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The Journal of The Institute of Hospital Engineering

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Contents

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News Features

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TOTAL ENERGY

Part 2

by R. MANSER B.Sc.(Eng.), C.Eng., F.I.Mech.E., F.I.E.E.

Turning to the deep-planned 1200-bed hospital involving air conditioning with refrigeration plant, Fig. 4 shows the prospective superimposed electricity and heating requirements based on the use of absorption refrigeration. The overall balance in favour of total energy is best achieved by the use of absorption rather than reciprocating or rotary plant; so I have only included this to save space. *For the actual demands, shown in Table 11*, we have had to synthetise the figures since we lack data for an adequate period for this class of hospital. Some people may consider the electricity figures to be too low, but some of the design figures now on the drawing board may well be high owing to the extreme difficulty of assessing diversity in the present generation of hospitals. No criticism of consulting engineers is in my mind; anyone who has worked on a new development where there is a *substantial increase in 'convenience' electricity supplies* knows how extraordinarily difficult it is to assess prospec-

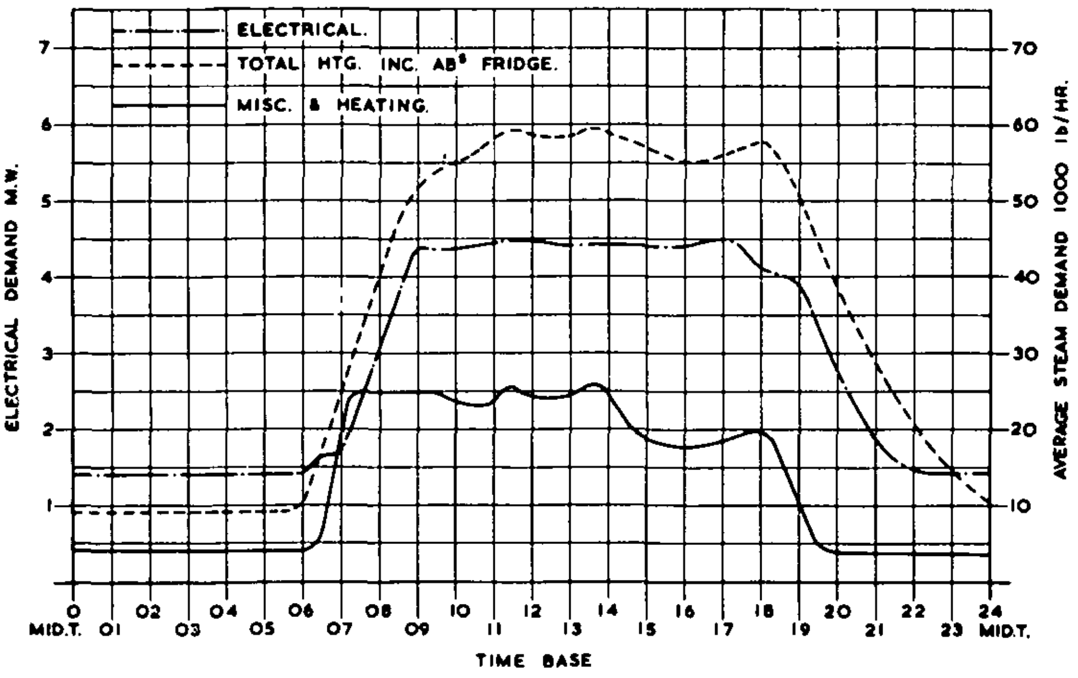
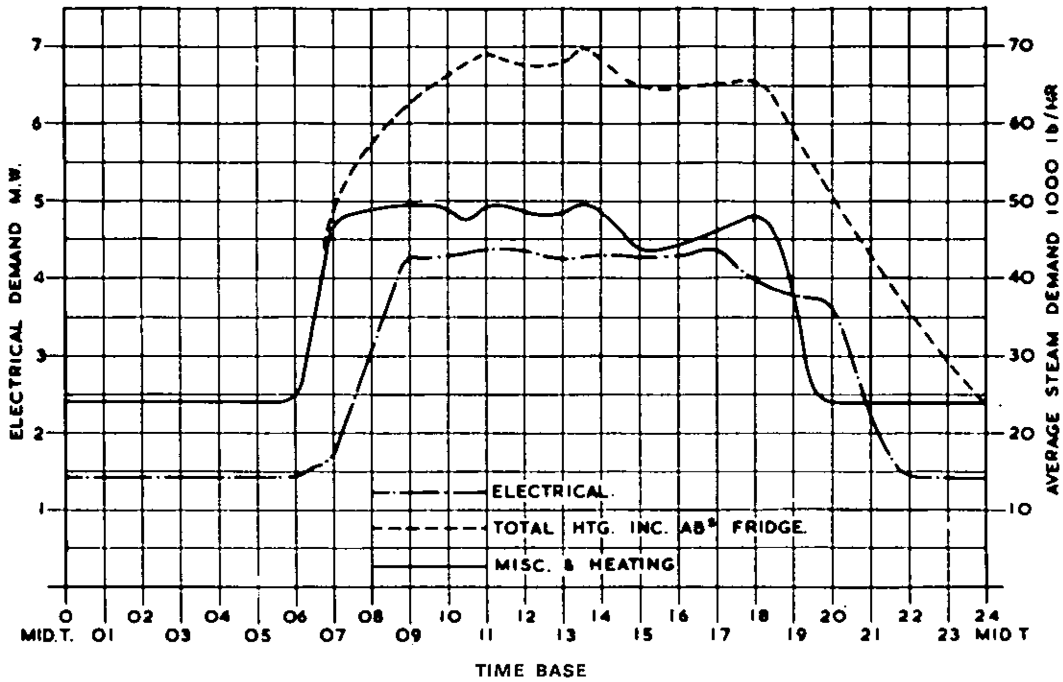


