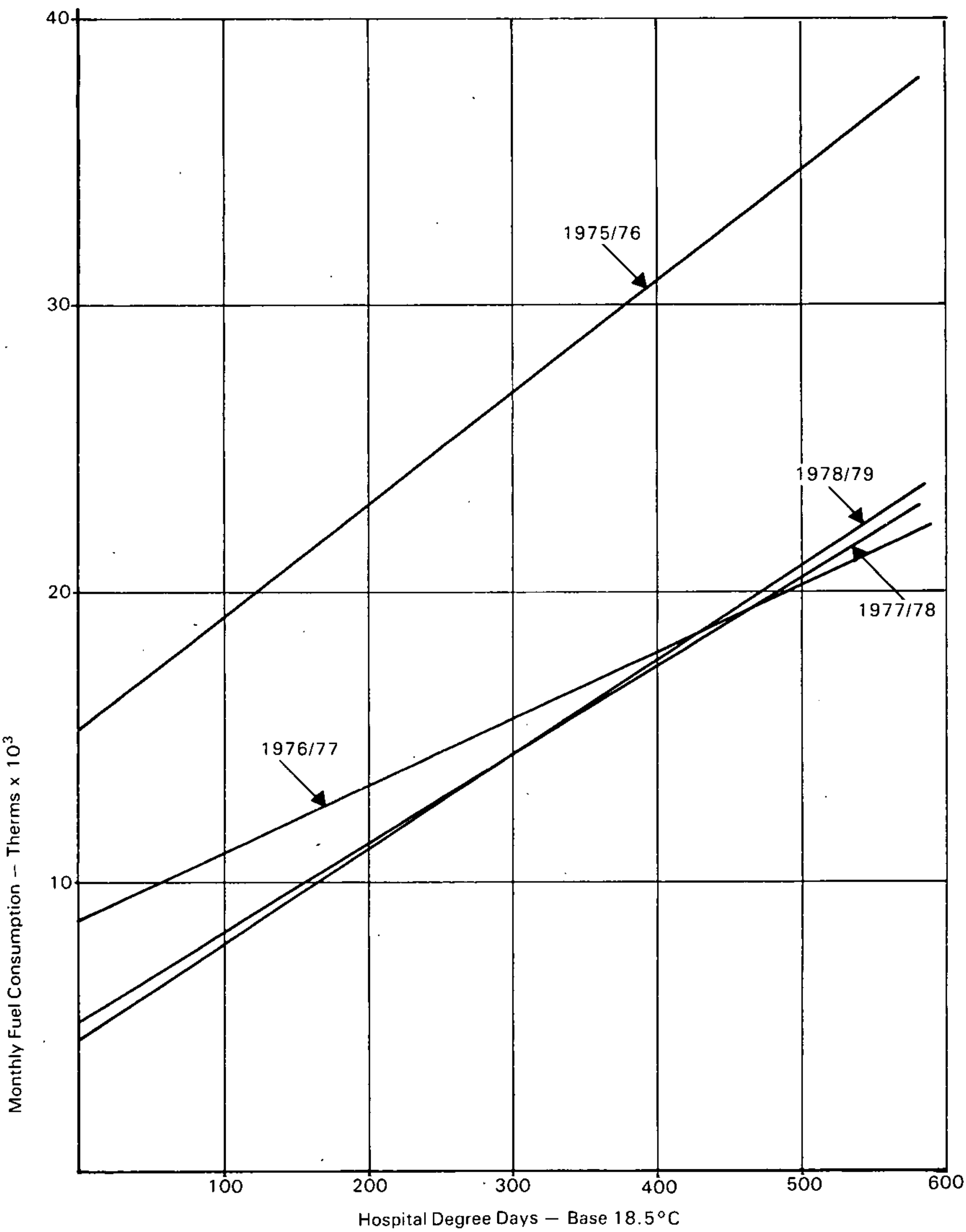
Other Aspects

The graph also shows the effects of failure to adjust the boiler thermostat in accordance with the milder weather conditions which prevailed in April 1979. This demonstrates very clearly the need for automatic outside temperature control in those buildings which are remote and which do not have an engineer on site. This summer outside temperature compensating controls have been installed.

The points on the graph for the summer months when the heating boiler was shut down show that the fuel consumed for the DHWS services amounted to approx 1,100 therms per month. The value for the new gas fired boilers will be similar since the only operational difference will be a slightly improved combustion efficiency.

As the DHWS draw-off is comparatively small in a building which is used as a Day-Hospital and office accommodation, a test is in progress to ascertain whether pumped circulation is necessary. If there are no complaints from the users, the DHWS system will be reduced to a gravity dead-leg basis which will enable the boiler to be shut down completely overnight. This operational change should result in a further saving of about 500 therms per month. In the long term it is hoped to be able to make local provision for DHWS in the form of Ascot and multi-point wall mounted heaters.

Figure 1.



Winford Orthopaedic Hospital

The author is Area Engineer, Redbridge and Waltham Forest Area Health Authority and was formerly employed as the Regional Energy Conservation Engineer in South West Thames RHA where operational experience with this equipment was first gained in the NHS.

Boiler Combustion Optimisation by means of oxygen control

R. E. STOKES CEng MIMechE MIMarE MCIBS FITE AMBIM

Introduction

The term boiler combustion efficiency has featured prominently with design and operation engineers for many years. Freely available fuel at relatively low cost relegated it to a secondary role in the National Health Service compared with capital spending in the one hand and continuity of services on the other. Now that significant investment on energy saving work is taking place and we are threatened with severe fuel shortages, boiler combustion optimisation is crucial, since energy lost in the boiler exhaust can never be replaced by improvements outside the boilerhouse.

Background and Development

Boiler burner manufacturers would possibly not agree but it is a fact that fuel burning and combustion control equipment have not developed at a rate commensurate with the worsening energy situation. This is for a variety of reasons, such as lack of demand in earlier years, too big a share of a captive market and the 'annual hardy' of the need to remain competitive. The fault is clearly not entirely of their own making but the response to a changing situation has been very slow. Another factor is the growth of fringe industries such as instrument and controls firms who provide monitoring and control equipment to help refine the fairly basic control equipment provided by the burner manufacturer.

Monitoring Equipment

The monitoring equipment has generally involved eductor systems with the use of chemical reagents such as Orsat analysis equipment or the more basic and robust Fyrite equipment. The former measures CO, CO_2 and O_2, while the latter can measure CO_2 and O_2 although generally only CO_2 is measured. Continuously reading and recording CO_2 instruments utilising the electrical conductivity properties of gases are often installed and these also use the eductor principle. The manual sampling devices provide only spot readings, they are time consuming and most eductor systems require considerable maintenance to ensure reliability. The latter is true also of the continuous reading devices which are rarely found in good working order.

Control Equipment

The most widely used control systems have been:

Fuel/air ratio control devices whose performance is limited by the ability to measure accurately the air and fuel at reasonable cost, the absence of feedback from the combustion process and the need to vary the ratio with the boiler load conditions.

The oxygen control system which has the advantages of compensating for fuel quality, ambient conditions, errors that may occur in flow measurement control and mechanical wear of burners, linkage etc.

One approach to oxygen control has been the utilisation of the paramagnetic properties of oxygen in conjunction with an eductor system. More recently the development of the zirconium cell in aerospace research has led to recognition of its potential in the combustion control field and it is the operating experience of this latter patented system that is the subject of this paper.

The Zirconium Cell Oxygen Monitoring and Control System

The oxygen sensor is installed in the flue gas stream at the nearest practical point to the boiler exhaust to minimise dilution. It is pointed away from the gas flow to avoid fouling and impingement. The sensor comprises a stabilised zirconium disc with platinum electrodes attached to its opposite faces and a pure oxygen ion conducting solid electrolyte. By supplying reference air to the inner face and exposing flue gases to the opposite face, a voltage is generated between the disc faces which is a function of the temperature and the ratio of the oxygen partial pressures at the disc faces as shown in the equation:

$$E = 0.0496\, T \log_{10} \frac{(P_0)}{(P_1)} + C \text{ millivolts}$$

where T is the absolute temperature (K); P_1 is the reference gas partial oxygen pressure; P_0 is the exhaust gas partial oxygen pressure; and C is the cell constant.

The cell temperature (T) is controlled at a fixed temperature. The reference air oxygen partial pressure is also maintained constant and the change in cell output is therefore directly related to the oxygen partial pressure of the flue gas increasing logarithmically with increasing oxygen concentration.

The signal from the probe is amplified and converted to a 4 to 20 milliamp signal supplying the linear motor controlling the continuous chart recorder between pre-set limits of 2 to 3% O_2 on gas and 2.5 to 3.5% O_2 on oil fuel systems. If the pointer moves out of the control band, an impulse signal is fed to the motorised trimming multi-leaf damper usually positioned across the existing combustion fan air intake. The impulses are for 2 to 7 seconds duration, six times every minute which permits a constant surveillance of the load requirements and avoids hunting between the fuel and air controls.

The probe heater takes up to twenty

minutes to stabilise at 850°C and does not attempt to control the O_2 level below that temperature. It is a design feature that combustion air below 35 to 40% load is not controlled, because the fixed O_2 control could lead to dangerous amounts of CO being generated and create difficulties at start-up.

The installation of the control cabinet within sight of the boiler front assists burner maintenance.

