The Journal of the Institute of Hospital Engineering October 1980

HOSPITAL ENGINEERING

Hospital Energy Conservation Year — A Success

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

Individual copies cost
£2.45 UK postage paid

The annual subscription is UK: £21.00
Overseas: £25.00 Americas: $56

Average circulation per issue
(January-December 1979): 2628

ABC

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'Hospital Engineering'
Mallard Publications
48 Southwark Street
London SE1 1UN, England
Telephone: 01-403 6166

UK ISSN 0309-7498

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

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HOSPITAL ENGINEERING

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Contents

October 1980

Volume 34 No. 8

Front Cover: The President, Mr Lawrence Turner, opens the third Hospital Energy Conservation Year Symposium on *Automatic Controls* at the Royal Festival Hall on October 1.

On his left is the Chairman for the day, Mr D F Rosborough, President of the Institute of Energy, and on his right Mr P B Lovering who spoke on *Traditional Controls.*

Institute News

Energy Conservation Year — Success

The Institute's Hospital Energy Conservation Year is drawing to a close, with excellent attendance at the special Symposia — the third, on Automatic Controls, held on October 1 (See Cover Photograph) was packed, with around 175 attending. Entries for the Energy Saving Competition have been encouraging, and the results will be announced in our December issue. The prizes will be presented by The Secretary of State for Energy at the final Symposium on November 12.

Help for Retired Staff

Each day about 50 people retire from the National Health Service, a total of 18,000 a year. The King's Fund Centre has been sponsoring the development of the NHS Retirement Fellowship and the first experimental Branches established in Gloucestershire, Croydon and Merseyside have proved very successful. Now there are over 40 such groups throughout the country with nearly 3,000 members.

The aims of the Fellowship are to provide a means of establishing and maintaining friendship, to help in overcoming loneliness and worry, to provide a visiting service to the housebound, and to enable former NHS staff to meet (regardless of grade or discipline) in a social and friendly atmosphere.

Mr Patrick Jenkin (Secretary of State, DHSS) has commended the Fellowship to all Health Authorities, and the General Whitley Council has also issued an amendment to its Handbook to this effect.

A Directory has recently been produced and it includes details of all known Branches up to last April. A supplement will be sent out free of charge in the autumn. Also included is a foreword by Miss I. James, Chairman of the Fellowship, together with a copy of the interim constitution. The Directory is priced £1 and is available from The Administrator, The King's Fund Centre, 126 Albert Street, London NW1 7NF, to whom all enquiries should be addressed.

North Western Branch

On Wednesday 11 June members of the Branch made a daytime visit to the Radio Telescope Complex at Jodrell Bank, Cheshire.

The party was received by Commander H Minns, the Chief Engineer who gave a brief outline of the programme and introduced our guides, Mike Daggett, Building Office and Ted Courtney, Engineer.

The Power House was visited first. Its considerable battery reserve system ensures immediate electric power in the event of mains failure while the standby generators come into operation. This is necessary in view of the computer controlled tracking mechanism of the telescopes which may be linked to other stations around the world.

After lunch Mr Ian Morrison gave a most interesting conducted tour of the control room and scientific laboratories in the concourse building during which he explained the operation of the various radio telescopes and the link-ups with other installations in Sweden, Puerto Rico and the USA, which are used for quasar observations and radio astronomy.

Finally, the party attended a Planetarium show and toured the permanent public exhibition. Despite torrential rain, which deterred members from having a close-up inspection of the largest Mark 1A telescope, a most enjoyable and informed day was had by all.

Northern Branch Programme of Activities 1980 - 81

Tuesday, November 11, 1980
Paper presented by John R Platts, the National Energy Sales Manager with the Electricity Council, on the subject of Britain's First All-Electric Hospital for the East Anglian Regional Health Authority under construction at the St. John's Hospital site at Peterborough. At 7.00 pm in the Lecture Theatre, Post Graduate Medical Centre, North Tees General Hospital.

Tuesday December 9, 1980
Visit to a Brewery — details to be finalised.

Tuesday February 10, 1981
Joint paper presented by Mr. K. W. Wilson (Regional Works Officer) and Mr W N Bewick, which will take the form of a synopsis of the papers presented at the 10th International Federation of Hospital Engineering Conference in Washington on the 4th-6th June 1980. At 7.00 pm in the Lecture Theatre, Post Graduate Medical Centre, Queen Elizabeth Hospital, Gateshead.

Tuesday — 10th March 1981
Paper presented by Northern Gas covering the new National Distribution Network.

This meeting will be held in the Exhibition Suite of the Gas Showroom, John Walker Square, Stockton, and will commence at 7.00 pm.

Yorkshire Branch

The Annual Dinner Dance of the Yorkshire Branch is to be held on Saturday November 15, 1980 at 7.30 p.m. for 8.00 p.m. at the Mercury Motor Inn, Selby Road, Garforth, Leeds (on the A63)

An enjoyable evening is promised and members are urged to support their branch and obtain tickets at £8.00 from the secretary or any committee member.

East Anglian Branch

At the meeting held on July 25, 1980 in Norwich, members received a presentation on 'Energy Conservation in Hospital Laundries' by J. P. Beaton, Area Engineer, Norfolk Area Health Authority and Mr L. G. Banks, District Engineer, Norwich Health District.

The presentation included efficient recycling and waste heat recovery from process equipment and was followed by a general discussion on the Hospital Engineers contribution to energy conservation in the future.

At the September meeting held in Great Yarmouth, the members enjoyed a presentation on Domestic Hot Water services in hospitals by Mr P. Malkin and Mr G. Mills of Beaumont (UK) Ltd. Following the formal presentation members inspected the recently completed energy conservation scheme at St. Nicholas Hospital which included the installation of a Beaumont Water Heater.

Mr Skegg is Superintending Engineer at the DHSS. He gave this paper at the Institute's first Hospital Energy Conservation Symposium held in London earlier this year.

The Inter-Relationship between Engineering Plant Replacement and Energy Conservation

V. E. SKEGG

The vast majority of our 2,400 hospitals were built at the beginning of this century, or were hastily erected to meet war-time emergency requirements. Both the buildings and their major engineering services reflect the standards and practices applicable to an era when fossil fuel was freely *available at very low prices.*

Despite a great increase in expenditure on upgrading and improvement works during the late sixties and early seventies, the engineering services and systems in many of these older hospitals are still archaic, and incompatible with contemporary requirements for the efficient and economical use of fuel. However there are an increasing number of instances within the NHS where replacement of old inefficient boiler plant and/or the radical re-appraisal of thermal distribution systems have resulted in a dramatic reduction in fuel consumption.

In terms of investment options there is often no clear distinction to be drawn between plant replacement (and modernisation projects) and straight energy conservation measures. The distinction is, perhaps, unimportant — if investment in plant replacement and modernisation projects results in fuel savings of 25% to 50%, with pay back periods, in many instances, of less than five years. The important point is to recognise the potential energy savings which can be achieved by applying current technology and installing modern equipment in these older hospitals whenever the opportunity and financial resources permit. The intention of this paper is to highlight

Table 1 — Schedule of Energy Savings Resulting from Replacement of Inefficient Boiler Plant

Hospitals	Type	No. of Beds	Fuel	Saving %
Lancashire Boilers to Modern Economic Installations				
East Birmingham	Acute	1300	3500 Sec. Oil (No Change)	19.2
Naburn Central Boiler House (York)	(Maternity (Mental Illness (Geriatric	120 315 50	Coal to 3500 Sec. Oil	21
Netherne	Mental Illness	1100	3500 Sec. Oil (No Change)	21.4
Barnet General	Acute	440	Coal to 3500 Sec. Oil	24.8
Napsbury	Mental Illness	1150	Coal to 3500 Sec. Oil	27.6
Brookwood	Mental Illness	920	3500 Sec. Oil (No Change)	28.9
Obsolete Economic to Modern Economic				
Watford General (Peace Memorial)	Acute	220	Coal to Gas	26.0
Bridge — Chelmsford	Mental Handicap	450	Coal to 3500 Sec. Oil	27.0
Cochran Vertical to Modern Economic				
Upton — Slough	Geriatric	88	950 Sec. Oil (No Change)	23.5
Lancashire (Steam) to Medium Pressure Hot Water				
Barrow — Bristol	Mental Illness	360	3500 Sec. Oil (No Change)	35.3

a number of success stories, and in so doing to demonstrate that there is a positive link between the timely replacement of engineering plant/ services and energy conservation.

Steam Boiler Replacement

A quick survey of records within DHSS revealed that over 200 of our approximately 800 steam boiler plants utilise inefficient and obselete boiler types such as Cornish, Lancashire, brick-set Economics or vertical pattern boilers. The actual savings achieved in service by replacing these archaic types of boiler by modern equipment are shown in *Table 1*. It should be noted that in all case histories listed there was no concurrent modernisation of thermal services within the hospital. Fuel saving consequent upon change of boiler type varied from 19% to 29%.

The Brookwood case study is particularly interesting in that — for experimental reasons — the boiler shell insulation was of double the normal thickness. This feature, in conjunction with a high standard of pipework insulation in the boiler house, not only resulted in a cool boiler room but also contributed to the above — average 29% reduction in energy consumption.

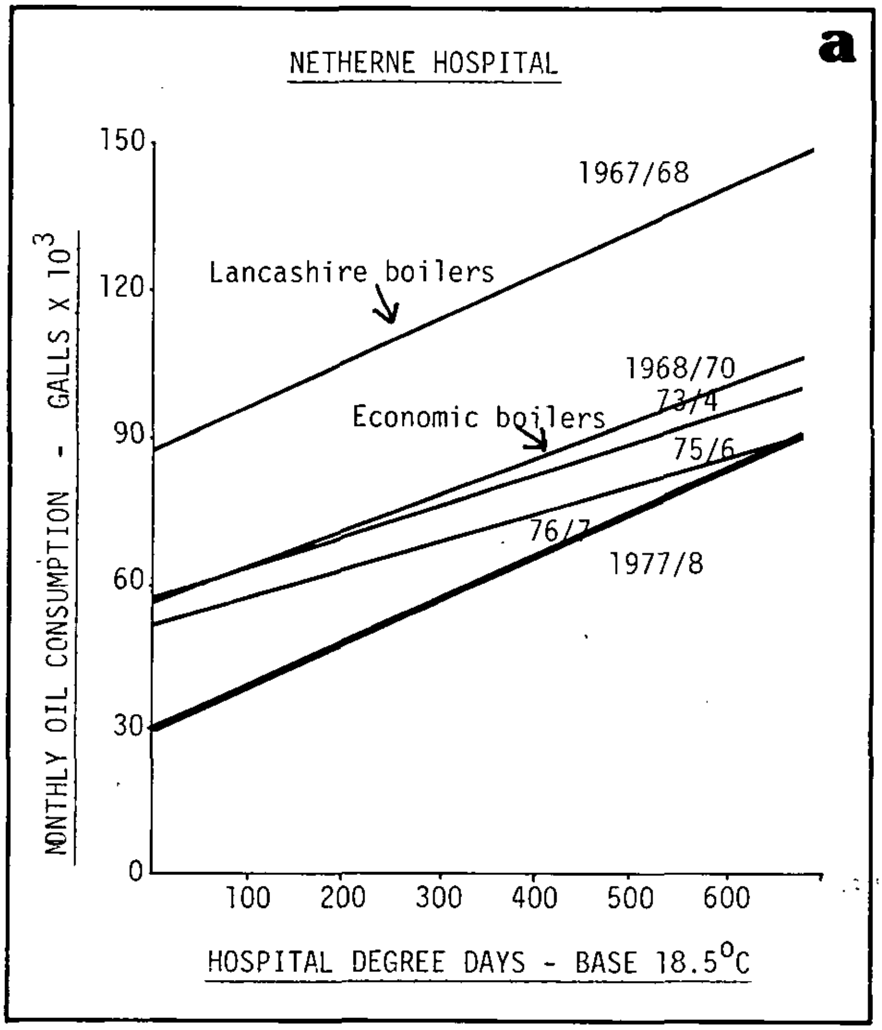
The Netherne case study is of interest in that the subsequent modernisation of the hospital's heating services and provision of controls boosted the overall fuel savings from the listed figure of 21.4% to 43%. This is an excellent example of the energy savings which can be achieved by modernising the engineering services in our older hospitals. The work sequence together with a graphical protrayal of the progressive energy saving is shown at *Case Study Summary 'A'*.

Case Study 'A' Netherne Hospital

Historical Detail

This hospital is a traditional Victorian built mental-illness establishment. The hospital was originally direct steam heated throughout from oil-fired Lancashire boilers. The chronological sequence of events which have contributed to the dramatic reduction in energy consumption are as follows:

- •1967/8 — fuel consumption with Lancashire boilers and uncontrolled steam heating
- •1969/70 — fuel comsumption after installation of replacement three-pass Economic boilers
- •1973/4 — fuel consumption after conversion of 24 wards in main complex to LPHW radiator heating
- •1975/6 — fuel consumption after upgrading heating installations in peripheral buildings — mainly fan convectors with internal thermostats operating off the original steam supply pipework
- •1976/7 & 1977/8 — fuel consumption after the provision of compensator controls.



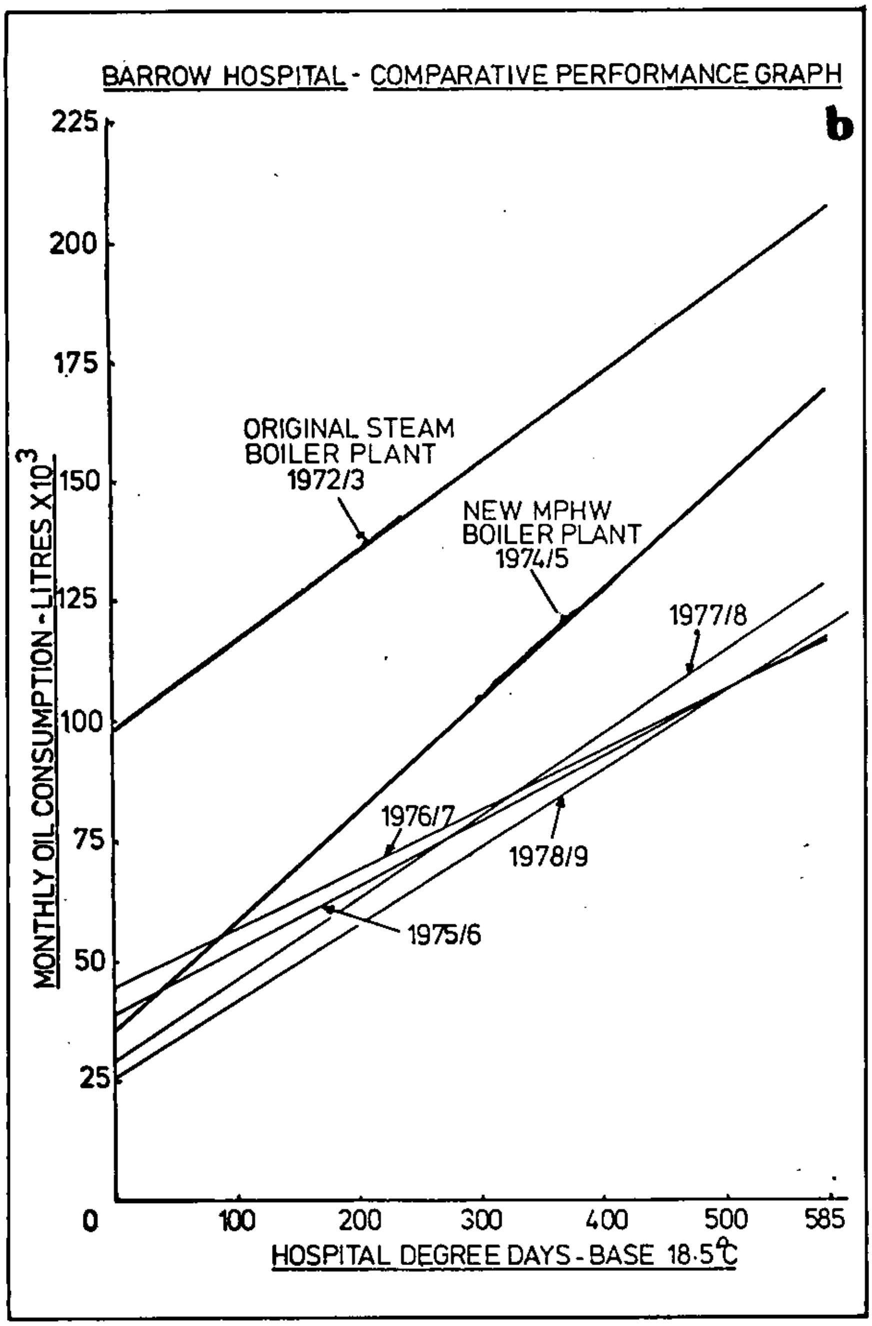
Overall reduction in Fuel Consumption — 43% (1967/8 to 1977/8).