Fig. 4A Typical average hourly demand for 1200-bed deep-planned hospital: summer tive maximum demand from theoretical considerations, and how easy it is to overestimate. The figures given are our best guess, substantiated by the most up-to-date data available.

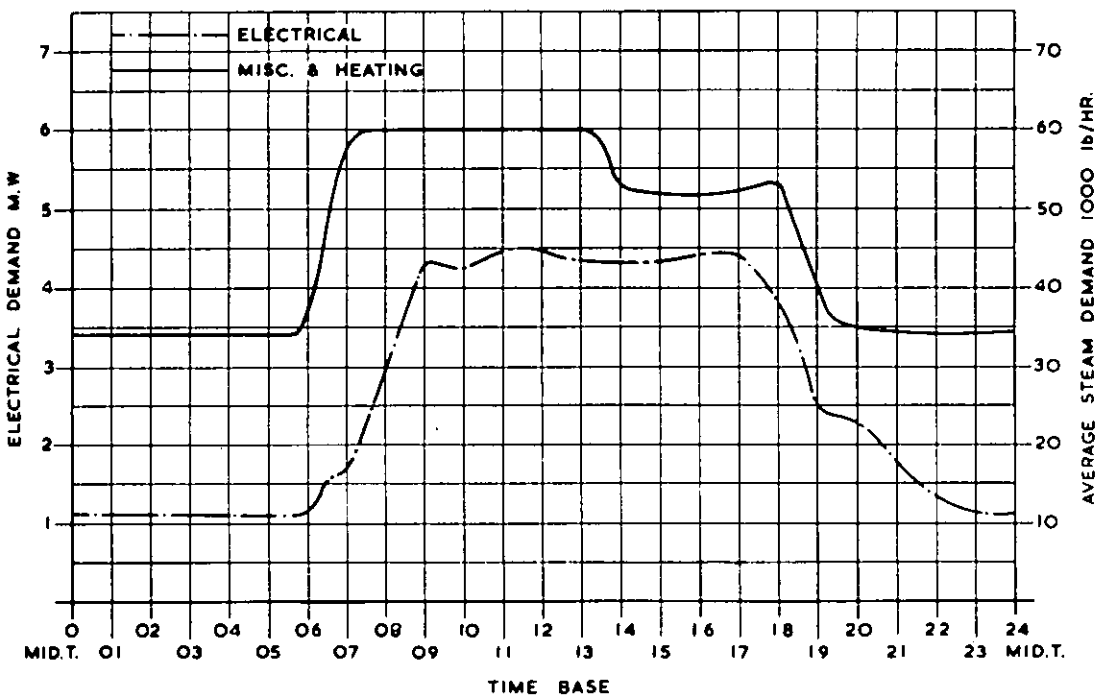
The load curves again show the vulnerable period at the beginning of the day when the recovered heat may not all be utilised, bringing about a drop in the overall efficiency of a total-energy system.

The cost comparisons are shown in Tables 12–20, and for this larger hospital viable financial returns on capital are indicated. For a capital investment of some £$\frac{1}{4}$m. for diesel sets, or £$\frac{1}{3}$m. for gas turbines, payback periods lying between $3\frac{1}{2}$ and $8\frac{1}{2}$ years are indicated, according to the system and the assumed efficiency.