Safety features are built in which always restore the damper to the fully open condition in the event of excessively low or high O_2 readings, or any mechanical or electrical fault condition and normal shutdown. In more complex installations than the standard packaged boiler, the control signal may be utilised to operate a by-pass damper circuit to the existing burner damper, or in some installations it may be utilised to operate an existing induced draught fan damper.

It is a pre-requisite of the system that sufficient margin should exist for control to take place and this is achieved by setting the burner up at 5% O_2 over the full range of modulation.

Equipment Selection for Trial Installations

Prior to deciding on the above type of equipment for the initial site a major burner manufacturer's alternative equipment was considered. However, fuel/air metering equipment operating on the eductor system was offered which was unsuitable for the twin burner shared flue system. This proposal was rejected.

As feasibility of O_2 control equipment was investigated at subsequent sites, consideration was given to the burner manufacturer's proprietary equipment but there appeared to be a reluctance to make a firm offer due either to uncertainty regarding performance or the possibility of patent infringement. Although the burner manufacturers' equipment was cheaper, the offer included the undesirable eductor sampling system and omitted continuous recording facilities of the boiler performance. These factors led to the original equipment selection being repeated for the subsequent installations.

The Trial Installations

The savings claimed by the firm on the basis of past experience varied from 1½ to 5%. Before recommendations were made, each site was examined and spot checks were made on combustion performance over the operating range. The site engineer's advice was taken on the fuel consumed annually per boiler. The writer's judgement of the best manner to achieve payback was then made. Generally this resulted in sufficient boilers being treated at each site to carry the baseload and the site engineer's being requested to utilise those particular boilers for the base load during the first year of operation.

This form of decision making usually resulted in boilers only generating at least 10,000 lb of steam per hour per burner being chosen, with the expectation that they would operate at that level for at least six months of the year on average.

The following installations in the South West Thames Region came within these parameters.

Two of four 40,000 lb of steam per hour water tube boilers with twin burners sharing a common flue and induced draught fan in a central boiler house feeding several psychiatric hospitals. One 12,000 lb of steam per hour package boiler of a 2½ boiler installation in a conventional district hospital boiler house. One 12,000 and one 10,000 lb of steam per hour boilers in a hospital with a CSSD and laundry attached. Two 12,000 lb of steam per hour boilers at a large psychiatric hospital. The first installation chosen consumed gas and 3,500 seconds HFO on an interruptable gas contract, the second and third used gas on firm gas contracts and the final site used 3,500 seconds HFO.

Ultimately the equipment was considered for use in a new boiler house comprising three 10,000 lb of steam per hour gas fired boilers incorporating an ICCO exhaust gas recuperator capable of use with either of one pair of boilers. It was decided to install the oxygen monitoring and control equipment to one boiler of the pair connected to the ICCO and to the third boiler. This installation is not yet complete and has been overtaken by events which are related later in this article.

Operating Experience

Minor teething troubles have occurred at most sites, which is not unusual with new equipment. The firm has always responded quickly to such situations and replaced components at no cost as one would expect. Occasionally when operating experience has revealed the need for desirable minor changes in the equipment, these have also been provided at no cost or significant inconvenience.

Two startling revelations have been the amount of defective burner and control equipment that has been in operation, despite being subject to the relevant burner manufacturers regular maintenance visits, and the number of installations that have been operating with dangerously low levels of excess air. The latter has naturally occurred in natural gas installations, because oil firing equipment would have produced smoke. Again the equipment has invariably been the subject of maintenance visits by the burner manufacturers.

The writer's theory for this situation is that dual fired installations are set up on oil with the air damper fixed. When setting up the gas burners, the claimed boiler output cannot be achieved within normal CO_2 settings at the fixed damper position and gas rich mixtures result. In fact there appears a reluctance by all parties concerned to accept a down rating of the boiler when operating on natural gas.

Yet another worrying aspect is the reluctance by maintenance and operations staff at all levels below Area Engineer to accept readily the operating principle of the equipment and apply themselves to making it work. It is a prerequisite of the equipment that it should be switched on the whole time the boiler is operational and in the event of faults, or perhaps the setting up of the burner, only the automatic control should be switched off. Site staffs have many times failed to follow these instructions. This has led to fouled probes because the heater has been switched off and sometimes fault conditions arising because when switching off the main power with the damper partly closed it has no opportunity to motor open. Problems have also occurred with flooding of the pen and chart due to switching off the recorder rather than leaving it in the operational mode.

Although the installation contracts were let by Area rather than Region, site staff have sometimes failed to involve themselves with the installation during the commissioning period and when the firm has left the site they have called in the burner maintenance operative to check the burner without advising him of the parameters required by the firm. These mishaps and others have led to a set of operational instructions being agreed by the writer and the firm and these are now fixed to the outside of the control box in full view of the operator.

Failure to achieve rapport with the burner manufacturers' operatives and the likelihood of this becoming a growing problem if further installations should follow, allied to the proposal to install the equipment in the new boiler installation within the burner warranty period, but outside the contract, culminated in a meeting between the writer and the directors of the respective burner manufacturing company. At this meeting it was stated that fixed O_2 control was not suitable for fixed geometry burner registers other than over a limited control band. The danger was stated to be the possibility of CO being produced and the possibility of damage to highly rated boilers. The alternatives appear to be:

Control O_2 only down to about 55% load at the levels previously stated;
raise the O_2 level and control over the full range from 35% load upwards: or
go to variable O_2 control.

Option one would limit the economic and safe operation of the boiler but hopefully boilers should be loaded to 55% and above anyway.

Option two would seriously affect the savings over the operational range and would be likely to waste money by incurring excessively high excess air levels.

Option three would mean the nullification of the prototype installations already completed.

The burner manufacturer's comments were put to the O_2 control firm with reservations. The reply was that variable O_2 equipment was available but that it had not been offered because the characteristics of contemporary burners did not warrant this refinement. Evidence was also produced of burner installations, commissioned by the manufacturers, operated at unsafe O_2 levels.

Future Developments

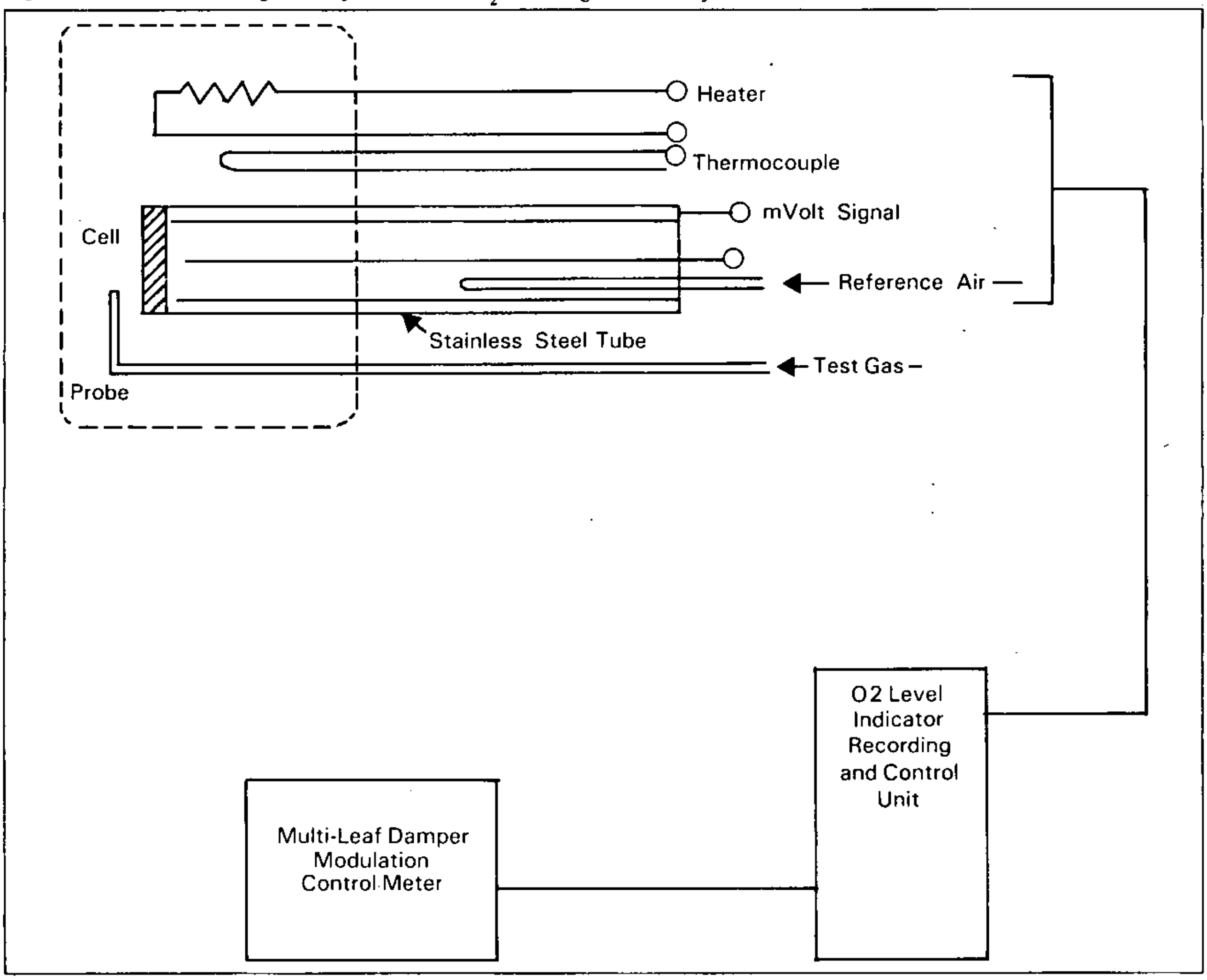
The divergent views of the burner manufacturer and the O_2 control firm regarding the acceptability and economics of fixed level O_2 control for boilers has led to Segas being invited to monitor both fixed and variable O_2 control units in the new boiler installation described. The O_2 control firm has readily offered a variable control device to replace one of the fixed O_2 devices in a bid to resolve matters and prove the acceptability of the system for NHS installations.