A broadly similar result was achieved at Barrow Hospital, Bristól which features in *Case Study Summary 'B'*. At this hospital, the replacement of the original Lancashire boilers by MPHW shell boilers resulted in an initial saving of 35.3%, which was subsequently increased to 52% by refinement of the distribution system, ceiling insulation and control provision. The level of the initial savings (35.3%) is well above the range of 19 to 24% achieved by straight boiler replacement at the other hospitals listed in the Table. This improvement is attributed to the simultaneous elimination of the normal steam system losses such as blowdown, leakage at steamtraps and condensate return loss etc.

Case Study 'B' Barrow Hospital (Bristol)

Historical Detail

This hospital dates from the 1930's and consists of about 20 major single and 2 storey villa type buildings fairly widely dispersed in open woodland. The chronological sequence of events which have resulted in the



Overall Reduction in Fuel Consumption — 52% (1972/3 to 1978/9)

significant reduction of energy consumption are as follows:

- 1972/3 — fuel consumption with Lancashire type steam boilers and centralised DHWS and Heating calorifiers
- 1974/5 — fuel consumption after installation of replacement shell type MPHW boilers
- 1975/6 & 1976/7 — fuel consumption after insulation of all ceiling spaces with glassfibre blankets
- 1977/8 — fuel consumption after alterations to DHWS calorifiers and heating distribution system
- 1978/9 — fuel consumption after time switch and motorised valve controls had been added to intermittently occupied buildings and zones

Change from Central Steam to Central LPHW

The outcome of the preceding study provides a natural stepping stone for the development of the theme in that many of the existing hospitals which now utilise steam raising plants no longer have a prima facie requirement for steam generation. This apparent anomaly arises from evolutionary development — the closure of small laundries; the transfer of the local sterilizing function to District CSSDs', and the replacement of bedpan sterilizers by macerators. In recent years there has been a growing trend to replace these inefficient and costly manned steam plants with modern fully automatic LPHW installations — the relatively small amount of steam-using kitchen equipment being replaced by gas or electrically operated equipment. *Table 2* lists 11 hospitals where central steam plant has been replaced in the last decade by centralised LPHW installations. The reduction in energy consumption ranges from 24% to 55% — the wide variation being a reflection both of the original combustion and distribution efficiency, and also of the amount of concurrent improvement made to the heating/hot water services and their allied controls. Where no pay back period is shown in the table, the cost of the replacement boiler plant (and associated work) was carried out as either plant replacement or as part of a capital development scheme. The other four schemes are straight energy conservation projects, and it will be noted that the pay back period is less than the DHSS five year guidance criteria in all cases.

Two of the case studies — St Andrew's, Norwich, and Wayland Hospital, Attleborough — are detailed in *Case Study Summaries 'C'* and *'D'* respectively. Wayland Hospital is particularly noteworthy in that, although the overall volume of the hospital was increased by almost 50% following the opening of a new 50 bed Chronic Sick Unit, the fuel consumption of the enlarged hospital was reduced to 76% of the previous level by replacing the original Cornish steam boilers by a centralised LPHW installation. In other words, the boiler/system change not only provided 'free' heating and DHWS to the new unit but also provided savings in both fuel and operational costs.

Before moving on and developing the argument further, it is appropriate to comment on the radical improvement achieved at the Tower Hospital, Ely, where the existing economic steam boilers were in good condition. At this establishment conversion of the existing boiler plant to LPHW by 'flooding' resulted in a dramatic saving of 45.6% of previous fuel consumption. Although combustion efficiency rose significantly — authenticated NIFE's test — as a result of the improved heat transfer the majority of the saving must have arisen from the elimination of exceptionally high steam system losses.

Case Study 'C' St Andrew's Hospital — Norwich

Historical Detail

This hospital consists of 2 major building complexes sited approximately 500 yards apart and separated by a major trunk road. The buildings are of heavy solid masonry construction dating from the 1800's. The original coal-fired Lancashire boiler plant was replaced during 1976/7 by a centralised LPHW boiler installation supplying a constant temperature primary flow at 180°F to local calorifier rooms. The distribution system is air-pressurised due to static head problems associated with difference in ground level of the two sections of the hospital. A separate small steam boiler was provided in 1976/7 for the laundry.

The following explanatory notes will assist in the interpretation of the following diagram:

- 1974/5 — fuel consumption of Lancashire steam boilers with steam driven generators in use
- 1975/6 — fuel consumption of the above plant with steam driven generators shut down
- 1977/9 — combined fuel consumption of shell type LPHW boilers and laundry steam boiler. All new boiler plant interruptible gas/35 sec oil fired.

Case Study 'D' Weyland Hospital — Attleborough

Historical Detail

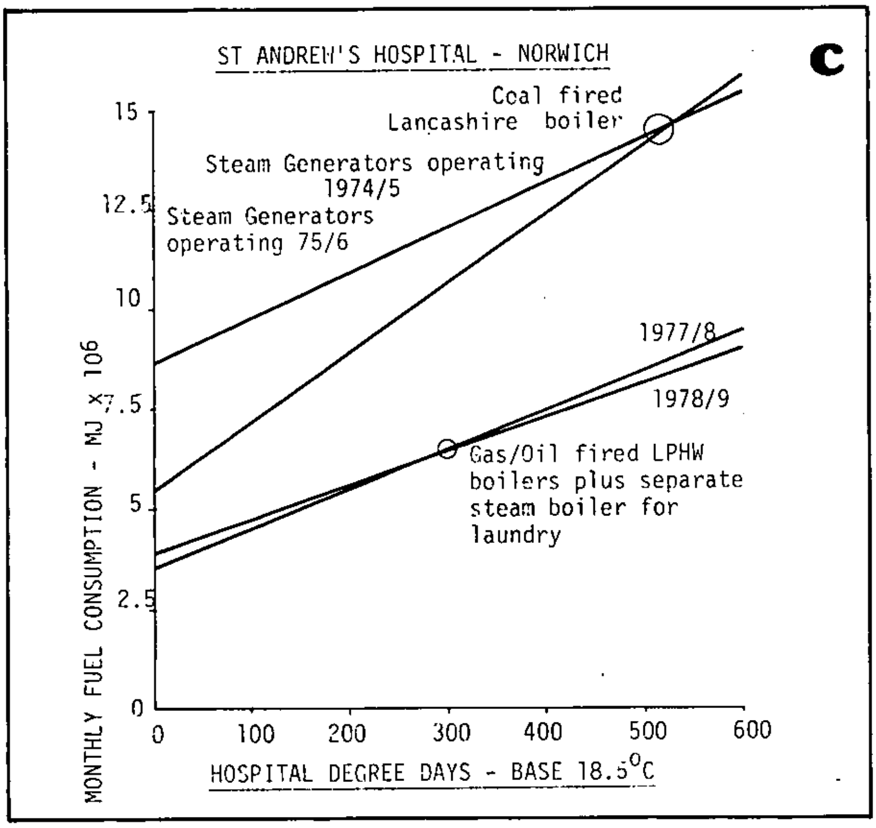
This hospital is a former Poor Law Infirmary with all buildings being of a late Victorian origin The construction of a new 50 bed Chronic Sick Unit in 1975/6 provided the opportunity to replace the original oil fired Cornish steam boilers by a centralised LPHW installation. The additional buildings increased the volume of the hospital by 49.8%

Table 2 — Schedule of Energy Savings resulting from Change to Centralised LPHW Installations

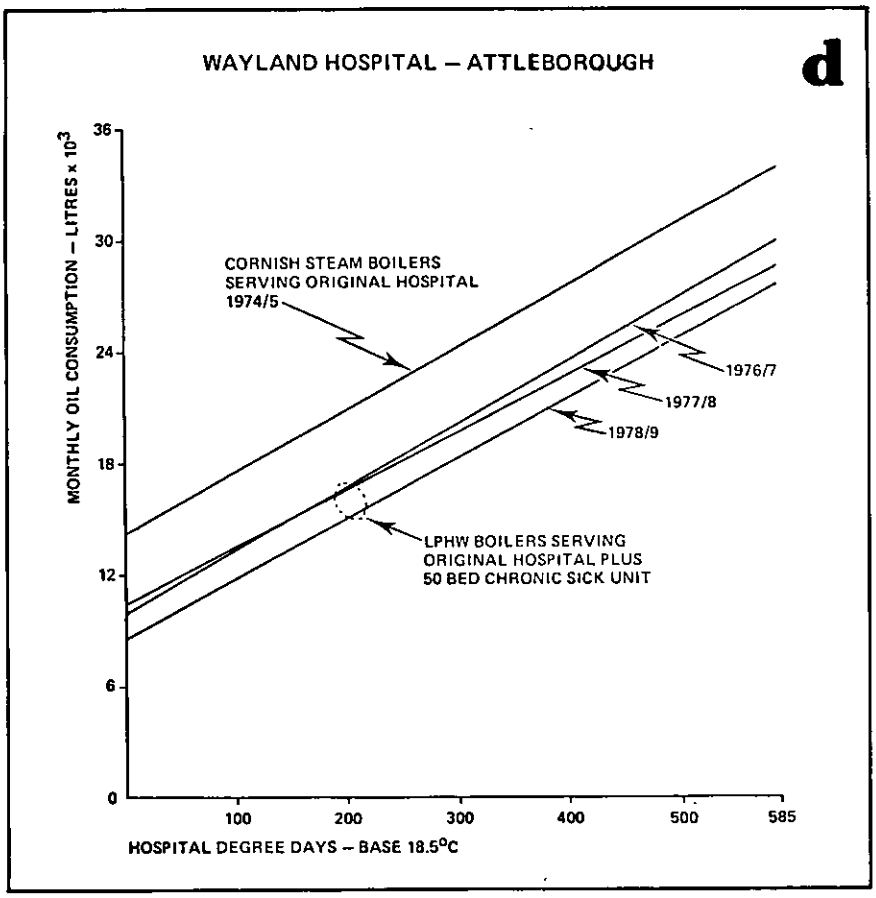
Hospital	Type & Size of Hospital	Fuel	Pay back Years	Saving %
Royal Homeopathic (Economic to C.I. Sect[L])	Acute 170 beds	Oil to Gas	Less than 1 year	24
St Mary's Tattingstone (Cochran to C.I. Sect[L])	Geriatric 110 beds	Coal To oil	—	31.5
King Edward — Old Windsor (Lancashire to Shell boiler)	Geriatric 100 beds	35 sec. to Oil & Gas	—	35.7
St Andrews — Norwich (Lancashire to Shell boiler)	Mental Illness 650 beds	Coal to Gas/Oil	—	40.7
Castleberg — Settle (Cochran to Modular)	Mental Handi-Cap 142 beds	Coal to Gas	2.4	41.7
Selwood — Frome (Cochran to Hoval Combination	Mental Handi-Cap 142 beds	950 sec. to 35 sec.	4.2	44
Tower — Ely Existing Economics flooded)	Geriatric 108 beds	35 sec. (No change)	—	45.6
Wayland — Attleborough (Cornish to Hoval Combination)	Acute 138 beds	950 sec. to 35 sec.	—	45 (Est)
Northgate & Estcourt (Mixed Lanc/Economic to Modular	Partly acute 312 beds	3500 sec. to Gas.	—	19.3 (40% of site)
St Mary's — Wallingford (Cornish to Sectional)	Geriatric 40 beds	Coal to Oil	—	50.9
Raikeswood — Skipton (Lancashire to Ygnis Combination	Geriatric 100 beds	Coal to Gas/Oil	2.25	55

The following explanatory notes are intended to assist in the interpretation of the thermal performance diagram:

- 1974/5 — fuel consumption of Cornish steam boilers serving the original hospital only
- 1976/7 & 1977/8 — fuel consumption of Hoval LPHW boilers serving both the original hospital and the new 650 bed Chronic Sick Unit
- 1978/9 — fuel consumption following the provision of 70 thermostatic radiator valves and other ancilliary controls.



Reduction in Fuel Consumption — 40.7% (1975/6 to 1978/9)



Saving in Fuel — 24%, despite 49.8% increase in volume (equivalent to 50% saving on original hospital).

Change from Centralised Steam to Decentralised LPHW

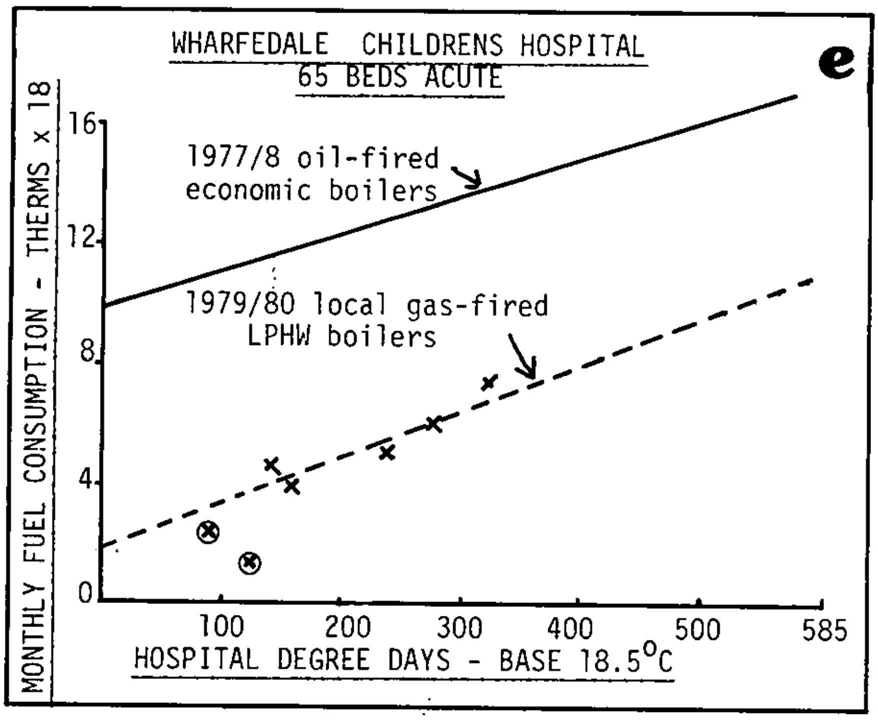
A logical development of the engineering concept when changing from central steam plant — particularly in hospitals where the buildings are scattered — is to provide either 'grouped' or localised boiler plants so that site distribution losses are minimised. *Table 3* shows the details of eight hospitals where this philosophy has been followed — the resultant savings range from 30% to 59% of previous fuel consumption. The level of saving is influenced by the degree of building dispersal and the extent to which local controls for intermittently occupied areas were provided at the time of the major work. All projects listed in this table were energy conservation schemes, other than St Wulstan's and Derwent Hospitals where the opportunity for modernisation was occasioned by failure of the steam raising plant. Payback periods in all these case studies conform with the 'Five year or better' criterion.

Feature articles covering the Wandle Valley, Winford Orthopaedic and Thistle Hill Hospital energy conservation projects appeared in our *October 1979* issue and we do not propose to repeat the details here. However, for the benefit of new readers, the engineering detail and graphical performance of two equally rewarding projects — Wharfedale Children's Hospital and Grassington Hospital — are set out in *Case Study Summaries 'E'* and *'F'* respectively. These are typical examples of 'complete decentralisation' and the 'grouped' solution. It should be noted that the decentralisation approach invariably dictates the use of premium fuel (gas or 35 sec oil).

Detailed scrutiny of *Tables 2 and 3* suggests that the simultaneous elimination or reduction of distribution losses results in a slight enhancement of the energy savings. Whilst pure logic dictates that this should be so, confirmation of the extent of the distribution losses which occur on some sites is obtained from a study of chronological energy consumption at Killingbeck and Seacroft Hospitals (Leeds). These hospitals are adjacent, and were originally served from a common boiler house by an extensive triplicated network of steam/condensate, LPHW and DHWS distribution mains. The progressive provision of

Table 3 — Schedule of Energy Savings resulting from Change to Grouped or Decentralised LPHW Installations

Hospital	Type & Size of Hospital	Fuel	Pay back Years	Saving %
Derwent — Derby (Economic to 13 local plants	Mainly acute 125 beds	Coal to Gas	5	30 (E)
Sandleford — Newbury (Cochran to 2 local plants)	Geriatric/ Maternity 80 beds	35 Sec. to gas	Less than 1 year	35
Winford — Bristol (Lancashire to 2 grouped Modular	Acute 230 beds	920 Sec. to 35 Sec.	2.0	46
Wharfedale Childrens (Economic to 7 local plants	Acute 65 beds	950 Sec. to Gas	1.3	50 (E)
Wandle Valley (Cornish to 5 Modular plants	Geriatric 48 beds	Coal to Gas	2.5	53.3
St Wulstans (Economic to 8 local plants	Mental Illness rehabilitation 260 beds	Coal to 35 Sec.	—	55
Grassington (Lanc/Economic to 2 grouped Modular)	Mental Illness 240 beds	Coal to 35 Sec.	2.5	59



Saving in Fuel — 50% estimated over first complete year of operation.

local DHWS and Heating calorifiers and the reduction of the external distribution mains to well insulated steam/condensate pipework only resulted in a saving of approximately 14.6%. The details of the annual fuel consumptions and engineering work is set out in *Case Study Summary 'G'*.