The test will attempt to determine the minimum safe levels of O_2 for gas fired plant, the likely savings and the levels of CO produced if any. The acceptability or otherwise of O_2 control equipment should thus be established.

Conclusions and Recommendations

The economics of a fixed O_2 controller (see *Figure 1*) must be verified at the earliest opportunity. Inadequate metering in most boiler houses coupled with teething problems, inadequate maintenance standards, equipment component failures and poor staff reaction have delayed continuous operation sufficiently to introduce the further difficulty of lightly loaded boilers. This probably means that conclusive evidence may be available from the Segas monitoring of the new installation before an assessment can be completed for the existing installations. The last statement demonstrates very clearly that

Figure 1. Schematic Arrangement of Fixed Level O_2 Inheating a Control System.



in addition to having the right combination of boiler size, number of burners and flueing arrangements for equipment payback, one must also have boilers matched to both summer and winter loads to effect savings.

The acceptability by some burner manufacturers of fixed O_2 control will only be achieved when it has been tested successfully by an independent body such as Segas. In the event that it is not successful, variable O_2 control will be available but the same constraints on effective savings and even more teething problems may be expected.

The question of suitable staff reaction could well be overcome by training by the firm who have indicated that they would be happy to provide it.

The writer's opinion is that fixed O_2 control will prove successful and savings of $1\frac{1}{2}$ to 2% will result, although a colleague in PSA who shared those views and who expected to verify them within the past month has met precisely the same staff and burner manufacturers' problems as described in the preceding paragraphs.

Some indisputable advantages of the equipment are the continuous performance record of combustion conditions, the opportunity to replace high maintenance cost/poor performance CO_2 meters and the ease and saving in boiler burner maintenance.

The rather jaundiced view by the burner manufacturer must be put in perspective by the facts that the O_2 direct readings are instantaneous and are more accurate than Fyrite spot checks. The lower O_2 figures relate to wet O_2 gas rather than dry CO_2 gas. It must also be realised that the O_2 set point acceptable to the burner manufacturer must allow margin for change in ambient conditions, burner linkage, wear etc, whereas the set point in a continuously controlled condition can be much lower.

Clearly O_2 control equipment has many desirable features but from the contractual viewpoint it would be much better incorporated in the initial boiler/burner installation in conjunction with the burner manufacturer.

The author is Regional Engineer, Yorkshire Regional Health Authority.

Energy Conservation at Thistle Hill Hospital, Knaresborough

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Thistle Hill Hospital

The hospital comprises five separate ward blocks together with an administrative block, a nurses' home, a small building housing a few items of laundry equipment and a porter's lodge. It was built as the Harrogate and Knaresborough Isolation Hospital in 1907 for tuberculosis patients and is now used as a 48-bed geriatric unit.

The Heating System

The original heating system was retained until quite recently and consisted of two Cornish boilers with chain grate stokers rated at 1,200 lb/hour and operating at 50 psig. Steam was distributed via pipework in concrete ducts to the various blocks where the pressure was reduced to 15 psig. Block D was the only one heated by low pressure hot water, the remainder being provided with steam heated cast iron radiators. Domestic hot water was provided by steam heated storage calorifiers in each block. The heating and hot water service controls were very basic and comprised hand wheel valves on radiators and direct operating automatic steam valves on calorifiers.

The New Hot Water Heating Systems

In 1975 the boilers were due for replacement and the fuel returns were most unsatisfactory. The Area Works Officer investigated the cause of the problem and, in so doing, found that the steam and condense mains were also badly corroded and would need replacement in the relatively near future. The matter was discussed with the Regional Engineer's Department, who decided to consult the North Eastern Gas Board. The resultant costings led to a decision to abandon a central heat source and to install four Hamworthy gas fired modular low pressure hot water heating systems to serve the individual ward blocks see *Figure 1*.

Two new boilerhouses were built to serve Blocks A and B, the former being fitted with 150 kW modular boiler and the latter with a 117 kW unit. Both installations incorporated two modules each. In addition two existing bathrooms were converted to boilerhouses to accommodate two three-module boiler units; both boilerhouses having a total capacity of 176 kW. One installation serving Wards C and F and the other serving Wards D and E.

The first phase of the actual work was carried out in 1976/77 and the final phase dealing with wards A and B and the porter's lodge were carried out in the following year. The new heating system comprised cill-line units and fan convectors, thereby providing safe surface temperatures for the geriatric patients, in all accommodation other than Blocks A and F and the porter's lodge; these areas being reserved for staff use. All heating surfaces are thermostatically controlled either by electrically operated valves or by thermostatic radiator valves with remote phials and the hot water services are provided by water to water calorifiers with direct acting controls.

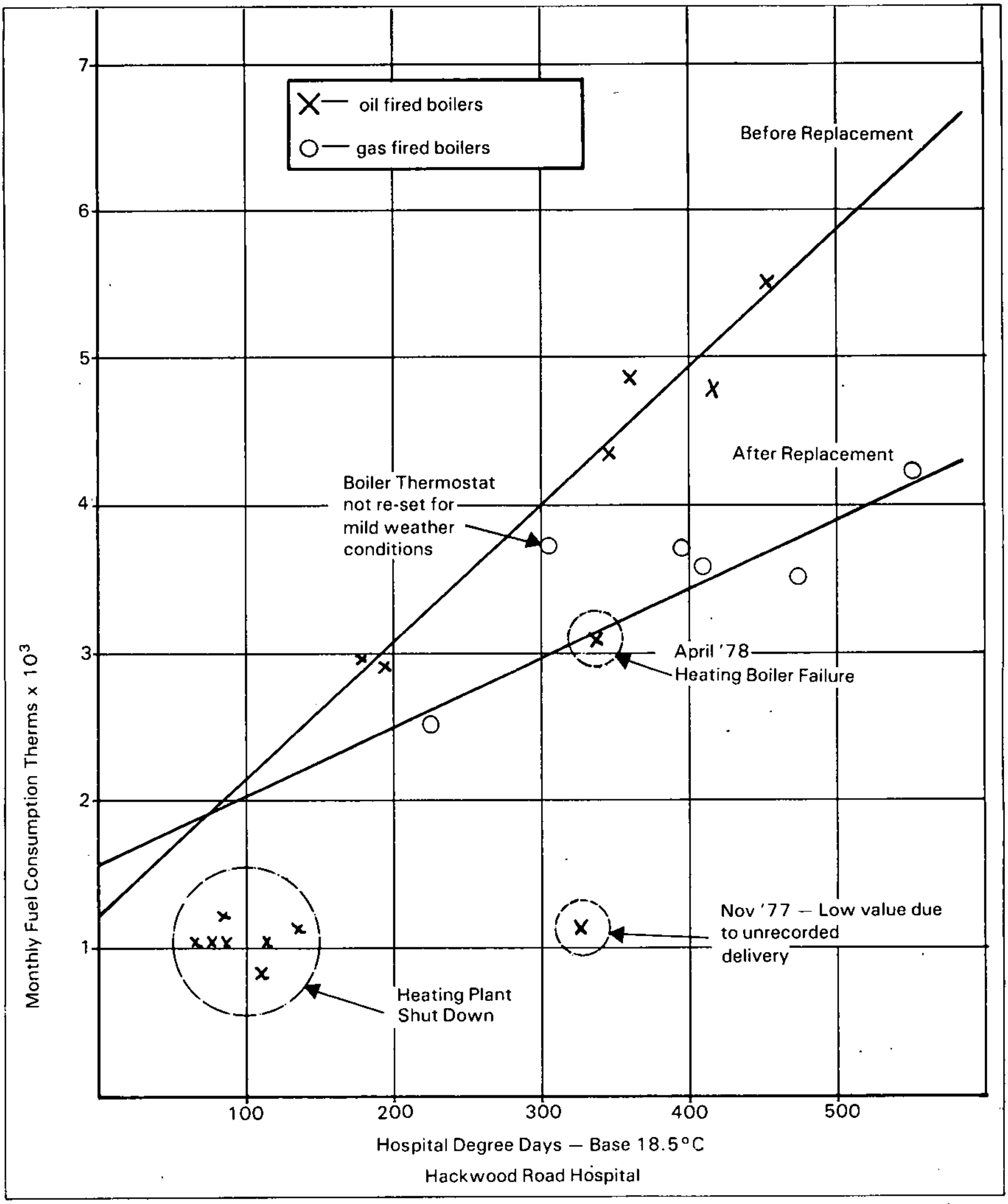

Figure 1.