Case Study 'E' ' Wharfedale Children's Hospital

Historical Detail

This hospital consists of 7 dispersed buildings which were originally served by a fully automated oil fired Economic type steam boiler plant. This installation was replaced in 1976/7 by 7 local gas fired LPHW boiler houses — each containing separate boilers for the DHWS and heating duties. Time clock controls were provided for intermittently occupied areas during the course of this work.

The fuel consumption of both the original and the new installation are shown on the diagram.

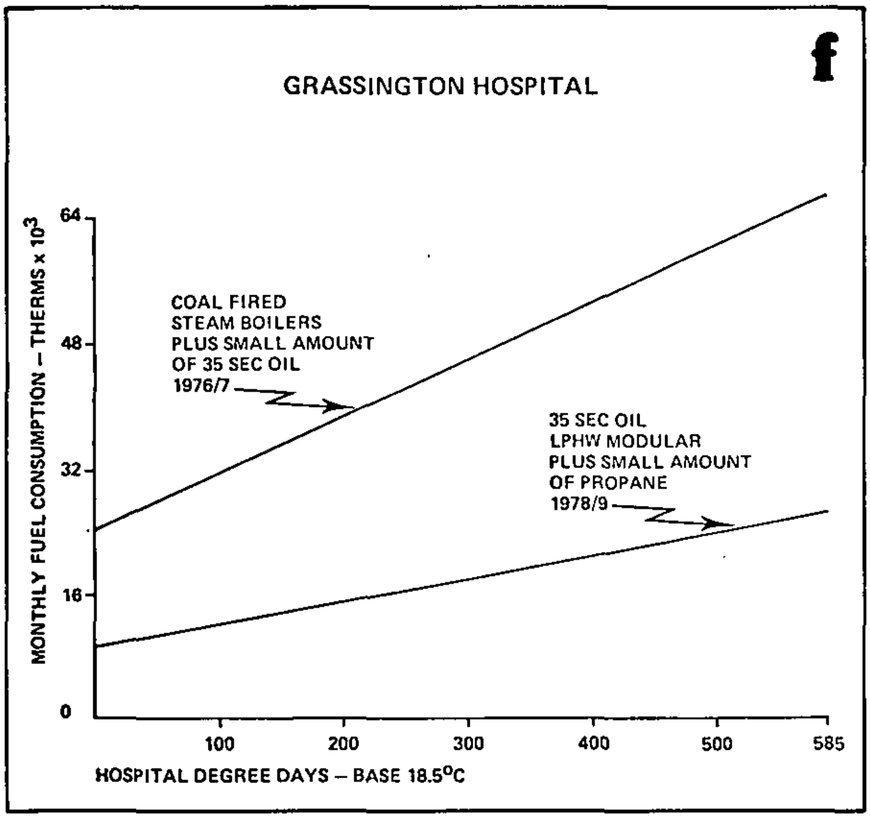
Case Study 'F' Grassington Hospital

Historical Detail

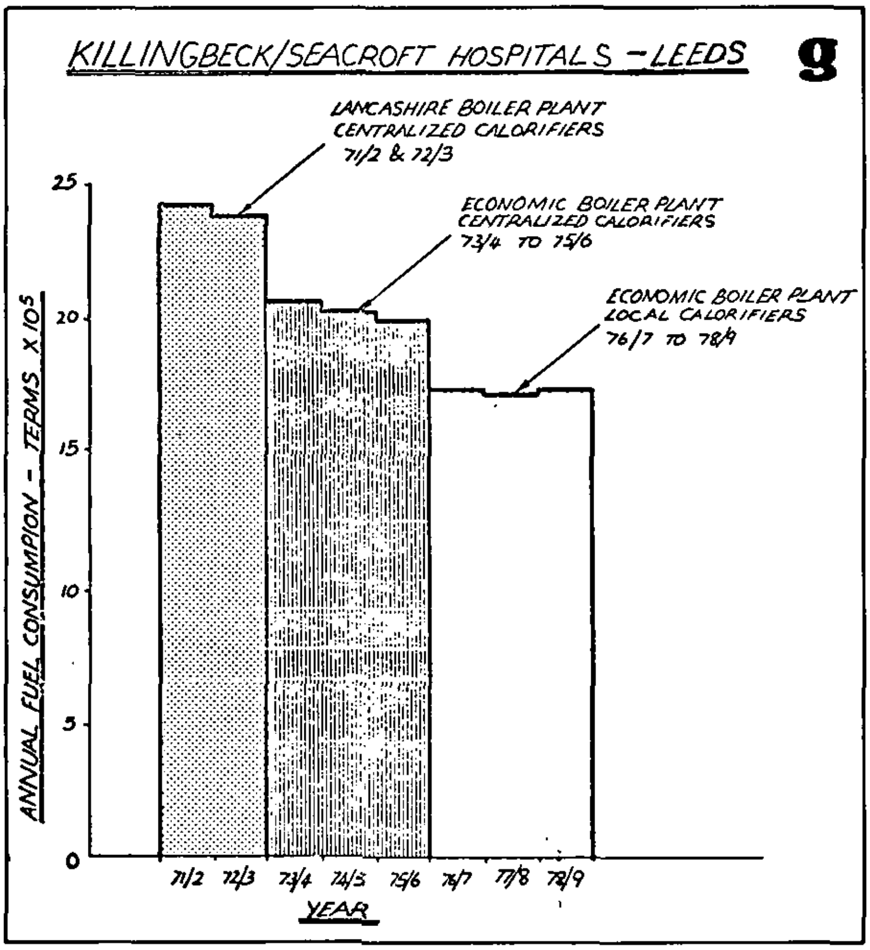
This hospital is a former TB sanitorium with a war-time hutted extension now housing a total of about 240 Mental Illness patients. The original central boiler house contained coal fired boiler plant (one Lancashire boiler rated 7,000 lbs/hour and one Economic 3 pass boiler rated at 5,000 lbs/hour which supplied steam to local calorifiers. There was an extensive steam distribution network and an appreciable amount of LPHW pipework in the hutted area. The standard of pipework insulation was poor. The majority of the local heating calorifiers had external compensator controls.

The main engineering services were re-organised during 1977/8 — seven local LPHW boiler plants being provided to serve the Southern portion of the site and a grouped boiler house containing six modular LPHW units to serve the Northern area. The extensive steam distribution network was abandoned and propane fired equipment provided in the kitchen.

The resultant reduction in fuel consumption is shown diagrammatically opposite.



Reduciton in fuel consumption — 59%.



Case Study 'G' Killingbeck/Seacroft Hospitals — Leeds

Historical Details

Killingbeck and Seacroft Hospitals date from the early 1900's and are sited approximately ½ mile apart. They are served by a central steam boiler house located in Seacroft hospital. Both establishments originally had centralised heating and DHWS calorifiers plus and extensive steam distribution system. The thermal insulation of all distribution pipework was poor being mainly of early 1900 standards.

The following notes amplify the remarks on the annual fuel consumption histogram below:

- 1971/2 & 1972/3 — fuel consumption of coal fired Lancashire boilers serving original centralised heating and DHWS calorifiers and utilising poorly insulated distribution network
- 1973/4 to 1975/6 — fuel consumption of new interruptible gas/oil fired 3 pass Economic boilers serving the original centralised calorifiers and distribution systems
- 1976/7 to 1978/9 — fuel consumption of new Economic boiler plant serving *local* heating and DHWS calorifiers

Saving in fuel:

(a) Replacement of Coal Fired Lancashire Boilers by Economic Boilers — 16.6%.

(b) Replacement of Central Calorifiers by Local Heating and DHWS Calorifiers — 14.6%.

The Hybrid Solution for Medium Size Acute Hospitals

The success of the engineering works at the hospitals listed in *Tables 2 and 3* results entirely from the decision to move away from steam raising plant. It is therefore relevant to consider what is the most realistic and practicable engineering solution for the many medium sized acute hospitals in the 100 to 250 bed sizeband where a strictly limited amount of steam for sterilization purposes is still required. There are two possible approaches where an irrevocable steam requirement exists — either to provide local steam generation in the form of electrode or coil boilers, or alternatively to utilise either HPHW or thermal fluids as the heat transfer medium. The use of HPHW offers only minimal advantage over centralised steam generation and is not really a practicable solution in the smaller hospitals. Thermal fluids have been considered, but there is no known hospital in which this media is used as the heat source for localised steam generation to meet the needs of minor but essential steam supplies.

Two hospitals have however recently adopted the hybrid solution of centralised LPHW boiler plant to serve the main heating and DHWS requirements, plus local coiltype steam generators to meet the limited steam needs. These hospitals feature in *Case Study Summaries 'H' and 'I'*. Whilst the 36% saving achieved at Bristol General Hospital is considered exceptionally high due to the distance of the original steam boiler house from the main hospital, there may well be other medium-sized establishments where these site conditions prevail. The 16% saving achieved at Ancoat's Hospital, Manchester is much lower than anticipated, even though the hospital concerned is located on a compact city-centre site and consequently had a very limited external distribution system. However it is known that teething troubles were experienced at this installation, and it is hoped that the second year's operation of the hybrid solution will show an improved level of saving.

Case Study 'H' Bristol General Hospital

Historical Details

Bristol General Hospital is sited in the dock area of the city — the hospital site is very compact. The original boiler house is located with the District CSSD approximately 200 yards distant from the the hospital.

There have been numerous engineering changes over the last 8 years which have influenced fuel consumption. These are listed below:

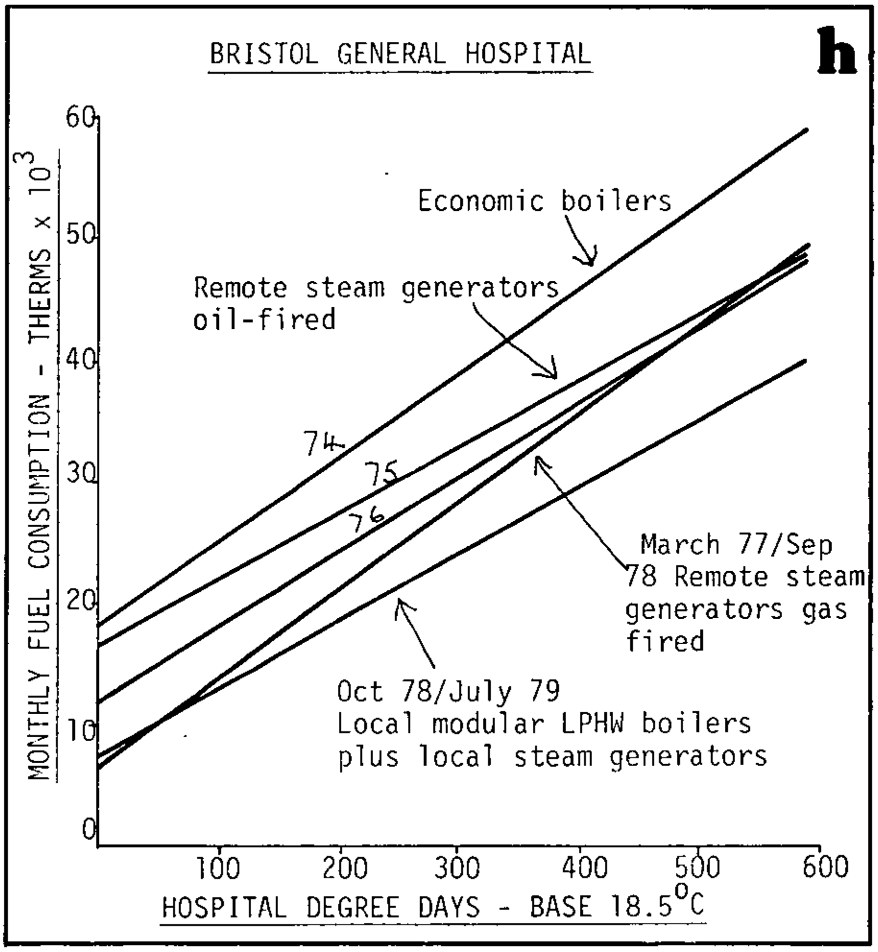
- Up to 1974 — Economic steam boilers — 3500 sec oil — located in remote boiler house (boiler originally coal fired)
- 1975 — Economic boilers replaced by 3 x 7,000 lbs/hour steam generators (fully automatic — 35 sec oil)
- Mar '77 — Steam generators converted to gas firing
- Oct '78 — Gas fired LPHW boilers installed in main hospital for heating and DHWS. Local steam generators provided for kitchen and steriliser loads
- Aug '79 — Steam generators (7,000 lbs/hour rating) previously serving CSSD only replaced by 3 x 1,700 lbs/hour unit surplus from another site

The resultant fuel consumption is shown below:

Total Saving In Fuel (1974 to Oct 78/Sept 79) — 36%

Saving by Replacement of Remote Economic Boilers by Remote Steam Generators — 23%.

Saving By Replacement By Local Modular Boilers & Local Steam Generators — (1976 to Oct 78/Sept 79) — 16.7%.



Case Study 'I' Ancoats Hospital — Manchester

Historical Detail

This 147 bed hospital is located on a compact city centre site and serves a predominantly Accident and Emergency role. The various buildings are very closely sited and the original steam boiler house is located close to the load centre.

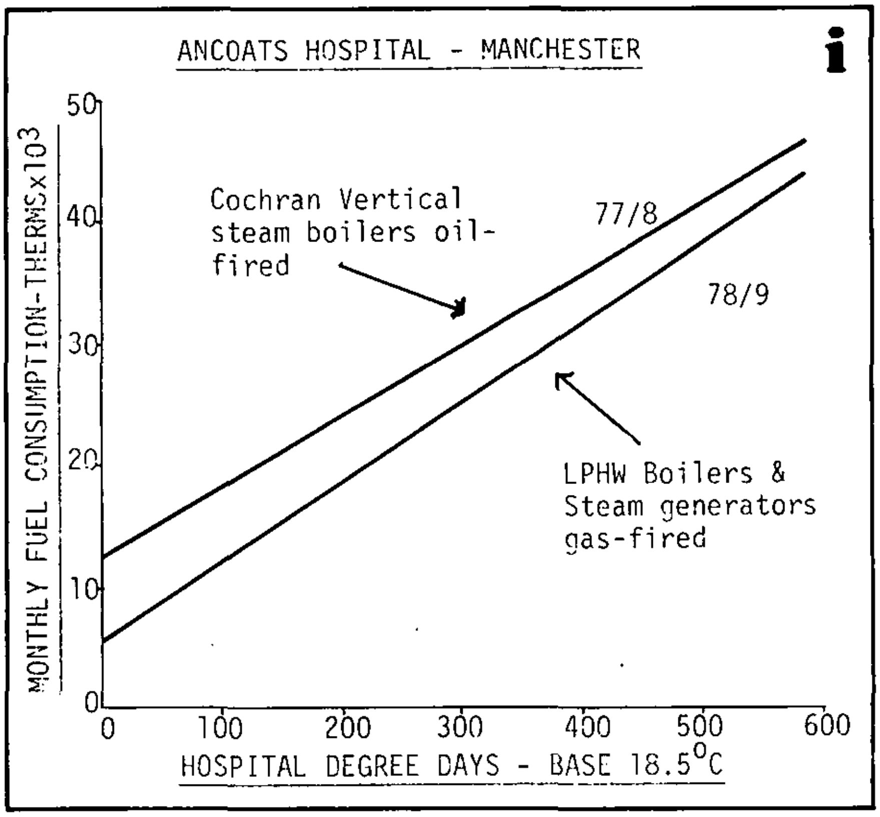
The original Cochran vertical steam boilers — 3500 sec oil — were replaced in 1978/9 by 3 Ideal Standard gas fired LPHW boilers for heating and domestic hot water plus 2 Stone Platt steam generators for the essential sterilising and kitchen steam loads.

The fuel consumption prior to and after this engineering change are shown on the following diagram

Hospitals with Existing LPHW Installations

Whilst up to now the emphasis of my remarks has been directed towards hospitals with inefficient or outdated steam installations, it is perhaps appropriate that some consideration be given to the many small hospitals and the peripheral buildings on major sites which have used LPHW as the distribution media since the date of their construction.

Most of these installations originally had coal or coke fired cast iron sectional boilers which were converted to gas or oil during the 1960's or early seventies. Most of these conver-



Saving in Fuel — 16%.

Table 4 — Improvements at existing Hospitals already equipped with LPHW Boiler Plants

Hospital	Type & No. of Beds	Original *Installation*	Modernized *Installation*	% *Fuel* Saving
Crewkerne (Somerset)	Acute (Cottage) 30 beds Beds	Separate C I Sectional Boilers for Heat & DHWS — No controls	DHWS Boiler replaced by modern package unit DHWS System improved. External compensator provided	19
Monsall (Manchester)	Mixed function (Former isolation) 300 beds	47 local C I Sectl. oil fired boilers-many gravity flow heat & DHWS systems — No controls	Boiler plant rationalized (11 replaced) converted to gas firing-pumped circulation & controls provided	
Marland (Rochdale)	Geriatric 98 beds	C I Sectl. boilers oil fired. Gravity flow DHWS no controls	Modern oil fired boilers DHWS converted to pumped circultn extnl Compstr provided	23
Avenue (Bridlington)	Mainly Acute 66 beds	Gas fired C I Sectl. Boilers serving combined Heating DHWS systems No compensating controls	Modular gas fired boiler plant serving Combined Heating & DHWS systems compstr controls added	27
Brandeth (Ormskirk)	Geriatric 50 beds	Separate C I Sectl. Boilers for heating & DHWS — both boilers in use during summer	Gas fired modular boilers serving combnd Heating & DHWS system	29
Kibworth Hall (Leicester)	Mental handicap (High grade) 38 beds	C I Sectl. boiler servg Combined heating & DHWS system- large boiler used for DHWS only in summer	Direct gas fired DHWS heatr (Beaumont) large boiler shut down in summer	30 (During period May-Oct)
Skipton (General)	Acute 47 beds	Coal fired C I Sectl. Boilers underfired stokers combined heating & DHWS systems	2 lge modular gas fired boilers serving combined heating & DHWS systems	35
Hollywood Hall	Mental Illness Illness 110 beds	8 local C I Sectl. LPHW boilers + Cochran Steam boiler for kitchen (All coke fired)	8 modern LPHW boilers 35 Sec. oil steam boiler converted to 35 Sec. oil time clock controls added	39

sions were of a primitive type — in many cases no measurable CO_2 reading is obtainable even when the burners are operating on 'high fire'. It follows from this brief statement that a high proportion of these comparatively small LPHW installations — which constitute the greatest single group of boiler plants within the NHS — burn a considerably greater amount of fuel than modern modular or combination boiler plants which have been purpose designed to operate at high combustion efficiencies even under light load conditions. The operational problem, in many instances, is exacerbated by gravity-flow circulation systems, lack of controls, and pipework layouts which necessitate continuous heating in intermittently occupied areas.

The foregoing scenario obviously raises the question of what saving will accrue from the modernisation of these comparatively simple but *out-dated engineering installations*? This question is surprisingly difficult to answer, mainly because accurate records of fuel consumption were not normally maintained for isolated buildings on a major hospital campus, or for many of the remotely sited cottage-type hospitals. However sufficient case histories have now been accumulated to provide a tentative indication of the potential savings. *Table 4* shows that the *reduction in energy consumption* actually achieved ranges from 20% to 39%, with the greatest return occuring where old coal- or coke-fired boiler plant has been replaced by its modern counterpart. If the two former solid fuel installation are ignored, the tabular evidence suggests that reductions of 20% to 30% are achievable.

The saga of Monsall Hospital was fully documented in our *October '79* issue. This account of progressive energy conservation works is commended as it provides a closer insight into the problems inherent in many of the older hospitals. The abridged engineering details for Crewkerne and Marland Hospitals are perhaps more typical and are given in *Case Study Summaries 'J'* and *'K'* respectively.

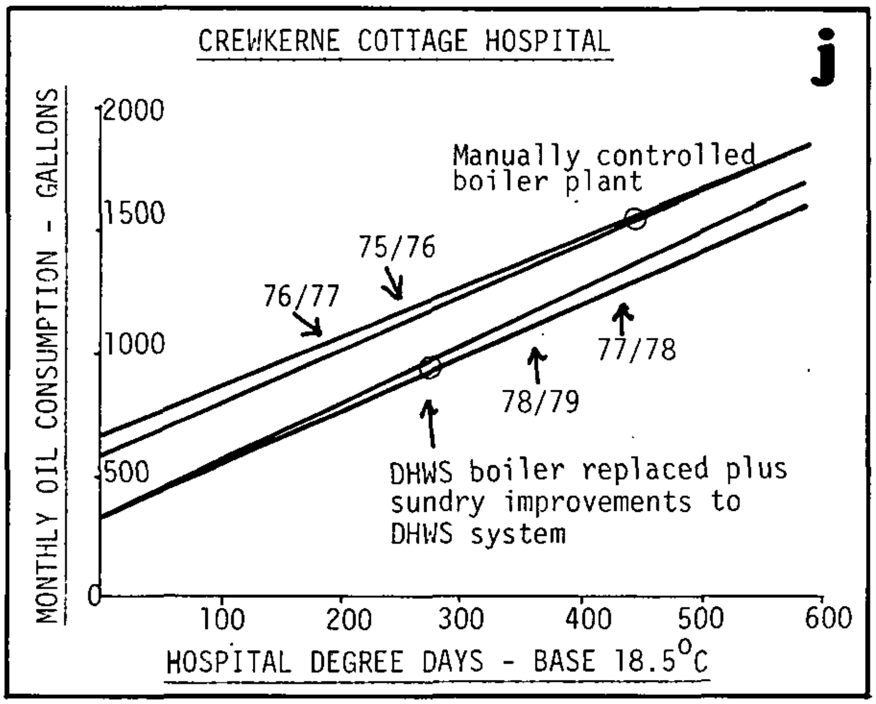
Case Study 'J' Crewekerne Hospital

Historical Detail

This 30 bed Cottage Hospital is equipped with a minor operating theatre, X-ray and out-patient department facilities. The building is a compact 2 storey structure with single storey extensions. Separate LPHW boilers serve the DHWS and heating duties.

The following notes are intended to assist in the interpretation of the following thermal performance diagram:

- 1975/6 & 1976/7 — fuel consumption of the original manually controlled C.I. Sectional boiler installation
- 1977/8 — fuel consumption after replacement of the DHWS boiler by a modern package unit plus improvements and insulation to DHWS distribution system. Ceiling insulation provided in certain areas of the hospital
- 1978/9 — fuel consumption after provision of external compensator and three way valve control on the heating system



Overall Saving In Fuel — 19%.

Case Study 'K' Marland Hospital — Rochdale

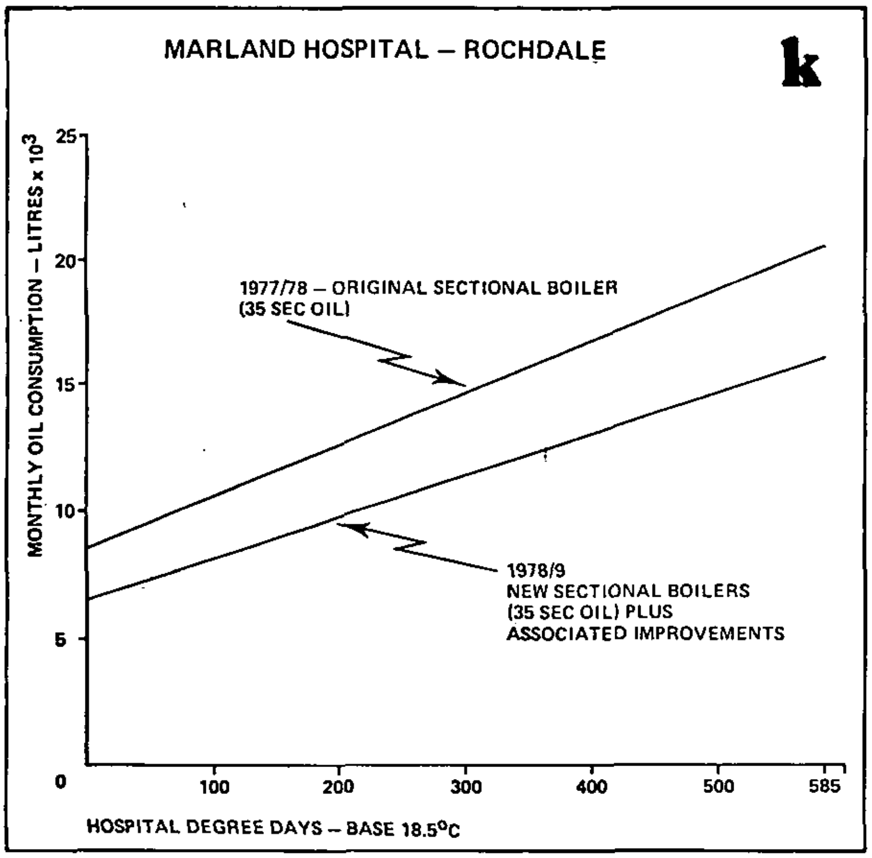
Historical Detail

This hospital is a former infectious diseases establishment which now accommodates 98 Geriatric patients. The buildings are of substantial brick construction dating from the early 1900's.

The original installation consisted of 2 CI sectional boilers (35 sec oil) serving independent heating and DHWS systems. The boilers were inefficient conversions from solid fuel and the DHWS system operated on gravity flow circulation principles.

In 1978, the following engineering work was carried out:

- Obsolete and inefficient C I sectional boilers replaced by modern LPHW boilers. The new boilers serve a combined heating and DHWS function.
- DHWS system changed from gravity flow to pumped circulation — flow and return mains insulated
- External compensator control provided
- Thermostatic radiator valves installed in day rooms and sun lounges.



Saving in Fuel — 22.9%.

Optimum Start External Compensator Controls

One of the most rewarding features in many of these older hospitals, even where the boiler plant and main services are reasonably efficient, lies in the provision of adequate controls. These are often next to nonexistant — heating flow temperatures being controlled by the manual adjustment of boiler thermostats, and heating systems operating continuously, even in buildings which are only intermittently occupied. This latter group of buildings includes not only clinics and office accomodation, but also Outpatient Departments, Day Hospitals and Dental Hospitals. The potential saving from the installation of optimum start or even simple time-switch controls in these areas will reduce fuel consumption by 40% to 50%. Mild weather overheating is a well known syndrome, but nevertheless is a common feature in far too many hospitals — the provision of external compensator controls will do much to alleviate the unnecessary opening of windows during mild weather periods.

The effects of providing optimum start and external compensator controls are shown in *Case Study Summary 'L'*. These two examples are taken from Highlands Wing of Enfield General Hospital, where there are about a dozen dispersed 2-storey ward or office buildings, each with individual gas fired LPHW boilers and a metered gas supply.

Case Study 'L' Highlands Wing— Enfield General Hospital

Background Detail

The major portion of this hospital is served from a central steam boiler house but there are 12 peripheral 2 storey ward and office buildings which have their own gas fired boiler plants. The latter are separately metered.

Office Blocks

These buildings were previously heated on a 24 hours per day basis — the effect of the provision of an optimum start controller is shown diagrammatically below:

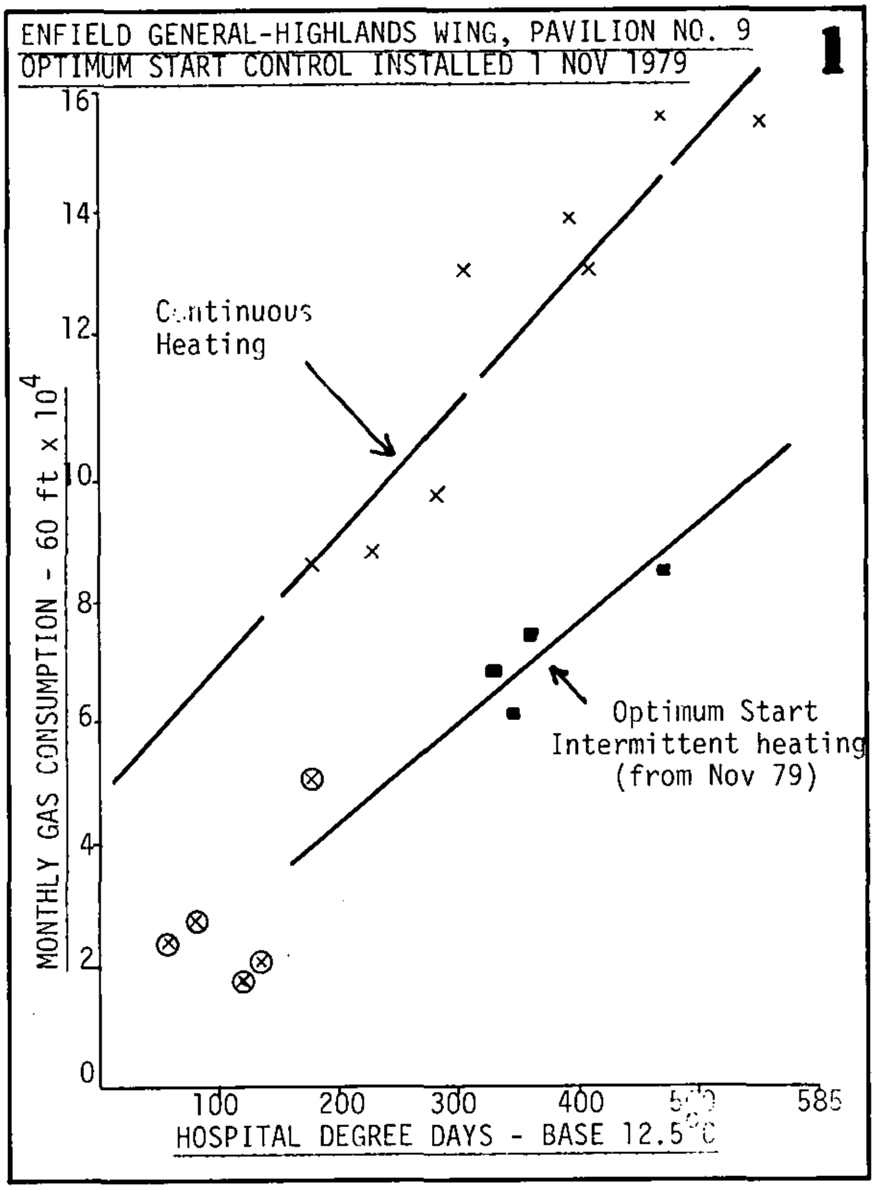
Ward Blocks

Temperature control was previously by manual adjustment of boiler thermostat — the effect of the provision of an external compensator and 3 way valve control system is shown on the graph below:

n.b — fuel saving will be increased when the new controls have been set to the correct slope

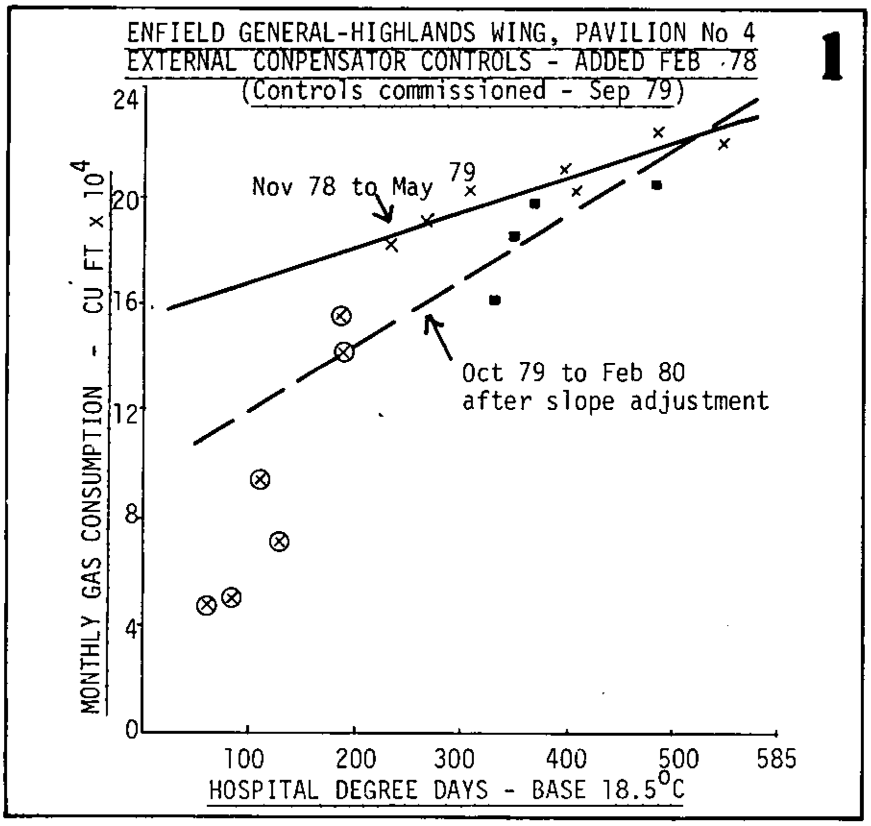
Conclusions

During the course of this paper reference has been made to the energy savings actually achieved in about 30 named hospitals — in every case the level of savings has been in excess of 20%. The fundamental reason for these savings is that the engineering installations have been modernised to standards compatible with the latter part of the 20th century. The hospitals listed represent only some of the establishments where modernisation work has been completed long enough for the new thermal performance to be analysed and the resultant savings quantified. Many more hospials have been identified where similar work has either been completed, is in progress, or is currently being planned. The author is aware of at least 30 additional cases of ongoing 'reboilering' and 15 further examples of hospitals moving from steam to LPHW. These two categories alone constitute a significant trend.