The porter's lodge was provided with a 15 kW small bore heating system with a wall-mounted boiler and the laundry room was heated by two Prometheus direct air heaters of the balanced flue type, rated at 10.5 kW each and provided with a Green Knight direct fired storage water heater. The visitors' toilet block is heated by two Baxi Brazilia 5000 wall heaters and provided with hot water via two Ascot 527 single point water heaters.

As a further step towards energy conservation the North Yorkshire AHA increased the existing roof insulation from 2 in to 4 in thickness of glass fibre.

The Costs and the Savings

Whilst in the past the temperatures in

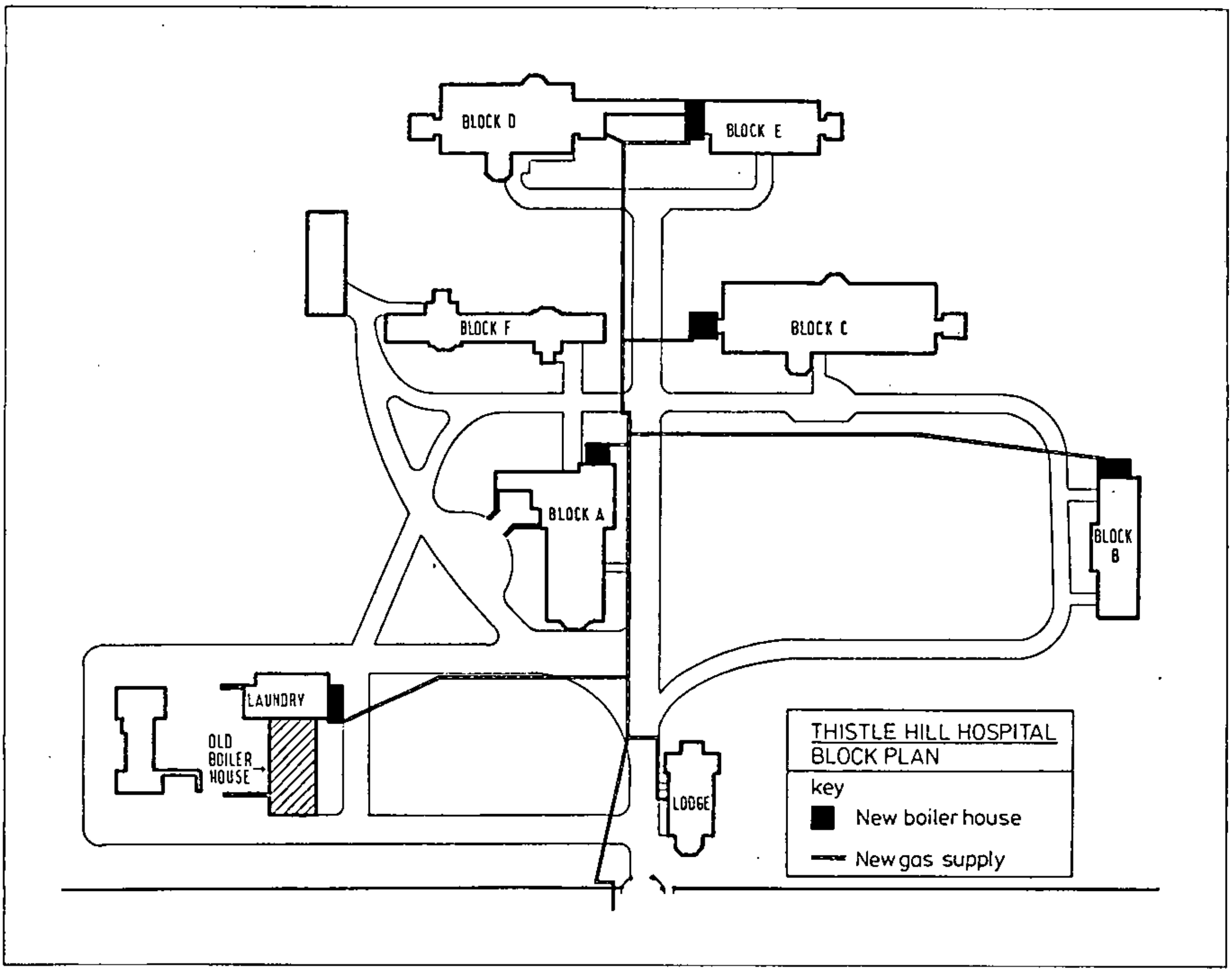

Figure 2.

the wards were inclined to vary appreciably, they are now held at a comfortable 21°C and the annual fuel consumption has been reduced from the equivalent of about 130,000 therms to the current figure of 68,000 therms/annum. In addition to the very considerable reduction in the cost of fuel, there has been a saving of some £16,000 per annum on boilerhouse manning.

The total cost of all building and engineering work, inclusive of the new gas mains, was £65,000. The resultant saving achieved by rethinking the engineering concept is shown on the thermal performance graph in *Figure 2.*

The author is Senior Engineer, District Works Office, Cambridge Health District (Teaching).

Energy Conservation at Newmarket General Hospital

R. A. EDSON TEng(CEI) MIWM MIHospE

This article explains briefly how fuel savings currently worth £20,000 per annum have been achieved by careful investment and a little enthusiasm at a typical 300 bed General Hospital in East Anglia.

Newmarket General Hospital is a 300-bed, mainly acute hospital based on workhouse buildings which date back to before 1830. During the second world war single-storey wards were built to provide EMS accommodation, at that time heated by individual pot-bellied stoves. Since then some further building has taken place and in 1962/3 a central steam boiler house was built to serve the whole site via LPHW radiators. The war-time buildings are of reasonably good standard, consisting mainly of 4½-inch solid brick walls with Strammet board/plaster lining and concrete/hollow clay pot flat roofs. In 1975 a consultant was employed to carry out an 'Energy-Survey' of the hospital concentrating on the heating aspects. His report made various suggestions each with a priority according to the anticipated pay-back period. (See Hospital Service Engineering No 31 page 16 and No 39 page 13). The following article summarises the investments and fuel savings subsequently achieved.

Building and Engineering Improvements

Day Hospital

This building was the odd one out on a heating circuit largely consisting of cast iron radiators heating single-storey wards. The day hospital had an installation of skirting heating, a lot of glazing and a generally light construction. As a result the heating circuit temperature had to be raised above the general level to heat the building adequately for geriatrics. Secondary glazing was installed to nearly all the windows; the drop in heat losses enabled the circuit temperature to be reduced to the level appropriate to the other buildings.

Physiotherapy

This single-glazed building was very draughty and had a high-vaulted roof which could not be insulated and poor heating controls. Secondary glazing was installed, a suspended ceiling was fitted with 50 mm of glass fibre on top and the heating controls were replaced.

Pitched Roof Lofts

These loft spaces were insulated in 1974/5 with 50 mm of fibreglass quilt and with an additional 50 mm in 1976/7 making a total 100 mm thickness.

Flat Roofs

The flat roofs of the EMS wards were due to have their felt replaced with asphalt. During this work money became available for 25 mm of 'PURLROOFER' insulation board to be built in under the asphalt. Four wards had already been asphalted but with no insulation built in. Two of these had the 'PURLROOFER' put on top under two layers of thin felt. The other two had suspended ceilings installed with 50 mm of fibreglass insulation.

The technique of building the insulation board in under the asphalt is very effective but has given rise to problems of differential contraction in frosty weather between the asphalt skin and the warm concrete roof slab. The asphalt splits!

On the adequately supported flat roofs an 'upside-down' insulation was installed, consisting of 40 mm of rot proof, impermeable, foam insulation board placed on the asphalt roof and then weighed down with gravel which is prevented from being washed off by 6 in × 2 in × 36 in sections of paving stones.

Oil Tanks

Two 16,000 gallon heated storage tanks for 3,500 second fuel oil were insulated with 50 mm of fibreglass slab wrapped in felt and chicken wire. The sludge coils have never been needed since and the outflow heaters have been re-set.

Burners

The three Paxman Ultranomic steam boilers were originally sized to deal with a laundry on site. The laundry had closed and it was found that the burners were spending much of their time on low fire or even stopping and starting. To overcome the inefficiency all three were downrated. by Hamworthy and the boiler brickwork altered to suit. The recommissioned burners gave a much improved performance.

Flue Gas Analysis

In order to maintain the improved burner efficiency a 'FYRITE' kit was purchased and the Grade 3 boiler attendant taught how to use it. His enthusiasm and skill is important to back up the investment.

Greenhouse

The greenhouse used a LPHW heating system with no adequate controls. Controls were installed and set up.

Heating Controls

The heating controls for the three main heating circuits were becoming unreliable. They were all replaced and a system of temperature monitoring introduced.

Balancing

A small amount of basic circuit balancing was carried out to ensure that the heating water (now at a reduced temperature) reached all departments adequately.

It can generally be seen from the above ten main items that the aims have been to:
reduce heat loss by insulation;
produce heat more efficiently; and
distribute only the necessary amount of heat.