Since its inception the NHS has lacked any form of logical or structured plant replacement programme. As a result of this shortcoming, there is an enormous backlog of plant, services and equipment which is long overdue for replacement. The energy savings actually achieved in the 30 named hospitals show, without any shadow of doubt, that there is a clear inter-relationship between plant/services replacement and the realisation of really significant energy savings.

The evidence which has been adduced in this paper suggests almost conclusively that the prospective overall saving is of the order of 30% in the older unmodernised hospitals which constitute the largest pro-



portion of our national stock. It is stressed however that this level of saving will only be realised if the gigantic task of refurbishing and updating the engineering services in these hospitals is tackled systematically and with resolution. This estimate ignores the further useful and economically viable contribution which can be achieved by the application of proven heat recovery techniques, central management control systems, and the other refined products of modern technology.

Numerous case studies in this paper have demonstrated that the pay-back period for the refurbishing work can be surprisingly short — in some cases less than two years. This immediately poses the question 'how can the NHS afford to ignore such golden opportunities for worthwhile savings?' Certainly it can be stated that the operational efficiency of the service will be lower that it should be, and that energy consumption will be greater that it could be, until this particular nettle is grasped and the opportunity for positive long-term financial savings is taken.

Miss Scott gave this paper at the First International Seminar held at the Hospital Engineering Training Centre at Falfield in the Autumn of 1979.

Developments in the Production of Sterile Goods Appropriate Technology

Miss SBR Scott RCN SCM, Nursing Officer, DHSS

Present day production of sterile goods both in the National Health Service and Industry results from a steady and logical sequence of change which has evolved during the past twenty plus years.

Although past history, reference to the various stages both users and suppliers have experienced can promote a fuller understanding of todays policies, practices and products.

Development in the production of sterile supplies has been made possible as technology in relation to industrial hardware has developed at the same time. The need to meet the changing needs of clinicians and nurses in the care of patients has certainly made increasing demands on the sterile supply department and probably this, in turn, has promoted the technological development of processing machinery and equipment. Another influencing feature has been the need for improvement in the microbiological standard of supplies provided. This need was the main initiative and continues to be so today. Also, in response to the need for improvement in standards, industry has co-operated and played a major part in the development of materials and packaging.

Over twenty years ago, the provision of sterile requirements in this country was very different from what it is now. In the late 50's all sterilization was being undertaken locally in the wards and in other hospital departments such as the operating theatre. Each area usually had its own water boiler, which was proved to be ineffective in achieving sterility. Metal drums containing dressings/linen were used, and even if the contents were sterile when opened initially, the repeated use of the drum was hazardous.

The first move in recognition for the need for improvement came when the Nuffield Provincial Trust published in 1957, the first of three reports — *Planning and Organisation of Central Syringe Services.*

In 1958, the second report was published and it was entitled *Present Sterilizing Practice in Six Hospitals.* This report related how sterilization was being conducted detailing situations witnessed. All indicated a gross lack of knowledge in relation to prevention of cross infection, with no acknowledged standards, controls and supervision. It is always easier to be wise after the event and while we may feel critical of such situations today, this report was the beginning of an awareness of the need for improvement in establishing a higher and safer standard of patient care, while acknowledging the critical aspect of cross infection.

The first major change, in the development of providing sterile supplies came with the establishment of a Central Syringe Service, usually undertaken in 2-3 rooms in the basement or some less needed, less desirable area of the hospital. Here syringes and needles were cleaned more effectively than they had been on the wards, and were sterilized by either Infra Red Conveyor Belt or Hot Air Oven. Ultimately, this method was superseded and users were supplied with syringes and needles, in standard sizes, from industrial sources. The product industry offered was an improvement on that produced by the Central Syringe Department. It was a single use item and it therefore eliminated the need to re-use something which previously had only been checked for cleanliness and efficiency by visual inspection — not always effective especially if undertaken in poor lighting.

Commercial production lines were more able — particularly with the introduction of disposable materials, such as plastics, and the use of Gamma Radiation as the sterilizing process — to meet the needs of the users and more importantly with strict quality controls they prepared a "safer to use" product — a single use item. Now every syringe and needle, apart from a few exceptions, is a disposable item and because of mass production and standard packaging, can be purchased at an economical price.

The improvement this brought to the patient was appreciated, the needle would not be 'barbed' or found to be blocked at the crucial moment of use. Development in industry had introduced with disposable syringes and needles a higher standard in patient care.

It was due to the growing drive of doctors, microbiologists, nurses and others that the **second major**

change came with the introduction of Central Sterile Supply Departments — CSSDs. One of the first was at Musgrave Park Hospital, Belfast. Also at this time sterile packs, using cardboard boxes, were improvised from the Cambridge Military Hospital, Aldershot, partly to overcome the problem of sterilizing on the spot requirements for dressings and other procedures, at the time of the Suez crisis.

The *Bri-pak* box used for packaging was a contribution from Industry in this development, and in many instances replaced the metal drum.

Initially CSSDs, some purpose-built, some in adapted accommodation of 2-3 rooms served only the hospital to which they belonged. They were responsible for producing the items, instruments as well as dressings, required for undertaking clinical procedures in wards and departments. They produced individual packs for procedures, eliminating the need for the metal drum and the use of Cheatle Forceps, thus aiding the effort to prevent cross infection. CSSDs aimed at providing a complete service which in turn meant the sometimes misused water boiler could be removed from each area, again another step in controlling infection. No longer would a trolley set with sterile items be used for a number of patients during a round of dressing procedures.

In time, some departments expanded their provision of service to all the hospitals within their own management group, thereby more fully utilising the equipment and staff within the department, the aim being to achieve maximum economy.

To gain this the CSSD had to serve a minimum of 2,000 beds. At the ultimate end of the scale of provision some give a service to over 4,000 beds, becoming an area, sub-regional or even regional sterile supply service, this depended, of course, on a standardisation of pack content. The largest organisation in UK is in the West of Scotland directed by Dr Cameron Weymes. The development of CSSDs within each region depended largely on the degree of priority each authority awarded this support service, and in some instances it depended upon the availability of accommodation and the funds required, to establish and run the service. One of the tempting factors put forward for consideration was the release such a service would bring to nursing staff. Work of this nature could, under supervision be performed by non-nurses in the CSSD. The provision of guaranteed sterile packs was, of course, objective No 1. Being centralised and under proper control aided this achievement. In other words, a department and certain persons were being identified as being responsible.

In addition, some CSSDs extended their service to operating theatres by giving a soft pack service, containing linen used to drape patients and the instrument trolley, and the swabs, wound packs etc required during surgery. It was also found possible for some CSSDs, where work space permitted, to extend their service further to include the surgical instrument requirements, using a pre-set tray method.

A third report was published by the Nuffield Provincial Hospital Trust in 1963 — *Central Sterile Supply, Principles and Practice.* Three reports in six years was quite an achievement.

This report set out to give an account of the long-term investigation into the organisation of central sterile supply and suggested methods whereby hospitals might plan and run their sterilizing practice.

The basic principles described in the report still hold good today, such as — "Future sterilizing policy to be effective, must provide a centralisation of facilities, where modern equipment can be employed, where routine tasks can be done by staff who are not so highly trained as nurses, and where supervision and control are assured".

Also —

"Costly pieces of equipment are likely to lie idle awaiting emergency use, and routine servicing is liable to be overlooked". They suggested that such equipment should be stored centrally. This would achieve economy and efficiency by ensuring an intensive use of equipment, a high standard of cleanliness and a periodic servicing by technicians.

With an appreciation of the many advantages that CSSDs offered in supplying wards and departments, demands were made for their application to the operating theatre, and so we come to **the third major change** in the development of provision of sterile supply.

In 1964, the Theatre Service Centre, at the Royal Infirmary, Edinburgh introduced pre-set trays of instruments to, initially, two general surgery theatres. This was the result of Dr John Bowie's pioneering work and great determination for improved conditions to eliminate cross infection in the operating theatre. The use of the recently developed, at that time, high-vacuum autoclave made this possible. Again a response, with the development of industrial hardware in the form of that particular type of sterilizer, to meet the requirements of users initiated by the desire for improved standards. The industrial hardware development also included the introduction of the aluminium tray.

The Theatre Service Centre or, Theatre Sterile Supply Unit, both are similar but, are more commonly referred to as a TSSU, is responsible for giving a service to the operating theatres in the form of trays and packs containing surgical instruments, utensils and dressings.

There is a choice, as there is with the provision to wards, between a composite pre-set tray or a split pack system. Basically, a composite pre-set tray provides all items except sutures and other miscellaneous items, on a tray or trays for one operative procedure. The split pack system is, as it suggests, a tray or type of pack containing surgical instruments and utensils with another pack providing the linen and dressings. They are brought together in the operating theatre by the 'Scrub' nurse and so two or more types of packs are used for the one operative procedure.

Generally, the majority of users prefer the composite system as this presents all requirements ready for use on a tray, thereby eliminating the need for handling when marrying together the soft goods, linen and dressings, with the instrument tray. Handling, in the preparation stage introduces an opportunity for contamination and may also be time consuming which can be crucial in emergency surgery.

The scale of provision of a TSSU varies from one unit to another, some serve only a few operating theatres while the largest, in the UK gives a service to over thirty theatres. Initially, those built in association with new hospital developments were often physically connected, with direct access, to the Operating Department. Others were provided in upgraded accommodation entirely separate from the Operating Department. With experience in use it was found that when the unit was physically linked and managed within the overall operational aspects of the Operating Department, its scale of provision was often limited to that one operating department. Other TSSUs have been built as a service department, often as part of the industrial zone of the hospital and as such are capable of a much wider service remit with easier supply and disposal traffic routes.

The main principles in provision of a sterile supply service from a centralised department, be it TSSU or CSSD can be expected to provide the following advantages:

1. Provision of guaranteed sterile packs resulting from properly controlled cleaning and sterilizing processes.
2. Improved standardised packaging methods which contribute to a higher standard of technique in undertaking clinical procedures.
3. Relief of nursing staff from time-consuming work which can, under supervision, be performed by others.

After 1964, it could be seen that sterile supply departments were a proliferation of the various developments so far, some departments remained small CSSDs, some became larger supplying more than one group of hospitals, some included theatre soft packs while a few actually included the processing of theatre instruments. A few became more industrialised and can be thought of as Pack Factories. The many variations of the theme clearly demonstrated a need for some rationalisation and policy guidance.

In 1967, a report on CSSDs was produced by the Joint Committee of the Central and Scottish Health Services Councils, the report became known as *The Collingwood Report,* after its Chairman, Sir Edward Collingwood.

The committee which wrote the report had been asked to advise on the policy which should be followed, on the provision of Central Sterile Supply Services, also the organisation and control of CSSDs.

This was probably the first sterile supply policy document to be issued from the DHSS. Although published 12 years ago many of its recommendations are certainly relevant to, and reflect aspects of, today's DHSS policy.

Note the following:

- "the number of sterilizers located outside a CSSD should be restricted and should be under the same kind of control as the CSSD sterilizers"
- "Generally hospitals should concentrate on using high vacuum steam sterilizers or dry heat methods of sterilization. Ethylene Oxide should be used only under routine control of a consultant microbiologist".
- Regional hospital Board should establish a policy for maintaining sterilizing equipment and appoint an officer to enforce it.
- The performance of all sterilizers should be tested regularly. There should also be regular planned maintenance of all sterilizers by specially trained engineers. (The 1980 revised Health Technical Memorandum 10 details this aspect fully and should be followed closely).

Recommendations regarding service policy included—

- Generally a CSSD should serve at least 2,000 beds or its equivalent in services that require sterile products and much larger numbers may be served effectively.

The Collingwood Report also recommended that —

- The Health Departments should promote vigorously the establishment of a limited range of standard packs and materials.

also

- The possibility of purchasing a standard range of dressing packs and materials on economic terms from commercial sources should be kept under review.

In 1969, **the fourth major change** in the development of provision of sterile supplies was initiated when the then South Eastern Regional Hospital Board of Scotland introduced standardised packs to that region; sterile for aseptic procedures and clean for clean procedures. They supplied to all 80 hospitals within the region, a comprehensive pack range obtained from commercial sources.

Although industry had for some time provided sterile dressings they were until then limited in range and without instruments. The new packs for the SE Region contained disposable instruments and those materials required to undertake the most common clinical procedures. In doing this the region's capital investment was directed to establishing sufficient TSSUs throughout the region, to provide all departments, wards and operating theatres with those requirements industry was unable to provide — hence a concentration of processing only the re-usable items within the hospital service.

One of the greatest advantages the provision from industry of basic disposable standardised packs offered, was the introduction of a common pack for a specific procedure, to be used whether you were a nurse working in one of the major teaching hospitals or if you were working in one of the smaller health care units. From a teaching point of view this was ideal and it dispelled the idea that teaching hospitals always appeared to have the best. Since then, for those reasons and others, the use of commercially produced pack has increased.

In 1967, *The Collingwood Report* recommended, as previously mentioned, a limited range of standard packs and materials and the possibility of purchasing a standard range of dressing packs and materials from commercial sources — this was what had been done is Scotland, but in England this recommendation promoted, in 1968, the formation of the Cunliffe Committee, chaired by Professor Cunliffe.

The interim report published in 1970 lists standardised pack contents and methods of packaging and materials — formed for use on a national basis this time. This gave the commercial interests a clear lead on what was required and in so doing increased the take up of commercial supplies within the NHS.

It was an enormous step forward in uniformity and the challenge of meeting the demand, both in terms of materials used and packaging methods was met by the necessary technological developments undertaken by industrial firms.

The final report of the Cunliffe Committee became available in 1976 and while most of the recommendations contained within have been commended by the Secretary of State to Health Authorities, one which is still debated is the cost implications of a supply from commercial sources as opposed to production from NHS-CSSDS.

In 1972, **the fifth major change** came when the Department of Health determined its latest policy in the development of provision of sterile supply and it is this policy which we follow today. Superseding CSSDs and TSSUs the Hospital Sterilizing and Disinfecting Unit — HSDU is established. This type of unit is responsible for supplying the following three main areas of work:

1. All sterile requirements for the

operating department and also disinfected items such as anaesthetic accessories. Anaesthetic accessories classifies those items used in connecting the patient to the anaesthetic machine.
2. Special procedure packs for use in wards and departments. They are packs containing re-usable instruments, linen and dressings — the type of pack with contents which are not available in disposable form and are therefore not obtainable, ready for use, from commercial sources. For example, Stitch Sets for Accident and Emergency. Intravenous Cut Down Sets and Aspiration Sets for general use.
3. The most recent inclusion to the centralised service department is a cleaning and decontaminating process for complex pieces of medical equipment such as Baby Incubators, Suction Machines and Lung Ventilators. As well as being cleaned, the Medical Equipment may be serviced and maintained to a pre-determined maintenance programme with quality control checks.

An HSDU is expected to be sited at a District General Hospital or at the hospital generating the highest percentage of need for re-usable items. Its scale of provision is to serve all health service users within the district provided the logistics of supply and return are satisfactory. The three main areas of work demonstrate a concentration of processing the re-usable items which can only economically and practically be catered for from within the hospital service. For the basic common use disposable pack for wards and departments *either* industry, with their strict industrial quality controls and advantages of mass production *or* large NHS pack factory type units can provide this type of pack.

The HSDU is functionally very similar in its workflow pattern to that already experienced in the earlier CSSDs and TSSUs.

Reception of soiled goods being returned leads into a Wash Room in which there are a number of washing processes available. The soiled equipment is processed by the most appropriate washing method. Of the surgical instruments, 95% can be cleaned and decontaminated by an automatic washing system. It is important that all washing machines in use function properly and to do this an adequate maintenance programme should be instituted. The purpose of a washing machine is firstly to remove all soil and debris followed by a stage at which the water is of a temperature sufficient to render the item socially clean and therefore safe to handle in the subsequent checking and packing activities. Apart from the washing machine, it may be necessary to provide a small ultrasonic unit which will more adequately clean those items which are difficult to surface clean also, some of the more delicate instruments which could be damaged if processed in large quantities. Anaesthetic accessories can only be satisfactorily cleaned by a suitable machine, which allows the water and detergent to reach soil within the lumen of tubing while, endoscopic equipment, due to its rather delicate nature, requires to be hand washed.

Once washed, the items require to be thoroughly dried. Some machines incorporate a drying process but should a drying oven be used, maintenance is again required to prevent any mishap such as overheating. Following cleansing, the equipment proceeds to the Work Area, where it is checked and assembled prior to sterilization. Once sterilized and allowed to cool it can be returned for storage within the user department or retained for storage within the sterile goods store of the HSDU.

Medical equipment, because of its highly technical and complex design, requires an area of its own within the unit but it can use where appropriate the processing equipment within the Wash area and other sections of the HSDU. Properly trained medical equipment technicians should be the only staff to undertake the maintenance and service programme and this to a laid down quality control assurance procedure.

Finally, an effective and satisfactory sterile supply service is dependent on a number of aspects. Namely:
1. Good communication between the user and supplier. It is unacceptable for the user to receive, albeit sterile, items if they are not what is required or in a manner which cannot be used safely and without contamination. Most departments have a Users Committee which is multidisciplinary, representing medical and nursing users, control of infection officers, sterile supply managers and supplies officers. This committee aids communication and hence an acceptable service.

It is equally essential to establish good communications between the sterile supply manager and the hospital engineering staff, and an understanding of each other's role.
2. Supervision and Control. A sterilization policy to be effective must promote a centralisation of facilities, where modern equipment can be employed, where routine tasks can be done by staff who are not so highly trained as nurses and where supervision and control are assured.
3. Training and Education. Firstly, for the staff in the sterile supply department which is becoming more technically complex. The staff, and this includes engineering staff, must be trained how to carry out the jobs and tasks assigned to them, in a satisfactory manner and with safety to themselves. The Health and Safety at Work Executive may wish to play an important role in determining safety Codes of Practice on this. For Sterile Supply Department Assistants, a training handbook has been published and this is helpful in guiding the instructions. Secondly, managerial staff require a proper training scheme. Today they are expected to be responsible for all the grades of staff on their department's establishment and this requires an appreciation of staff management and personnel matters including employment, industrial relations etc. They are frequently responsible for their department's budget and must be able to assess by a costing system the minimum budget that will maintain the required standards. They are also required to forecast requirements ensuring that adequate supplies are always available including contingency plans of supply tc meet serious emergencies.

Until now no formal training has been organised and managers have been left to learn 'on the job', sometimes in an unsatisfactory way. However, plans are proceeding for the introduction of a formal and recognised training programme for managerial staff. Education must also be extended to the users. They should be taught how to use a pack correctly and strange as it may seem, they need to be reminded to select the correct pack for the job. Too often a pack is opened without thought and this can lead to waste. Once good communications are established, supervision and control implemented, and education and training becomes an accepted feature, the sterile supply service will be one suppliers are proud to offer, and the users pleased to accept and rely upon, for the care of patients.

The author is Head of Electrical Engineering Group (STB6), Scientific and Technical Branch, Department of Health and Social Security.
He read this paper at the 36th Annual Conference of the Institute at Newcastle in May, 1980.

Advances in X-Ray Equipment Design

R. T. ROGERS BSc FInst P

Introduction

The medical equipment industry is very quick to incorporate advances in technology into the design of equipment, and in changing designs to cope with advances in medical techniques. The medical X-ray industry is no exception and this paper outlines a few of the more recent advances in design. Some of the design aspects which are discussed were introduced a few years ago, but they are nevertheless mentioned becaude they have yet to make their full impact in the NHS.

Generators

The days of four-valve, full-wave rectified units with mechanical switching have just about gone. Present day generators use solid state rectifiers and solid state switching, with a move towards crystal-controlled timers and, of course, generally solid state circuitry thoughout. One effect of this has been a significant reduction in the size of equipment assemblies. Control desks are now usually of the small pedastall type, and are often available in a modular form, allowing an initial installation to be up-graded at a later date.

This modular idea has led to the concept of a shared generator. Conventional generators have one control desk allowing single operator use only. A shared generator has one HT tank but several control desks, each of which can be sited in a different room and each manned by a different operator. Although exposures cannot be made simultaneously at each control desk this is not a serious limitation, at least for radiography, because exposure times are very short -- typically a few tenths of a second. However for examinations involving long exposure times, ie fluroscopy, the limitation is serious and prevents any sharing between fluoroscopy rooms. Despite this the concept has its applications.

The use of solid state rectifiers in X-ray HT generators led some years ago to the introduction of mobile X-ray sets with X-ray generators in 'unibloc' form (ie with X-ray tube, transformer and rectifiers all within the X-ray tube head) thus removing the former restriction of this type of construction to self-rectified generators. Typically the HT generator is 2-pulse, 5 to 10kW. To date no so-called 'unibloc' head powerful enough for general radiography has been made — a power rating of 40kW or more would be necessary. However if in the future such an assembly became possible, the need for a free-standing HT tank would obviously disappear.

A number of the more recent changes in generator design relate to the use of microprocessors which most manufacturers now incorporate in their equipment. A few of the interesting uses to which microprocessors are being put at present are discussed below, but many more will undoubtedly arise in the future.

Anatomically programmed generators have been available for some years. With conventional three-knob control of radiographic exposure facotrs, a radiographer X-raying for example a lateral hip, looks to an exposure table for guidance as the the kV, mA and time to be used, and these are set with three controls. With an anatomically programmed generator a single button labelled 'lateral hip' would be pressed and the exposure factors are automatically set. However until recently the equipment supplier had to pre-set the variables for each anatomical view and the user needed to call in the supplier if a change was found desirable.

With modern microprocessor controlled generators this is far easier — basically the desired exposure factors are set and entered into the microprocessor memory by the user pressing an 'enter' button. The programmes remain pre-selected until the user wishes to change them. With some units as many as 60 anatomical programmes can be stored and altered at will. With some equipment assemblies the pressing of a single button labelled, for example, 'chest' not only leads to the automatic selection of appropriate exposure factors, but also leads to the automatic selection of other factors such as the grid, automatic exposure control and tube focus, and to the mechanical movement of, for example, the tube support to the correct distance from a chest stand with the tube correctly centred on the film.

Another application of microprocessor control relates to protection against X-ray tube over-loading. Without overload protection it would always be possible to select a tube voltage, tube current and time combination which would overload an X-ray tube by feeding too much power into the anode target. Each type of X-ray tube has its own power rating so that, on installation, overload circuits need to be set according to the type of X-ray tube to be connected One manufacturer now has a programmed chip for each of the X-ray tubes they supply so that on installation of their latest generator all that is necessary for overload protection is to plug in the chip for the tube to which it is connected.

Equipment using a microprocessor in another interesting way has recently been introduced. Tomography is a technique for viewing a particular slice of the body. This is achieved by moving, during exposure, the X-ray tube and the film in opposite directions so that features in the plane of the pivot are sharply focused, and those above and below that plane are blurred out. However when the tube is at either extreme of its movement, X-rays pass through a greater thickness of body that when at the mid-point, due to the obliquity of the X-ray beam. This, plus anatomical thickness variations, means that the rate at which radiation reaches the film varies as the tube moves over the patient. Preferably this should not be so. With the system just introduced, a radiation detector (an ionisation chamber) is placed over the film and assesses the dose-rate. Through a feed-back circuit facilitated by the microprocessor, the X-ray tube kV current are altered to keep the radiation-rate constant. In fact the X-ray generator secondary circuit contains tetrode control to achieve rapid kV adjustments, but the above is the basic principle.

What is interesting is that the principle can be extended to other fields such as peripheral angiography of the blood vessels of the leg, where a series of rapid radiographs are taken as the patient's leg passes through the X-ray beam by moving the table tops in steps. As the leg gets thinner so the kV and mA need to be reduced — the system can achieve this automatically and probably to a finer degree than hitherto achievable.

Microprocessors, together with appropriate X-ray tube control circuitry, may also present the opportunity of achieving more satisfactorily the aims of another relatively new feature of genertors — 'falling-load'. The principle of falling load is best illustrated by a theorectical example. Assume that a user has a 100 kW generator and wishes to use 80kV for a particular radiographic view. The amount of radiation required corresponds to 600 mAs. The power rating of an S-ray tube will allow this mAs to be achieved in any one of a number of mA and time combinations as determined by the loading curve in *Figure 1.* Thus 300 mA for 2 seconds or 600 mA for 1.0 sec is permissible but not 1000mA for 0.6 sec. In the latter instance heat may be injected into the target too quickly for any significant cooling to occur during the exposure. However with a falling load generator a 600 mAs exposure might in principle be achievable in 0.6 sec or even less. A falling load generator might in principle be achieved in 0.6 sec or even less. A falling load generator would start an exposure at maximum mA available at the kV selected (in this case 1250 mA) and allow the tube current ot fall during the exposure so as to follow the power rating curve. Provided the two hatched areas in *Figure 1* are equal, then a total of 600 mAs is achieved in 0.6 sec.

This is the principle of falling load, and theoretically it allows the shortest possible exposure time for a desired mAs or quantity of radiation. Often, getting the shortest exposure is very important, just as in photography, to reduce movement blurring. However with this system all exposures start with the maximum tube current. This is not good for tube life, particularly since attaining the shortest exposure is not always of prime importance, for example, with a limb, which can be kept stationary. What is more, falling load generators in practice often operate as shown in *Figure 2.* The tube current does not follow the loading curve exactly, but drops insteps, starting therefore at a tube current below the maximum. It can be seen then that the 0.6 second exposure which seemed possible from *Figure 1* is now impossible and might extend to say 0.7 seconds, which might have been achieveable anyway with a normal

Figure 1.

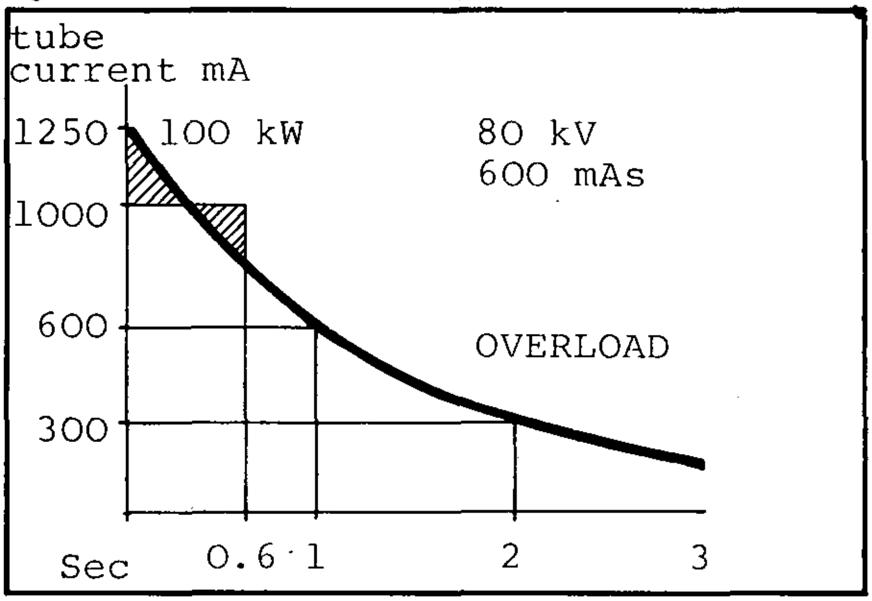
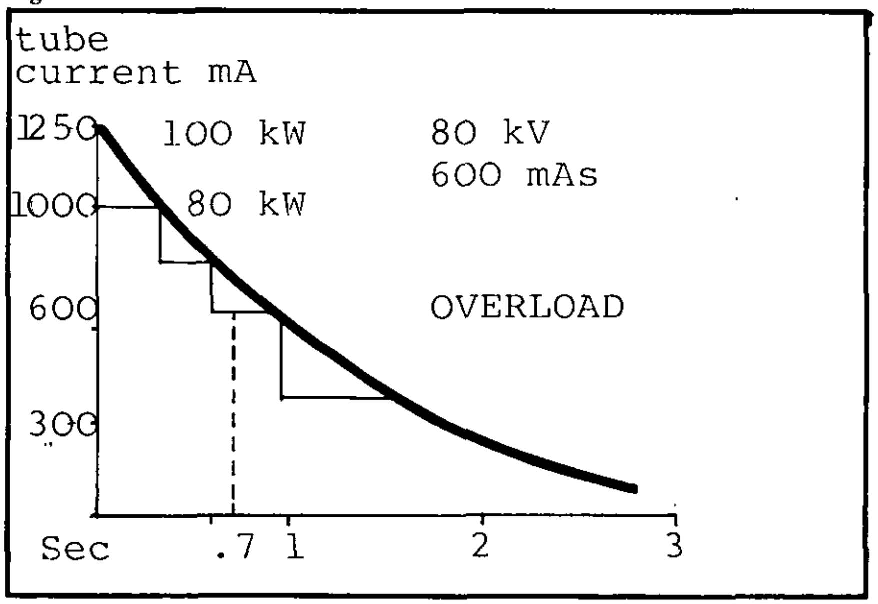


Figure 2.



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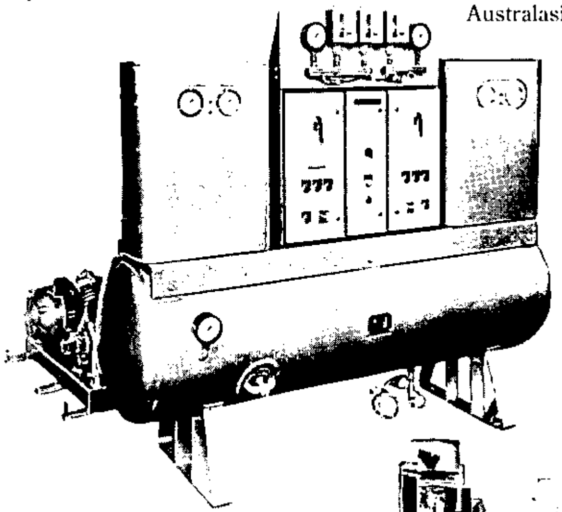

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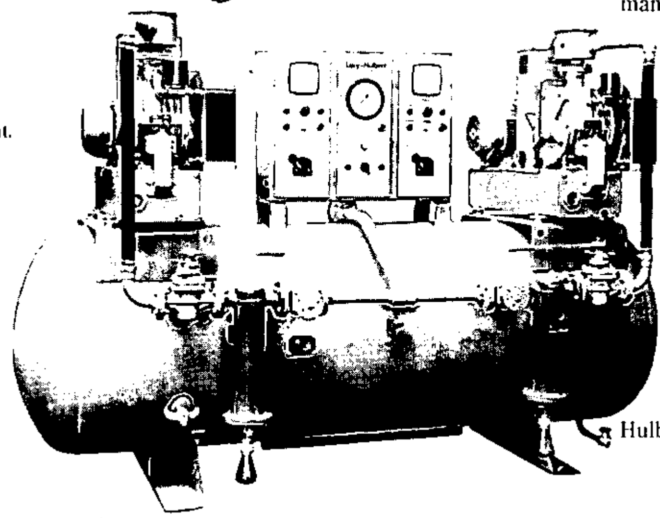

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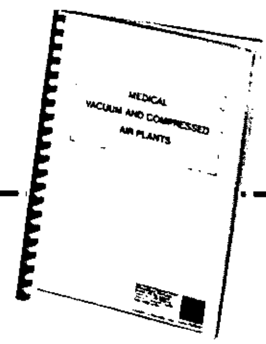

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generator. Also the maximum tube current is no longer available and the generator has been effectively down-rated — in this case to 80 kW. With a microprocessor generator and suitable HT control circuitry, together with a programmed chip for the actual tube type connected to the generator, it should be possible to follow a loading curve very closely. Also with microprocessor anatomical programming it should be possible to start exposures at maximum mA only when advantageous, and start at a lower value when this is not the case — for example a limb. We must await developments to whether this proves possible.

The final use of microprocessors in generators which is worth mentioning is their use in signal control and fault analysis. Conventionally there is a significant bulk of interconnecting wiring between control consoles, cabinets and equipment, all carrying a limited number of input/output signals. Already microprocessors are claimed to reduce this bulk by appropriate coding and recognition circuits, whereby a single cable can do the work of many in a conventional assembly. In fault analysis most microprocessor generators include a system of interrogating circuit test voltage points so that any fault can be detected. Once detected the nature of the fault can be indicated by a numerically coded display. This will enable a radiographer to alert a supplier's engineer of the nature of a fault before he leaves his base so that he has the right spares for the job, or can by telephone give guidance as to what to do to repair it. 'Suitcase' kits for setting-up and fault analysis are already becoming available to engineers in some companies.