Schedule of Expenditure

Expenditure on the improvement work and on the normal replacement of worn out and obsolete items over the period was £40,016. The detail is listed in the following table:

Fuel Consumption

Annual fuel consumptions (January to December) were as follows:

	Litres	Hospital Degree Days (°C)
1974	1,431,395	3256
1975	1,302,569	3273
1976	1,105,198	3252
1977	1,069,345	3246
1978	1,045,573	3382

		Annual Expenditure
1974/5	— Flat roof & Loft insulation	£8,000
1975/6	— Lagging oil tanks — £780	
	— Suspended ceilings (Wards C3 & C6, Physiotherapy) — £5,500	£6,835
	— *Double glazing — £800	
1976/7	— Boiler burners — £5,000	
	— Greenhouse controls — £585	
	— Physiotherapy controls — £920	
	— Sundry small items — £330	£20,683
	— Roof insulation — £11,300	
	— *Double glazing — £1,500	
	— Secondary glazing — £1,048	
1977/8	— Heating controls (hospital) — £1,698	
	— Balancing hydraulic systems — £300	£4,498
	— *Double glazing — £2,500	
	TOTAL	£40,016

*Starred items relate to window frames which were replaced with double glazed units.

It will be noted that the climate as measured by degree days was not subject to great variation other than 1978 being a trifle cooler than the preceeding four years — fuel consumption has however diminished annually.

The comparative annual performance is shown graphically in *Figure 1*.

It will be observed that significant fuel savings were achieved in both 1975 and 1976 with further marginal savings being made in 1977 and 1978. These savings are the outcome of the energy conservation expenditure and housekeeping. The hospital remained otherwise unchanged over the period. The following points are also evident from study of the graph in *Figure 1*:

Datum base — 1974 consumption 1,431,395 litres

	litres		pence per litre
1975 saving = 1,431,395 - 1,302,569 =	128,826	@	3.74 = £ 4,818
1976 saving = 1,431,395 - 1,105,198 =	326,197	@	4.45 = £14,516
1977 saving = 1,431,395 - 1,069,345 =	362,050	@	5.47 = £19,804
1978 saving = 1,431,395 - 1,045,573 =	385,822	@	4.89 = £18,867
	1,202,895		£58,005

The effect of the improvements to the building insulation are dramatic — consumption at the 30°F ambient design point has dropped from around 180,000 litres/month (1974 and 1975) to 141,000 litres/month (1978).

Adjustment of the heating controls during 1975 also produced a dramatic improvement in mild weather performance — the intercept on the 'y' axis dropped from 65,000 litres/month in 1975. Subsequent engineering work had reduced this value to 39,000 litres/month in 1978.

The estimated base load for this hospital is 37,000 litres/month and the 'Y' axis intercept of the mean performance lines is very close to this figure. The inference is that the control performance is higher than normal — the calculated performance ratio of 0.98 reflects the extent of work carried out on the heating control systems in recent years.

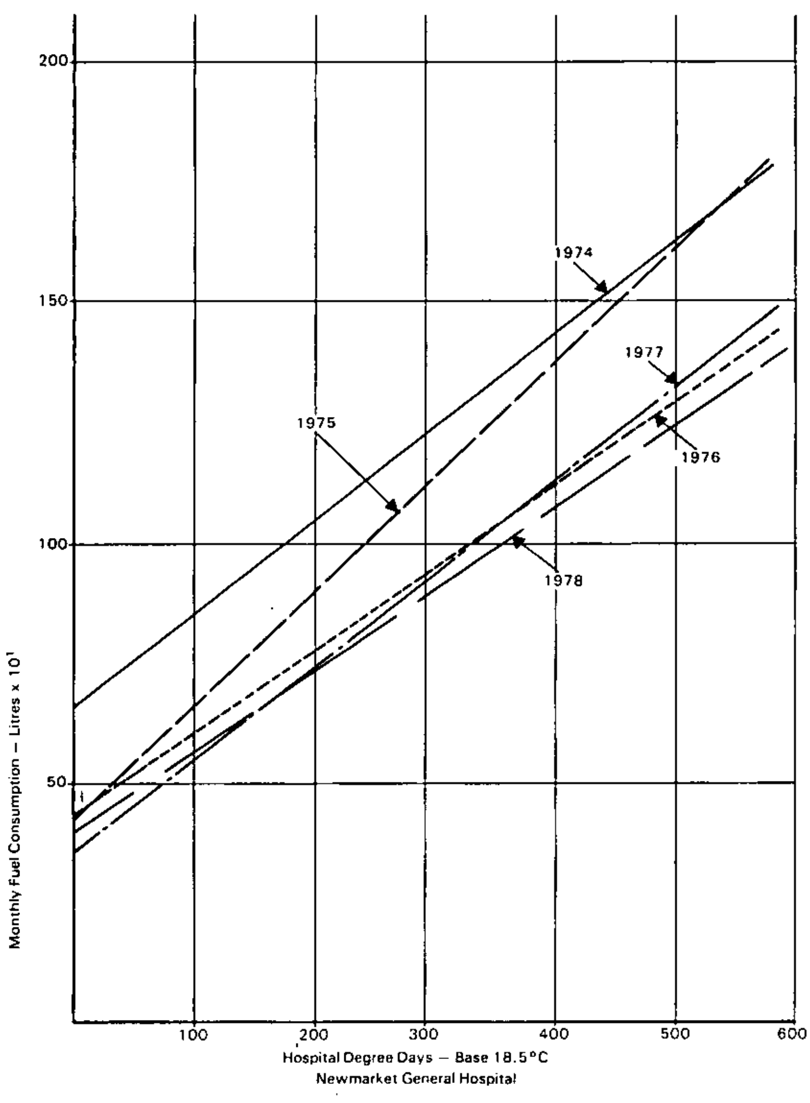

Figure 1. Monthly Fuel Consumption.

Estimated Savings

The approximate value of the savings achieved from the energy conservation/deferred maintenance expenditure of £40,016 (ignoring the effects of inflation) are £58,005 *see table above:*

The savings made to date exceed the value of the cumulative investment — the resultant annual reduction in running costs is of the order of £20,000 per annum.

Housekeeping

I think it is worth mentioning that for this type of energy conservation work to succeed the enthusiasm of the whole hospital staff must be gained. To make the savings, which the investments make technically possible, the Engineer must provide only the minimum satisfactory level of heating. People become used to the notorious 'overheated' hospitals and would expect to work in blouses etc right through the winter. It is only by personal contact that they can be made aware of the costs involved and imbued with the 'save-it' type of enthusiasm.

Needless to say, if the Engineer is not interested nothing will be monitored, nothing turned down and nothing saved. Unfortunately enthusiastic energy conservation is making a rod to beat your own back "How am I going to save yet another 10% this year? — if I had not saved so much last year life would be easier:"

Conclusions

The analytical investigations into the thermal performance of this hospital revealed that the base load actually applicable to this establishment is somewhat higher than is reasonable. The most probable reason is that the distribution losses are excessively high — perhaps due to uninsulated DHW circulation pipework in occupied areas. These factors are now being investigated in depth to find what improvements can be reasonably and economically carried out.

Although this case constitutes a success story so far, there are other marginal improvements which can be made, eg time clock control in 9 am — 5 pm areas, provision of local controls etc. These areas of potential saving are now being explored and weighed against others within the Area in the competition for resources.

Mr D. F. Nicholson is District Works Officer, Ormskirk District, Lancashire Health Authority and Mr A. W. Schaffel is District Engineer.

Energy Conservation at Ormskirk District General Hospital

D. F. NICHOLSON MIHospE MIPlantE
A. W. SCHAFFEL TEng(CEI) MIHospE

Introduction

In October 1976 a newly appointed District Engineer, Mr A. W. Schaffel and District Works Officer, Mr D. F. Nicholson, joined the works management team at Ormskirk Health District.

The normal first steps when senior engineers change post in the Health Service are to ensure that the steam raising boiler and associated plant operate at maximum efficiency and to examine as secondary priorities the distribution and uses of steam, electricity and other energy sources.

In this case a decision was made to reverse the procedure, this was because a boiler had already been installed.

After a very thin inspection it was decided to divide our approach into two phases:

The Panic

Immediate measures to cope with the most evident problems.

The Plan

To be carried out at the same time but involving longer term more complicated energy conservation work.

After the first examination a feeling emerged that the attention to Energy Conservation at Ormskirk had been less than in other Areas of the Health Service, because in the preceding decade much discussion had centred around building a District General Hospital at Skelmersdale and running Ormskirk down as a major site. It was only in the mid-1970's that a firm decision had been reached to develop the existing site.

This insecurity had led to an understandable reluctance to invest capital into major engineering/building maintenance.

The Panic

This was perhaps the most rewarding stage, since the pay back periods tended to be very short. Perhaps one or two examples would illustrate the type of problems experienced and how they were tackled.

Flash Steam Recovery

As the visitor drove into the main gate at the Hospital they could see and hear a pipe venting steam to atmosphere, 24 hours a day, 365 days a year, and this had been so for many years.

Examination showed that most of the condensate return from the site was collected in an uninsulated copper vessel from which it was pumped down a 2 in. uninsulated copper pipe, some 400 feet long, to one of four uninsulated Hotwell tanks in the boilerhouse. These four tanks were used to cool the condensate by holding and transferring it from one to the other to prevent cavitation of the boiler feed pumps. Included in one tank was a cold water make-up with the ball float permanently open.