X-ray tubes

In an X-ray tube, X-rays are generated by accelerating electrons from a hot filament onto a tungsten target which comprises the anode. Even with tungsten, only about 1% of the energy is converted into X-rays, leaving 99% to appear as heat, and with 30 or 40 KW input this represents a great deal of heat to get rid of. Much of recent design effort has been directed at dissipating this heat whilst at the same time raising the kW rating to allow smaller exposure times with more radiation. There are two main ways of tackling this problem. The first is to rotate the target to spread the heat around its circumference. Modern X-ray tubes have larger diameter targets than in the past, and rotate at 8500 rpm compared with 3000 rpm a few years ago. The other approach is to construct the target, its supporting stem and the rotor assembly. This increases the rate at which heat is radiated away, and at which it is conducted through the target disc down the stem and rotor, and hence into the thermal capacity of the cooling and insulating oil which surrounds the tube.

There have been a number of advances in construction, starting years ago with a rhenium/tungstem alloy target more able to resist thermal stress than tungsten alone, and with the use of molybdenum for the stem. A number of different base materials for the tungsten surface have been evolved to strengthen the disc, preferably without increasing the weight. In the last few years heavy duty tubes with a graphite base have appeared. Discs have also been made with angled radial slots to relieve stress in heating and cooling.

One of the most interesting tubes to appear recently has a tube envelope of metal and ceramic instead of glass. The HT cables plug directly into the tube and insulation is provided by ceramic. The metal envelope is earthed and this combination gives interesting advantages. There is now no need for oil for insulation although means for cooling are still required. Because the envelope is earthed, the window of the envelope can be brought very close to the exit port of the housing, meaning less oil between the two to scatter X-rays and degrade the emerging beam. Also, secondary electrons emitted from the target are captured by the earthed envelope, instead of returning to the target or other parts to produce unwanted off-focus radiation. The use of ceramic insulation also means that the stator coils and the rotor can be in closer proximity, allowing a larger target disc to be rotated to full speed in the same time as a smaller disc in a conventional tube — this increases the kW rating. The other novel feature is that the target disc is supported by stems on both sides, each with its own bearings — this should increase tube life. Despite its larger target disc and higher power rating, the tube is no larger physically than conventional tubes.

Rare-earth screens and daylight film handling systems

Most radiographic examinations used a hinged cassette containing two intensifying screens which emit light under the action of X-rays. A film is sandwiched between the screens which emit light under the for most of the film blackening. Screens of different sensitivities are available, but in general thicker screens with a larger crystalline structure are required to increase sensitivity which degrades resolution. However one of the most startling innovations in screen design took place a few years ago with the introduction of the so-called rare-earth screens — that is screens containing rare-earth elements which have the effect of substantially increasing sensitivity without degrading resolution. In practice this has made it possible to reduce radiation exposure to a patient by a factor or two or even more.

A barrier to their more widespread introduction into radiology is now finance — they are significantly more expensive than conventional screens. Their use may well however reflect on the power requirements of X-ray tubes and generators, particularly perhaps mobile X-ray units which in their most powerful versions create troublesome loads for hospital mains supplies. It may however be that radiographers in using rare-earth screens will take the opportunity of shortening exposure times with smaller focal spots rather than accepting a reduction in generator power ratings — the trend has yet to be firmly established.

Another substantial innovation at the film end of the business has been the introduction of daylight film-handling systems. Du Pont were first with a system a few years ago, but it is only very recently that all major film suppliers have been able to offer systems. The Du Pont and Ilford systems are based on cassettes which are sealed but have a light-proof slot at the end. An empty cassette is pushed into a wall-mounted film loader which causes the light-proof slot in the cassette to open, a film drops in and the slot closes as the cassette is withdrawn — all in the open — no dark room. One loader for each film size is necessary. Once the film is exposed, the cassette is taken to a specially adapted processor and pushed in; the film drops into the processor and the cassette is withdrawn — again no darkroom. There are variants of this system. Agfa Gevaert and Fuji systems are similar but based on convetinal hinged cassettes. The loader opens the cassette, loads it, closes it and delivers it back. There is one loading station for each film size. An exposed cassette is put into an adaptor on a processor, it is opened, the film extracted and fed into the processor, and the cassette delivered back empty. Kodak and 3M also use hinged cassettes but with the loading and unloading statins is opened and the film extracted and conveyed to the processor. By sensing cassette size, loads and closes the cassette and delivers it back — all in one operation.

Each variant has its advantages and disadvantages, but the importance of these systems is immense since they will undoubtedly eliminate the need for almost all darkrooms although, at least at present, one safe-lit area or darkroom will be required for processing special film and film, for example, from rapid filmchangers. To get the most out of theses systems, processors, loaders, and unloaders will need to be close to radiodiagnostic rooms. The processors will stand in well-lit areas, preferably with access all round unhindered by plumbing and controls. If appropriately planned, it should be possible with daylight systems to achieve a significant reduction in staff movement, better working conditions and greater job satisfaction.

Processing and Chemical Mixers

Whilst improvements in processing may not have been as startling as in other areas, they ahve nevertheless been evident. For example, the introduction of infra-red drying of films rather than the use of hot air has cut down on the heat injected into the environment and is more efficient. A variety of economy measures such as low-consumption standby conditions, water economy devices and control of replenishment of chemicals have reduced running costs. Microprocessors are of course being introduced, for example for fault analysis and control, and there is plenty of scope remaining for monitoring and controlling processing conditions.

Silver recovery is practised almost universally now with efficient systems, but one new process is particularly worth mentioning, and that is a silver recovery unit which, having extracted silver from fixer and reduced its concentration to acceptable levels, recirculates the fixer. Recirculation of fixer in this way could lead to considerable savings in the NHS.

One excellent innovation which all major processor manufacturers have recently introduced is the automatic chemical mixer. Instead of undertaking the messy and unpleasant business of manual mixing, these new units are plumbed into the processor. All that is necessary is to buy cartons of liquid fixer and developer concentrates and push them onto the mixer, where they are pierced. The concentrates are drawn off as required, diluted, mixed and fed into the processor automatically. An alarm indicates when a carton is close to empty. Simple — but a great advance, particularly where processors are distributed around a department in a daylight system, and unpleasant fumes and slopping of liquids are most unwelcome.

Image Intensifiers and 100 mm 'Photofluorography'

About 5 per cent of all radiological examinations are of the dynamic type rather than the static radiographic type involving just a film for producing an image. Dynamic examinations (flouroscopy) require the use of image intensifiers. With the latter, X-rays stike a flourescent material producing light. The phosphor is in intimate contact with a photo-electric surface which produce electrons which are accelerated and focused onto a small output phosphor, and turned back into a light image. The minification of the image plus the acceleration of the electrons provides a brighter image. This is the amplification which makes these devices so sensitive to X-rays. The output phosphor is viewed with a TV camera, giving a dynamic picture on a TV monitor. By means of a light beam splitter the output phosphor can in addition be viewed with a 100mm cut film camera and/or a 35mm cine camera.

The most widely used image intensifier has an input diameter of about 23cm, often with the facility to switch a field of about 16cm to look at the central part of the image in more detail. For fluoroscopy the image intensifier is normally mounted over a table top on a movable carriage, including a serial changer which allows a large-size film to be brought into the X-ray beam to take a spot film so as permanently to record any critical part of the examination. The X-ray tube is normally under the table.

There have been some very exciting innovations in this area of equipment. The most substantial took place a few years ago with the development of caesium iodide input phosphors instead of zinc cadmium sulphide. This led to a big increase in sensitivity, allowing reduction in patient dose but, most important, also gave a very significant increase in resolution, the implications of which will be discussed later.

Another important development relates to input field sizes — 23cm has been just too small for some tempting applications of image intensifiers, but over the last few years larger intensifiers with input field sizes from 30 to 36cm have appeared. However the greater the input size, generally the lower the resolution and greater the distortion, particularly at the edges of the image. Very recently these intensifiers have improved in this respect. A new 36cm intensifier is particularly interesting. Instead of a glass envelope it has a metal envelope with a titanium input window. Also, the output phosphor is provided with a fibre optic plate shaped to correct for distortion. These innovations lead to better focusing, better resolution and less distortion.

The exciting possibilities these intensifiers present are as follows. Resolution is now so good that it is possible to take spot films during fluoroscopy with a 100mm camera attached to an intensifier, rather than with large film in a serial changer. The large intensifiers are big enough for all such work (serial changers are often troublsome items, which radiologists will be pleased to do without).

The big debate now is whether these large intensifiers are, or will become, good enough to allow general radiography with an attached 100mm camera. If so, the question arises whether the large savings in film costs, and possibly reductions in patient dosage, and the savings in film storage space and film retrieval costs will outweigh the large extra capital costs of the necessary equipment. In due course this may well be so, but financial argument is by no means clear. However in the future all radiographic tables and chest stands might be fitted with large image intensifiers and 100mm cameras. As a result virtually all the film handled in an X-rayDepartment would be 100mm. The storage of film of that size might require merely a row of filing cabinets rather than the large and generally unsightly large-film stores now so evident in X-ray departments. Filing and retrieval would be immensely simplified. Also the majority of processors in such a department would be designed for 100mm film, that is, they would be much smaller and use far less chemicals, water, heat etc., than large processors.

Casetteless Large Film Systems

A cassetteless radiographic table comprises a normal radiographic table, in the base of which is stored a selection of different film sizes. The size required is selected, a film is automatically transferred to the 'expose' position and clamped between flourescent screens. After exposure, the film is automatically transferred to an attached processor. A unit of this type has been available for several years, but only recently have nearly all big X-ray companies introduced a model. Needless to say, many of the newest tables involve microprocessor control — for example the light beam field size can be automatically checked for the film size selected. For tomography the kV and mA required can be automatically ascertained. It is interesting to note that many new radiographic tables allow for the fitting of an image intensifier below. With a microprocessor and suitable X-ray tube and generator control, equipment can be envisaged which could greatly automate radiography. A radiographer in the future may be able to position a patient and press a button labelled 'set conditions'. A few short pulses of radiation would give a crude frozen image on a TV monitor to check correct positioning and the output phosphor would be interrogated to ascertain the ideal radiographic factors which would then be set automatically. The correct film size would be automatically selected from the setting of the light beam diaphragm and the distance of the tube from the patient. The film would go to the processor automatically — indeed with underfloor conveyance one processor could serve several tables and one manufacturer offers just a conveyance system.

This cassetteless principle has for some time been incorporated in dedicated chest radiographic equipment. Again there is a film store incorporated in a chest stand from which a film is automatically moved to the 'expose' position and after exposure automatically transferred to an attached processor. Most major manufacturers now offer a system of this type. The cassetteless principle has also been applied to some fluoroscopic tables, but not so successfully. It is worth noting how with these cassetteless types of equipment, the processor is becoming part of the diagnostic room.

Fluoroscopic Tables

There have been significant changes in the design of fluroscopic tables over the last few years, and a few of them are noted below.

In the UK, at least to date, the conventional arrangement of a fluoroscopic table is to have the image intensifier and serial changer above the table and the X-ray tube below. However more and more tables are being introduced of the type where the X-ray tube is above the table and the image intensifier below. Most of these tables are so-called 'remote controlled' tables. A radioligist can stand at a distance behind a protective screen and from there operate all the table motions and controls. He can even compress the patient remotely, using a cup-like device on an arm over the table. This type of table can be more versatile than the more conventional type. It readily allows conventional radiography with its over-table tube, and it allows tomography sometimes with a circular or elliptical tube motion. Some such tables can readily also be adapted for peripheral angiography by having a table-top which can move in programmed steps, and which is designed to allow a rapid film-changer to be inserted under the table surface. At the moment however UK radiologists, unlike their continental colleagues, are not too keen on remote-control, but this may be slowly changing.

Mobile X-ray Units

Mobile X-ray units with a conventional HT generator, especially the highest power mobiles, do cause problems. For example there is a need with some for 30amp sockets, or for specially marked sockets of known and low mains impedence, or for an unfused so-called 'red' plug. Not all mobiles present these problems, but the more powerful units are irksome in this respect.

However for a number of years mobiles of two different basic types have been available that eliminate all these problems. First there is the capacitor discharge type which is connected by normal plug and socket to the mains, simply to charge internal capacitors which are then discharged through the X-ray tube when an exposure is made. The other type is so-called cordless — that is, independent of the mains. Tube power at a suitable kV is derived from batteries by means of an HT inverter-transformer-rectifier chain Both types tend not to be quite as powerful as the most powerful conventional mobile, but with rare-earth screens they have become adequate for most purposes and are being bought in increasing numbers.

Equipment for Special Procedures

A wide variety of equipment is appearing on the market dedicated to, and designed for, particular special radiological procedures. In this respect design changes have been particularly evident in cardiac and neuro-angiography. A few years ago equipment for a cardiac or neuro-angiographic suite would have comprised an assembly of various individual items. Typically it would have consisted of a pedestal-type table, a ceiling-suspended X-ray tube over the table, a ceiling-suspended X-ray tube lateral to the table, an image intensifier with a cine camera under the table together with a rapid film-changer placed lateral to the table. The table and the equipment would be manoeuvred around to get the right view with the right equipment at the right time, and even then the X-ray beam would always be vertical or horizontal.

Modern equipment is far more flexible and highly dedicated to the nature of the medical techniques. The central feature of such equipment is a U or C-arm ceiling-suspended or floor mounted. On one arm of the C or U is mounted the image intensifier and rapid film-changer or cine camera, and on the other the X -ray tube. This arrangement allows considerable flexibility in directing the X-ray beam to any part of a patient and at any angle without moving the patient. One manufacturer has recently introduced an equipment, assembly comprising two such ceiling-suspended C-arms.

Ultrasonics

Although not X-ray equipment, this paper would not be complete without a mention of the use of ultrasonics in radiology, since the position is rapidly being reached where no reasonably sized X-ray Department will be complete without at least one ultrasonic room.

Ultrasonic equipment has developed extremely rapidly in the last few years. Equipment is well past the simple crude, two-dimensional solely static image, and firmly in the real-time or dynamic mode whereby movement of organs and body structures can be visualised at up to 60 frames per second. Ultrasonics was at one time limited primarily to obstetrics, but it now has an important role in abdominal examinations and cardiology. Its full potential has by no means been fully realised yet — innovations and improvements take place almost daily.

Computer Reporting

Some X-ray Departments already utilise computers to aid in appointments, scheduling, record keeping and statistics etc, and microprocessor business machines will no doubt soon find their way into more X-ray Departments as they will into other similar busy areas of hospitals. However, particularly in America, computers have been used for a different purpose — that is to stylise and assist in diagnostic reporting. The systems basically prompt the radiologist along a diagnostic pathway and allow him to select standard phrases and descriptive terms from which a report is compiled and printed out. For example, a radiologist can select one of a number of words and phrases on a display with a light pen and the computer will collate his selections and print out a report. Whether UK radiologists will take to this is perhaps doubtful, but some are moving in that direction.

The future

The possibilities of doing all fluoroscopy and radiography with 100mm cameras has already been mentioned, but in future we may well go one stage further. After all, with a high-resolution large-image intensifier and a high resolution TV system, there exists a video signal with all the information needed for diagnosis. The challenge is to store this huge amount of spatial information economically without resort to a silver-based process so that it can be called on at will, processed if needed, displayed on a visual display unit at any appropriate point in the hospital if that is desirable, and stored away in a tidy small space. The cheapness of microprocessor technology may well, in the not-to-distant future, be combined with cheap laser-produced video discs which already have the capacity to store hundreds of radiographic views on a single disc. This may be the system of the future, but when it will be achieved, or whether the hospital world will be able to afford it, is anybody's guess.

Mr Rattue gave this paper at the Institute's second Symposium on Energy Conservation in June.

Economic thickness of Pipework Insulation

P J RATTUE BSc CEng FIEE
Principal Engineer DHSS

Introduction

I have been asked to supplement Mr Gillett's paper on 'Insulation of Engineering Services' by outlining the findings of NHS and DHSS engineers (Working Group No 6) on the particular aspect of economic thickness of insulation for hot and cold pipework (indoor and outdoor).

The Group's main objective was to revise NHS standards for insulation thickness — last issued as CS14 in 1970 — mainly to take account of the large increase in energy costs. They felt that the thicknesses should be calculated specifically for the hospital service, rather than adopt the tabulated sizes of BS 5422 1977 because hospital periods of operation per year tend to be greater than average; and that it would be useful to provide correction factors for further increases in energy and capital costs, and for various values of temperature difference and insulation conductivity.