It soon became necessary to replace the boilerhouse roof timbers above these Hotwells, because they had rotted through after being constantly wetted by condensation. Also, soon after our arrival we had an urgent request to purchase a load of polyurethane balls to float on top of the Hotwell to prevent the condensate attacking the roof timbers!

Figure 1 shows the schematic arrangement of the condensate cooling set designed by Mr Schaffel to use the laundry flash steam efficiently — this had three main effects:

The entire hot water supply for the Laundry (30,000 articles throughput per week) was supplied from the flash recovery system;

The venting from the newly lagged collector ceased;and

The temperature in the Hotwells went down to such an extent that flash steam was no longer produced.

This system paid for itself in less than six months.

Space Heating

The high temperatures experienced in the Hotwells was further raised by the method of space heating a large part of the site.

The system basically consists of 2 × 4

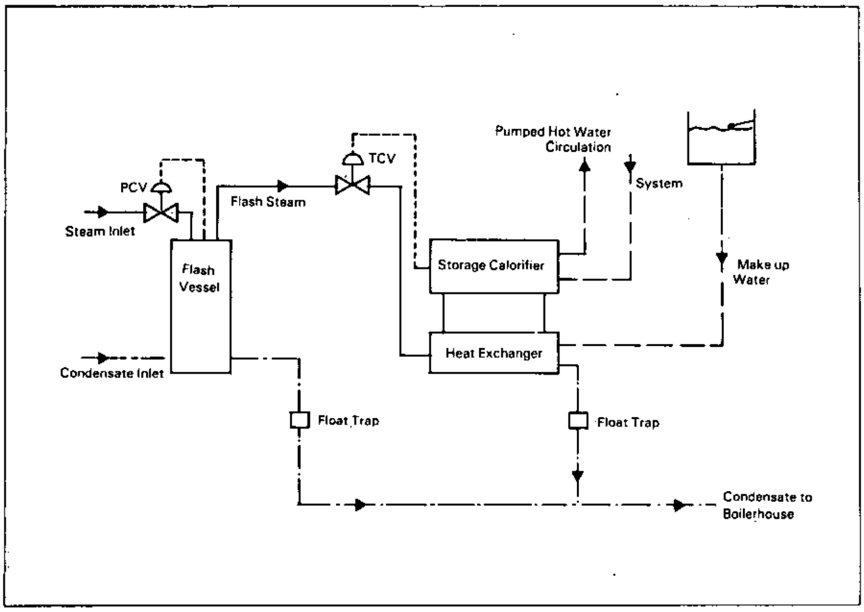

Figure 1. Layout of flash steam recovery system in the laundry.

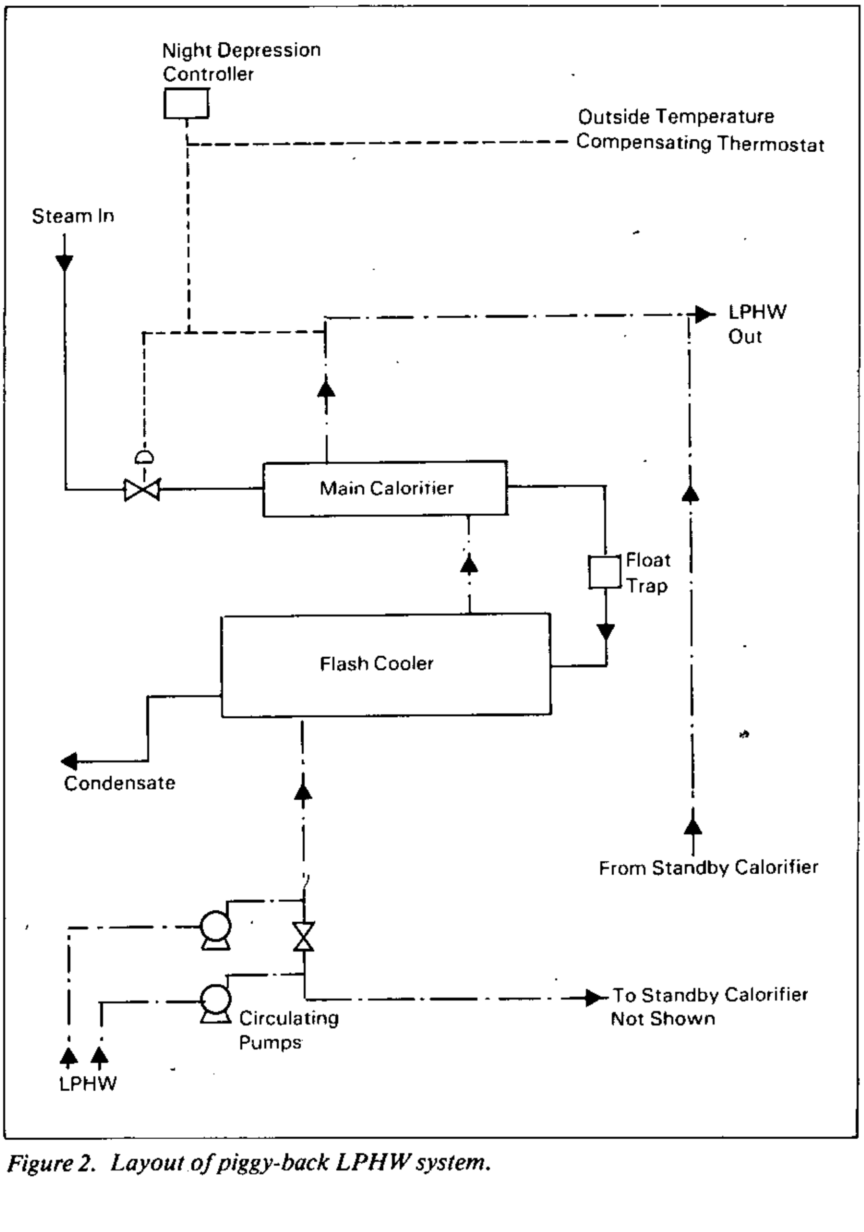

Figure 2. Layout of piggy-back LPHW system.

million Btu single pass Calorifiers fed at 5 psi through a 4 in. reducing valve. Oliver Lyle in the 'Efficient Use of Steam' says, "A reducing valve is an invention of the Devil, it sets out to degrade good heat".

Figure 2 shows the reducing set dispensed with, a small 2 million Btu Calorifier operating at 90 psi mounted piggy back on top of the existing LP Calorifier which then effectively became a condensate cooler.

The examination of the space heating also showed that in the majority of areas there were no temperature controls, no outside compensators and most importantly the eight hour occupancy areas (Administrative, Finance, Works etc) were heated 24 hours a day, 365 days a year.

The installation of a JEL optimiser control with variable start up and minimum temp times together with motorised valves immediately improved the eight hour day areas situation and the installation of a Spirax Sarco externally Compensated Control Valve enabled control of the LPHW flow temperatures to be acheived.

However, during night visits it was seen that even in January and February almost all the wards had windows open throughout the night. Thermograph readings indicated a daytime Wards temperature of between 70°-75°F but between 8.00 pm and 6.00 am when the patients were generally in bed, the bustle of the day to day Ward activity ceased and the Wards generally 'bottled up'. The very much reduced air change rate produced a rise in temperature of up to 85°F. This led us to take the view that we could reduce the flow temperatures at night from the calorifiers without reducing the Ward temperatures in any way.

A night depression unit was added to the Spirax external control system to achieve this objective. Similarly, local overheating was tackled by the installation of thermostatic radiator valves. *Figure 3* shows the resultant improvement.

I wonder how many of you have been in hospital as a patient or visitor and have felt how very much overheated the place was? Stress must be put on the fact that the depression of the flow temperature was not intended to, nor did it reduce Ward temperatures below 70°-75°F.

The Main Distribution

Boiler pressure of 90 psi was reduced to 60 psi in the boilerhouse through another 6 in. reducing set and distributed throughout the site via a 6 in. main. The insulation was in a very poor state and at a critical bend in the main duct had fallen off its hangers on to the floor and crushed the condensate return main.

A separate 4 in. main at boiler pressure fed the laundry and a further high pressure main fed the theatres, CSSD and kitchens. Both mains were in a poor state of repair and their insulation left much to be desired.

A decision to feed the entire site via the 4 in. high pressure main to the laundry was made, but when attempted the steam flow rate was insufficient. The 4 in. main should have been ample. When it was examined along its entire length it appeared that some years earlier a burst had necessitated immediate repairs and the only length of pipe available was 3 in., so this had been used and not recorded on the drawings.

The distribution gave more problems than expected and this led to a change in direction, a move from Panic to Plan.

The Plan

A plan was being formulated from the start, discussed within the Works Department, discussed with any other interested parties and most importantly critically appraised by the Area Engineer of the Lancashire Area Health Authority and the Regional Engineer of the North West Regional Health Authority.

The Plan effectively brought together all the Panic measures and attempted to project future energy targets for the District and how to achieve those targets.

Targets

The Department of Health's Engineering Division and in particular, Mr V. Skegg have done much research into Thermal Performance Analysis. *Figure 4* shows Mr Skegg's graph for Ormskirk Hospital using the heavy oil consumption v Degree Days for 1976–1977 and also the ideal target line we should aim for. The 1977/78 and 1978/79 mean performance lines are also shown together with the revised ideal target line which is now our new objective. You will see that improvements in fuel consumption have been achieved annually and that there has been a sizeable reduction in the base load.

In June 1977 as a first step in the Plan a system of daily dips in the Heavy Oil Tanks was instituted.

Figure 5 shows a typical histogram. Indicated on this diagram is the total usage of oil for the same month last year divided by the number of days in that month and used as a target.

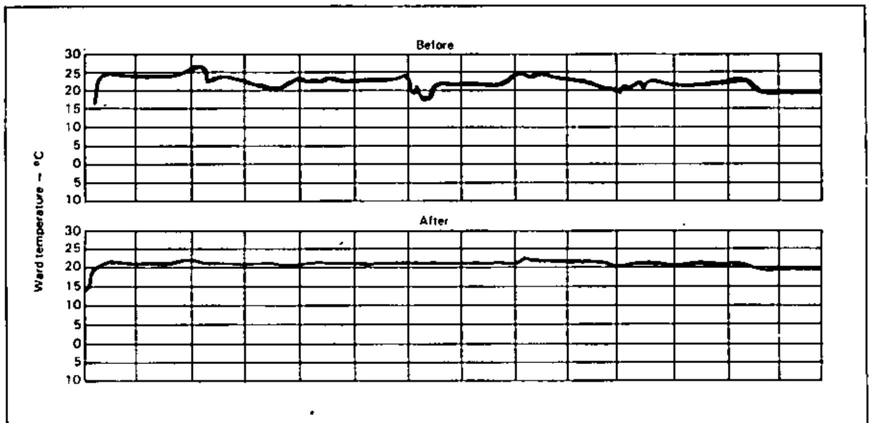

Figure 3. Showing the differences in temperature in two similar wards; the upper without thermostatic radiator valves, the lower with thermostatic radiator valves.

It records the daily dip in litres. If an increase in usage is shown an immediate investigation is carried out. Generally because of the very poor condition of the condensate main, leaks show up on every dip very easily as do LPHW temperature increases, DHW leaks and eight hours day areas in which the heating controls have been over-ridden.

Results

The effects of all these works have resulted in a progressive reduction in annual fuel consumption — see table below. The overall reduction of 23% has been achieved without any fall in the standards of patient welfare or of supporting services.

The Cost

To date the following works have been completed or are in the progress of installation.

Heat recovery from the laundry tumble dryers via an air to air plate exchanger.
The removal of all reducing valves in the boilerhouse.
The removal of the 6 in. LP main.
The installation of one boiler pressure main to feed the entire site.
Conversion of the oil fired boilers to interruptable gas. (March 1979).
Renewal of much of the original condensate main and re-insulate.
The re-organisation of the Hotwells from four to two, one of which is the

Consumption of Heavy Oil April 1975 to March 1979 (in litres)

	1975/76	1976/77	1977/78	1978/79
April	229,300	202,538	205,684	168,349
May	210,298	189,909	182,415	138,175
June	164,020	122,441	131,550	110,382
July	148,291	120,992	96,200	110,971
August	139,608	112,376	98,525	121,438
September	170,478	159,388	139,817	106,637
October	208,752	191,044	163,309	146,878
November	200,024	221,273	183,789	160,674
December	204,524	237,095	192,453	188,728
January	230,909	243,174	203,587	214,160
February	225,077	211,433	186,922	197,332
March	236,173	216,258	186,032	155,692
TOTAL	2,367,454	2,227,921	1,970,283	1,819,466
		Saving on 1975/76 139,533 Litres 5.9%	Saving on 1976/77 257,638 Litres 11.5%	Saving on 1977/78 150,817 Litres 7.6%

Overall reduction between 1975/76 and 1978/79 = 547,988 litres/annum equivalent to 23% of previous consumption.

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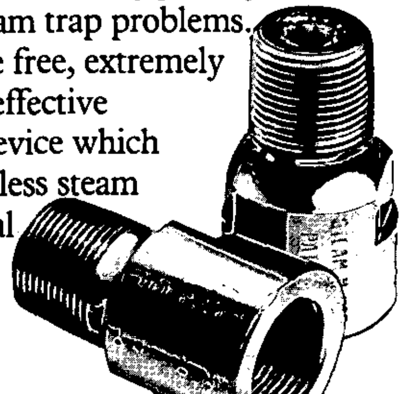
analysis of flue gas, and facilitates the calibration of associated control instrumentation. Significant economies can be achieved with this inexpensive unit.

What about Steam Miser? With this device, which has no moving parts, you can say goodbye to steam trap problems. It is a maintenance free, extremely simple yet highly effective continuous flow device which loses substantially less steam than a conventional steam trap.



Talk to Telegan now — the people who really do something about energy saving.

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main usage tank, both of which are insulated.
Installation of thermostatic radiator valves in all situations where there are no local controls on the LPHW heating.
An intensive programme of replacement of tungsten lights by fluorescent fittings throughout all the site in the District.
The centralising of DWH supply brought about by capacity made available by the installation in the laundry of the flash steam recovery system.
Insulation of much of the unlagged pipeworks.
Insulation of all valves and flanges on steam mains.
Examination for increase in roof space insulation.
The removal of steam equipment, where possible, that necessitates extensive mains both steam and condensate.
The removal and possible destruction of all portable electric heaters.

A high proportion of the expenditure incurred over the four-year period has been on overdue maintenance items and on the replacement of antiquated and out-dated engineering items. The annual expenditures have been as follows:

1975/76 — 18,000
1976/77 — 23,450
1977/78 — 1,000
1978/79 — 12,000
TOTAL — £54,450 + £20,000 maintenance work.

The value of the fuel saved at 1978/79 price levels is:

547,988 litres at 6.3 p/litre = £34,520 per annum.

The theoretical payback period is thus approximately 2.2 years, but the cumulative savings achieved to date means that the overall expenditure has already been recovered.

The Future

The Works Department have, based on the experience thus far gained, made several decisions that are generally accepted by local management in terms of future energy planning.

Where new windows are to be installed because of maintenance needs these shall be double glazed.

Where electrical installations are being designed, unless there are very special circumstances, all lighting shall be fluorescent.

Where new buildings are being planned window areas shall be double glazed and shall be as small as is practicable.

All new buildings shall be insulated to the highest standard available and practicable.

All new buildings must have energy usage controls built in as a priority.

The following items are being considered for future works:

Heat recovery from laundry wash water.
Heat recovery from incinerator.
Heat recovery from boiler flue gases.
Change from 35 sec oil burning equipment to gas firing at off-sited buildings and in small cottage type hospitals where supplies of 'firm' gas are available.

Conclusions

The scale on which energy savings can be made is highlighted by the fact that with all the work at Ormskirk we saved approximately 6% in the first full year of audited returns. The second year showing something like a further 11% saving and we feel there is scope for

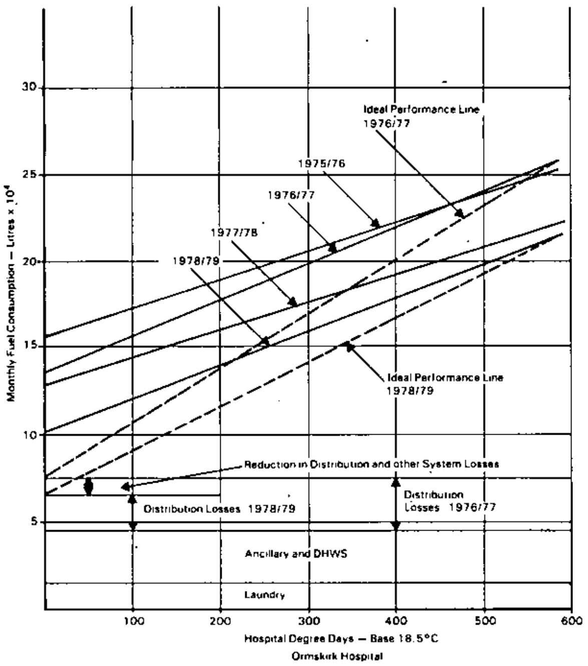

Figure 4.

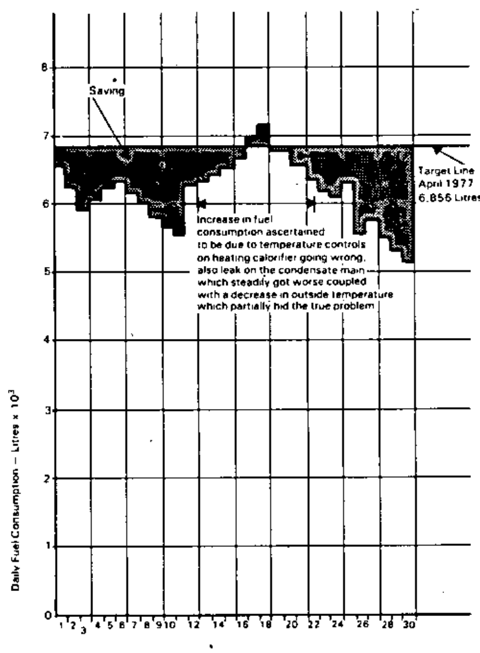

Figure 5. Histogram showing April 1975 daily usage in comparison with April 1977 average daily usage.

another 15% over the next three years.

What is needed most of all in our Service is the **Will**. The Will to try, to put ourself out, to stand the abuse when cutting down on unnecessary energy usage, and to be prepared to develop a case based on facts and figures that can be argued in terms of money and priority.