Study Method

I will not explain the concept of economic thickness in detail, but will simply say that for each kind of service, the Group considered a range of typical pipe sizes with a preferred type of insulation; and for each pipe size they plotted the annual capital charge per metre run of insulation and the annual cost of heat (or cooling) loss per metre run — against radial thickness of insulation, in order to find where the minimum sum occurred. The WG found that factors that are small or vary little with thickness such as the cost of coverings, supports and maintenance could be excluded.

(It is useful to bear in mind that economic thickness increases with temperature difference, life of the installation, cost of energy and conductivity (k); but decreases with capital cost).

Results

These are in three parts
Indoor pipework for Hot Water and Steam (major part of study)
Indoor pipework for chilled water and refrigerants
Outdoor pipework generally

Indoor pipework for Hot Water and Steam

The examples in the table below were selected from tables in the WG report to show the trend in recommended thicknesses for various services (taking the nearest larger commercially available sizes to those calculated). All are based on the use of fibreglass or mineral wool in preformed sections, an ambient temperature of 21°C and an 1979 energy cost of 0.25 p/MJ (marginal ie fuel only and allowing for an overall system efficiency of 60%. Note: 1 MJ = roughly 1 lb steam). Other conditions are in Col. 1

Cols 3 & 5 — Take Steam/HTHW — NHS thickness has roughly trebled in 10 years
Take Condensate — NHS thickness has roughly doubled in 10 years
Take Lower Temperature (contin.)— has roughly increased 50% (Doubled for largest pipe) in 10 years
Cols 6, 7, 8, 9, Correction Factors — appreciable for energy cost — (especially for condensate pipes) significant for K and temperature negative for capital cost.

Notes

a. The heat losses corresponding to the new recommended thicknesses for space heating and HWS are well within the limits proposed by the Department of Environment for inclusion in the Building Regulations.
b. The 1979 NHS thicknesses are in close agreement with figures recently produced by PSA computer for hospital conditions.
c. The increase in NHS energy costs since the 1979 economic thicknesses were calculated, is about 0.1 p/MJ; so these thicknesses could, on the method of calculation adopted, be increased by the % in column 6, (subject to adjustment by column 9). It whould however be borne in mind that:

i. The corresponding increase in energy saving may be quite small (diminishing returns).

ii. Very thick insulation (for high temperature services) may present practical difficulties; and the costs of coverings and accommodation may begin to affect the economics of the case.
iii. For the lower temperature applications (particularly intermittent) the U curves of total annual charges for various energy costs tend to be closer together; so variatins in economic thickness with energy cost become rather academic.

In other words, even if the price of fuel rises in a spectacular way, relative to capital cost of insulation, further increases in standards will need very careful consideration before adoption.

Application	Pipe Size (mm)	Thickness of Insulation (Radial, mm)			Thickness Correction to column 5 for:			
		NHS 1970	BS 5422 1977	NHS 1979	Energy Cost +0.1 p/MJ	K 0.01 50°C	Temp 50°C	Capital Cost +10%
Column 1	2	3	4	5	6	7	8	9
Steam or H.T.H.W. (Flow) 180°C k = 0.043 W/m°C 25 years life	100 (I.D)	32	75	90	+15%	±7%	±14%	-3%
Condensate 95°C k = 0.041 W/m°C 10 years life	42 (O.D)	19	38	38	+30%	±8%	—	-4%
L.T. H.W. HTG 76°C K = 0.039 W/m°C 25 years (i) continuous	40 (I.D)	25	32	38	+14%	±8%	—	-3%
(ii) 50 hours/week and 30 weeks/year	"	—	—	25	+9%	±4%	—	-3%
H.W.S Continuous 60°C k = 0.035 W/m°C 25 years life	42 (O.D.)	25	32	38	+10%	±6%	—	-4%

Indoor pipework for chilled water and refrigerants

WG6 took as preferred insulation material expanded, closed cell, phenolic resin in preformed sections, an ambient temperature of 25°C and cooling cost of 0.31 p/MJ. The thicknesses were found to be much less critical economically that for hot pipes, (ie The U curves of annual costs were flatter); and the economic thicknesses were about the same as the corresponding thicknesses recommended in BS 5422 for prevention of condensation on the outside surface of the insulation. So no special standards needed for NHS.

The correction factor for an increase of 0.1 p/MJ in cooling cost was found to be +12%; and the counter effect of an increase in capital cost was found to be negligible. So the situation should be watched — if energy prices continue to rise rapidly, thicknesses greater than BS 5422 recommendations may be justified but no sudden or drastic change is expected.

Outdoor pipework

Insulation thicknesses for outdoor hot pipes were specified in CS14 to be the same as for indoor pipework. Outdoor cold pipe insulation was rather thicker than for indoor pipework.

For outdoor pipe exposed to wind, rain, sun and extremes of air temperature the economic study of insulation design is often complicated by considerations of access; fixings; and condition of the pipe contents at the point of delivery eg in respect of temperature, condensation and freezing. The insulation material may be chosen more for its properties of weight, specific heat, permeability to moisture and durability than for its conductivity, fire and health properties and cost.

Accordingly, instead of attempting to provide standard NHS solutions in this field WG6 recommends that in preparing individual designs careful reference should be made to Bs 5422 and BSCP 3005.

Product News

New Autoclaves

The new Labclave Series autoclaves manufactured by Dent & Hellyer Ltd have been designed with the Howie Report very much in mind to meet the diverse requirements of modern laboratories in the medical, pharmaceutical, microbiological and other fields. Particular attention has been paid to safety, ease of use, ease of maintenance and straightforward installation.

At present there are two models in the range, designated Labclave 005 and 007. Labclave 005 has a hinged door while the larger Labclave 007 has a vertical sliding door. The chamber in each case is rectangular which gives approximately fifty per cent more usable volume than a cylindrical chamber of the same width and length.

There are comprehensive safety arrangements. The doors have thermal and pressure locks supplemented by a residual pressure release complying with TD45 recommendations, which are controlled by a fluid load simulator and an entry point is provided for thermocouple testing, as recommended in the Howie Report. The chart recorder provides both a visible check and a permanent record that correct sterilizing procedures have been carried out.

Further enquiries to: Mr Bryan Lockhart, Dent & Hellyer Ltd., Walworth Industrial Estate, Andover, Hants SP10 5AA. Tel: Andover (0264) 62111.

'Fap-Fibo System'

The cost saving benefits of the 'Fap-Fibo' clip-in conduit system are being realised in the second phase of the multi-million pound Queens Medical Centre and University Hospital, under construction at Nottingham.

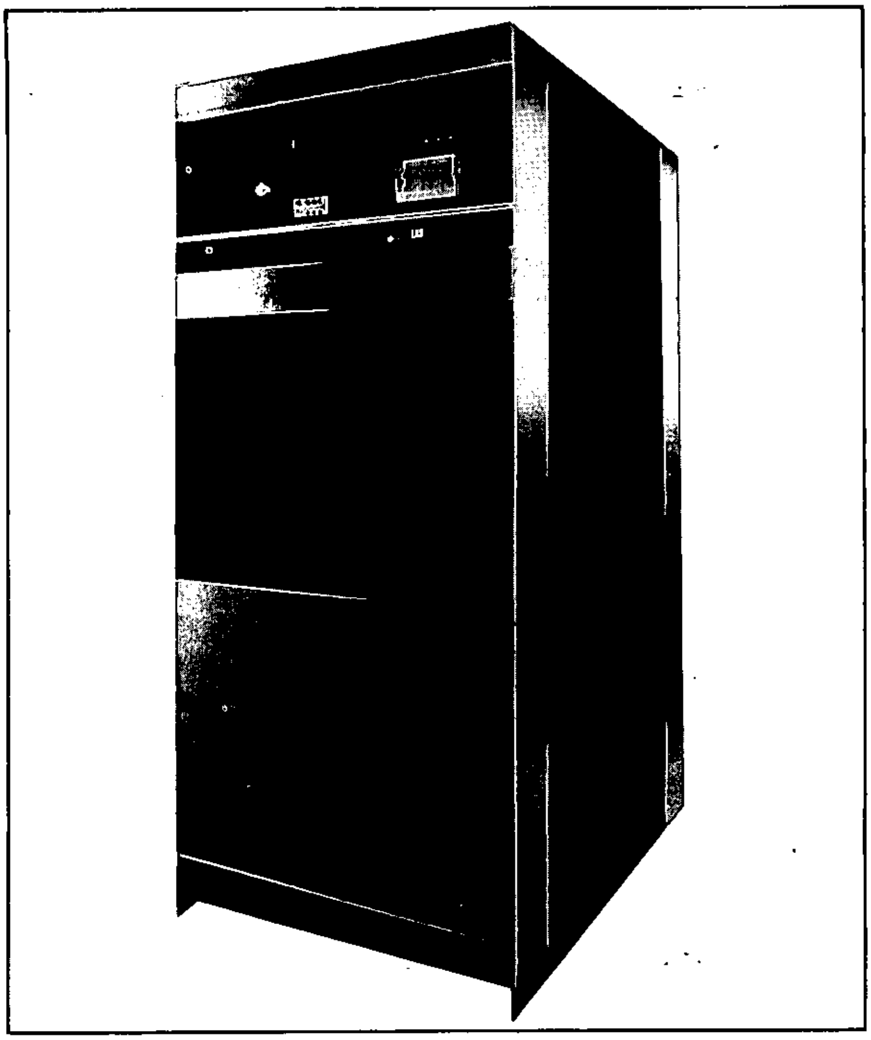
This is the first time that the Trent Regional Health Authority has authorised the use of the 'Fap-Fibo' system which is faster to install than traditional screwed conduit.

In the largest ever single contract for its use, the 'Fap-Fibo' system is being used throughout the new Obstetrics and Paediatrics blocks of the hospital — a total of over 150,000 conduit fittings having been used with a value in excess of £100,000. The manufacturers claim that on-site savings of up to thirty per cent can be achieved.

In the 'Fap-Fibo' system, a tempered spring steel claw inside each conduit fitting bites into the conduit and provides a strong connection. The use of the system, which involves three simple operations namely cutting conduit, deburring and clipping in, eliminates the time consuming operations of threading and screwing together conduit fittings and the resultant waste oil and swarf associated with these operations. It also does away with the need for stocks, dies and guides.

Contact: Fitter and Poulton Ltd, Fortnum Close, Kitts Green, Birmingham B33 0LB.

Dent & Hellyer's new 005 laboratory autoclave.



Protection for Interior Floorcoverings

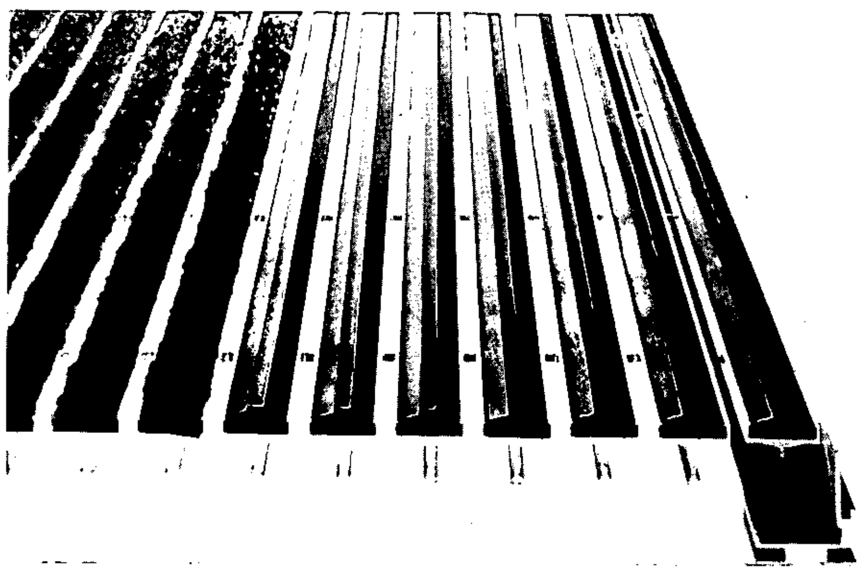
A practical and economical solution to the problems of outdoor dirt and water being trodden into interior floorcoverings is now available from NEACO of Malton, Yorkshire.

Neatgrille, a grid-like system of aluminium tee bars with rubber compound or durable, anti-static carpet inserts, acts as a scraper, automatically cleaning footwear and allowing removed dirt to fall through the grid. To facilitate use in all entrance areas, the tee bars have been placed less that 5mm apart to ensure that ladies' heels will not become trapped.

Conventional vacuuming equipment can be used for cleaning Neatgrille, although its modular, lightweight construction allows easy removal when necessary. Having good loadbearing properties, it can be used for most types of raised walkways and platforms. Neatgrille's modular construction also means that units can be supplied in almost any size or shape. For use in entrances fitting can be flush with the surrounding floor if a shallow well is provided. Where this is not possible, specially designed ramps are available which fit snugly around the Neatgrille units. Ten carpet colours will be available and the rubber inserts can be either black or beige.

For further information contact: Norton Engineering Alloys Company Ltd, Norton Grove Industrial Estate, Norton, Malton, North Yorkshire, YO17 9HQ. Malton (0653) 3921.

A section of Neatgrille flooring incorporating both rubber compound and carpet inserts.



Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

SENIOR ENGINEER

Following promotion of the present holder a vacancy exists for a Senior Engineer responsible to the District Engineer for the operation and maintenance of Orsett and Thurrock Hospitals and their associated properties.

Applicant should hold an HNC in Mechanical or Electrical Engineering or an acceptable equivalent, together with a recognised qualification in Industrial Management.

Salary scale £6,015 rising by five increments to £6,963 plus £141 per annum Outer London Weighting, plus bonus allowance as applicable.

Application form and Job Description from District Personnel, Basildon Hospital, Nethermayne Basildon Ex. Tel: Basildon 3911 Ext: 3606.

Closing Date: October 17, 1980.

BASILDON & THURROCK HEALTH DISTRICT

ESSEX AREA HEALTH AUTHORITY

TAYSIDE HEALTH BOARD
Angus District

SENIOR ENGINEER

Applications are invited for the above post. The successful applicant will be based in the office of the District Engineer at Stracathro Hospital and will require to travel throughout Angus.

Candidates from outwith the National Health Service must have completed an apprenticeship and possess a Higher National Certificate or City and Guilds Certificate in Mechanical or Electrical Engineering with either Electrical or Mechanical and Industrial Administration Endorsements or alternative qualifications acceptable to the Secretary of State.

Salary scale £6,015 rising to £6,963 per annum in five annual increments.

Application form and job description can be obtained from the District Administrator, Tayside Health Board, Angus District, Whitehills Hospital, Forfar, to whom completed forms should be returned by November 1, 1980.

WOLVERHAMPTON AREA HEALTH AUTHORITY
Electrical/Mechanical Engineer

Are you: Aged 25+ and looking for a worthwhile job with a really secure future? Have you: Got what it takes to keep an entire hospitals power system running smoothly? Then read on!

We are looking for a person like you to carry out all necessary operational maintenance and become involved in the design of small capital works, in one of the country's most modern, up-to-date hospitals. Proven managerial experience is essential as the successful candidate will be in direct control of labour, craftsmen and contractors.

If you hold HNC or HND in Electrical or Mechanical Engineering plus endorsements in electro-technology and have/or are prepared to study for, a certificate in Industrial Administration, then put your know-how to real use.

A salary scale of £6015 to £6963 pa (plus bonus allowance of 15%) with a salary increase in the pipeline is awaiting the right person.

Further information can be obtained from Mr J A Simpson, Area Engineer, New Cross Hospital, Wolverhampton. Telephone: Wolverhampton 732255 ext. 2735. Application forms available from Personnel Officer, Administrative Offices, New Cross Hospital, Wolverhampton, Telephone: Wolverhampton 737221.

Closing date October 27, 1980.

NOTHERN IRELAND EASTERN HEALTH AND SOCIAL SERVICES BOARD
North and West Belfast District

DISTRICT ENGINEER

Salary: £10,167 – £12,033 pa.

Candidates must hold and HNC (Mechanical Engineering) or an alternative approved qualification and have completed an apprenticeship in mechanical or electrical engineering or have otherwise acquired a thorough practical training as appropriate to the duties and responsibilities of the post and have appropriate experience.

Further details of the qualification and experience required are set out in the job description for post.

Application forms from the Personnel Department, Londonderry House, Chichester Street, Belfast, BT1 4RH. (Tel: Belfast 35100) For return by November 21.

HOSPITAL ENGINEERING

Please note our new address:

'Hospital Engineering'
Mallard Publications
48 Southwark Street
London SE1 1UN, England
Telephone: 01-403 6166