When we are asked how much time is devoted to Energy Conservation it is perhaps difficult to answer. We do not know. A school of thought exists that says Energy Conservation is good engineering, safe engineering, well-designed practical building, and this is the view to which we at Ormskirk subscribe.

One thing is clear however, once you start on the road of Energy Conservation you must keep it up. Do not weaken and YOU WILL SAVE IT.

SENIOR ENGINEER

(Barnet and Finchley Sectors 526 beds)

For management duties within the Authority associated with the maintenance and operation of engineering services. Duties will include the implementation and operation of a Planned Maintenance and Bonus Incentive Scheme. The post will be based at Barnet General Hospital, Wellhouse Lane, Barnet, Herts. Previous hospital experienence is desirable.

The post will give an ambitious Engineer considerable delegated management responsibility. Applicants (male/female) shall have completed an apprenticeship in mechanical or electrical engineering or have otherwise acquired a thorough practical training as appropriate to the duties and responsibilities. He/she shall have a minimum qualification of an HNC in Engineering or an appropriate equivalent with five years relevant experience in the management of mechanical and electrical plant and up to date methods of maintenance planning; in the control and deployment of maintenance and operational staff; in the preparation of maintenance estimates and of reports and in the carrying out directly or by contract, small works of engineering construction or renewal.

Salary Scale £5,292-£6,072 plus incentive Bonus Scheme Allowance in accordance with appropriate PTB agreements.

ENGINEER

The post offers a worthwhile career in Hospital Engineering with the opportunity of day release to continue studies.

Applicants (m/f) shall have completed an apprenticeship in mechanical or electrical engineering or have otherwise acquired a thorough practical training as appropriate to the duties and responsibilities and shall have a minimum qualification of an ONC in Engineering or an appropriate equivalent.

Salary Scale £4,851-£5,427 plus Incentive Bonus Scheme Allowance, in accordance with the appropriate PTB agreement.

For further information about the post, interested applicants should telephone Peter Horne, District Works Officer 01-440 5111 Ext 458.

BARNET/FINCHLEY
Health District
Barnet Area Health Authority

East District
LEICESTER GENERAL HOSPITAL

ENGINEER

Applications are invited for the above post. The successful candidates will be responsible for the supervision of the day to day operation and maintenance of the hospital's engineering services. The Leicester General Hospital is a teaching hospital with approximately 750 beds.

Candidates should have previous experience of the supervision of maintenance staff and a good knowledge of works services in either hospital or factory environment. They will have an ONC in engineering or equivalent and have served an engineering apprenticeship. This post may be particularly suitable to an officer already on the engineer grade who wishes to obtain experience in a large General Hospital.

Salary scale £4,497-£5,073 (38 hour week) the salary is currently under review. Other allowances in connection with the maintenance of an incentive bonus scheme may also be applicable. New entrants to NHS usually start at the minimum of the salary scale.

Job descriptions and application forms are available from the District Works Department, Towers Hospital, Humberstone, Leicester. Tel: Leicester 767184 Ext 381.

Leicestershire Health Service

WEST RODING DISTRICT

REDBRIDGE AND WALTHAM FOREST AREA HEALTH AUTHORITY

ENGINEERING OFFICER

Salary £4,851 to £5,427 pa (inc) plus bonus for Management of Incentive Bonus Scheme

A capable, experienced Engineering Officer required to be based initially at Claybury Hospital, to assist the Senior Engineer over the full range of his duties, including Management of Maintenance, Staff & Projects associated with the Mechanical, Electrical, Ventilation, Laundry and Engineering Services at the Hospital.

Applicants, in addition to relevant experience will have completed an apprenticeship in Mechanical or Electrical Engineering and have a thorough practical training, and an ONC in Engineering or an alternative qualification acceptable to the Secretary of State.

Mr D. Helm, Senior Engineer at Claybury Hospital (Telephone 504-7171) would welcome informal enquiries about the post.

Application form and job description available from: District Personnel Department, West Roding Health District, Langthorne Hospital, Leytonstone E.11. Telephone: 539-5511 Ext 53.

Closing date October 29, 1979.

LANCASHIRE AREA HEALTH AUTHORITY
Blackburn Health District — District Works Department

ENGINEER REQUIRED AT BLACKBURN ROYAL INFIRMARY SECTOR

To assist the Senior Engineer over the whole range of his duties, mainly in a busy acute hospital and offering a full range of engineering experience.

Applicants to have served a mechanical or electrical engineering apprenticeship and be qualified to at least ONC or OND level.

Salary scale £4,497-£5,073 with additional "on call", overtime and bonus allowance, as appropriate.

Application form and job description available from The District Personnel Officer, District Offices, Queen's Park Hospital, Blackburn, Lancashire, BB2 3HH. Tel: 661311 ext 281 or 223.

Closing date: October 26, 1979.

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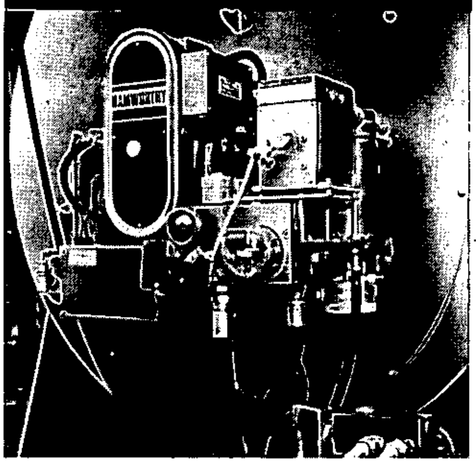
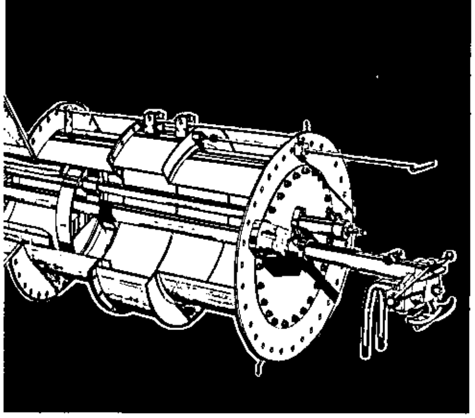
Hamworthy AW burners

Recently developed to meet coming changes in fuel characteristics and energy conservation methods. Three models in one — oil, gas and dual fuel. Downward firing is available if required.



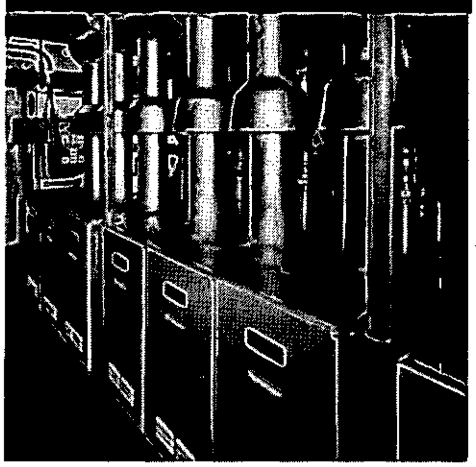
Hamworthy register type burner

For all sizes of water tube boilers, process work, cabin heaters (petro-chemical) or complete air heaters.



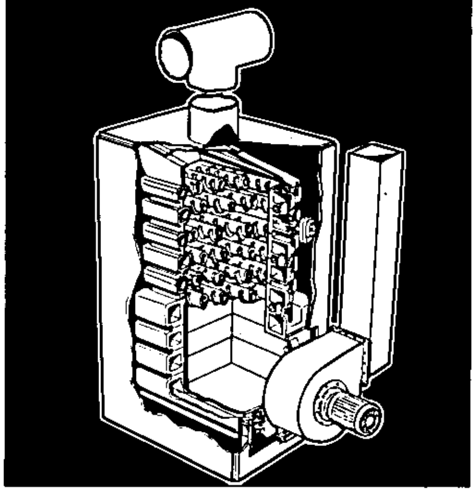
Modular boilers

Boilers grouped in modular layouts to cover ratings up to 1200 kW with full individual control facilities for maximum fuel economy. Natural draught units with 5 individual ratings from 42 kW to 75 kW



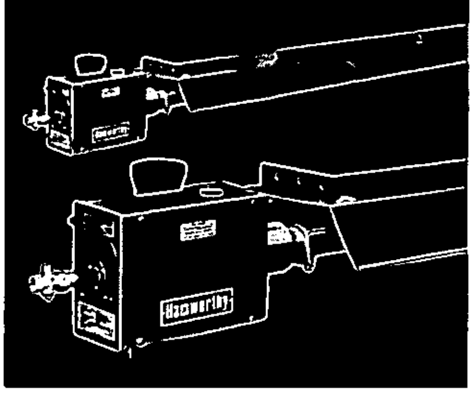
Waste heat recovery

A range of waste heat recovery units, economisers and control systems for fuel and energy conservation.



Gas fired radiant tube heaters

Roof or wall mounted for factory, garage, warehouse and similar industrial usage. Cover effectively 75 sq m radiated warmth per unit. Fully automatic black body space heater — output 15 kW per unit.



Controls

A range of electronic control systems designed to improve the efficiency of combustion plant.
Electronic efficiency trim systems, air flow ratio control systems, gaseous flow meters, sequencing etc.