Again I must emphasise that the tabulated figures show the economic case alone; there is a tendency to regard this as the sole criterion. For a process plant, where everything is reduced to costs, this may be so, and a major shutdown can be measured in terms of financial loss which may be acceptable or unacceptable to the board of directors of the company concerned. In contrast, the shutdown of a major hospital for a period of days is unthinkable, and the cost just does not come into this particular prospect. Thus there are two major additional



(a)



(b)

Fig. 4B Typical average hourly demand for 1200-bed deep-planned hospital
(b) Midseason
(c) Winter

Table 11 Energy demand, 1200-bed hospital

Item	Units	Gas turbine		Dual fuel		Diesel		Conventional	
Electricity demand ..	kWh $\times 10^6$	—	23·18	—	23·18	—	23·18	—	23·18
	Btu $\times 10^6$	—	0·79	—	0·79	—	0·79	—	0·79
Heat demand	Btu $\times 10^6$	—	3·74	—	3·74	—	3·74	—	3·74
Total energy demand ..	Btu $\times 10^6$	—	4·53	—	4·53	—	4·53	—	4·53
Total heat input to meet energy demand	Btu $\times 10^6$	65% efficiency	7·00	60% efficiency	7·55	65% efficiency	7·00	—	—
		90% efficiency	5·04	70% efficiency	6·45	75% efficiency	6·05	—	—
Heat input for generation of electricity demand $0{\cdot}79 \times 10^6$ Btu	Btu $\times 10^6$	—	—	39% efficiency	2·26	36% efficiency	2·19	—	—
		—	—	40% efficiency	1·975	38% efficiency	2·08	—	—

Table 12 Capital cost: conventional system, 1200-bed hospital

Six steam boilers each rated at 15 000 lb/h

The electricity supply consists of an Area Board intake 11/3·3 kV to give a 'firm' supply of 5 MW

Three standby diesel alternators, each 500 kW rating, have been installed

Item	*Cost*
Six steam boilers each 15 000 lb/h complete (excluding flues and chimney)	£97 000
Oil storage and handling plant	£15 000
Builders' work associated with engineering ..	£8000
Induced and forced-draught fans	£22 000
Transformers and 3·3 kV switchboard, cables etc.	£12 000
Three diesel alternator sets complete (each 500 kW) for standby/emergency electrical supplies ..	£66 000
	£197 000

Note: Items common to all the alternative projects have been omitted from the cost summaries; e.g. refrigeration plant (absorption), chimney etc.

Table 13 Capital cost: dual-fuel system, 1200-bed hospital

Dual-fuel engines each rated at 1000 kW 750 rev/min with waste-heat boilers, jacket and oil heat exchangers and supplementary boilers of total rating 75 000 lb/h

Item	*Cost*
Six dual-fuel engine alternators complete	£242 000
Six waste-heat boilers, heat exchangers complete	£26 000
Six supplementary boilers, feed treatment and ancillaries complete (12 500 lb/h each)	£81 000
Oil storage and handling plant for use on interruptable gas tariff	£7500
Builders' work associated with engineering, including overhead crane etc.	£14 000
Insulation and ventilation in plant room ..	£6000
Gas service—contribution to Gas Board for service and metering	£3500
Fans, including emergency facilities when operating on gas oil	£7000
	£387 000
Additional building provision (3000 ft²)	£30 000
Additional for ducts and flues to chimney	£9000
	39 000

Table 14 Capital cost: diesel plant, 1200-bed hospital

Six diesel engines each rated at 1000 kW with waste-heat boilers, jacket and oil heat exchangers and supplementary boilers of total rating of 75 000 lb/h

Item	*Cost*
Six diesel-engine alternators complete 1000 kW each (6000 kW at £40/kW)	£240 000
Six waste-heat boilers with heat exchangers complete	£28 000
Six supplementary boilers, feed treatment and ancillaries complete (12 500 lb/h each)	£81 000
Oil storage and handling plant	£16 000
Builders' work associated with engineering, including overhead crane etc.	£18 000
Insulation and ventilation in plant areas	6000
Induced and dilution fans	£18 000
	£407 000
Additional building provision (3000 ft²)	£30 000
Addition for ducts and flues to chimney	£10 000
	£40 000

Table 15 Capital cost: gas-turbine plant, 1200-bed hospital

Five gas-turbine sets (1100 kW) with waste-heat boilers each rated at 20 000 lb/h plus two dual-fuel engines rated at 750 kW each as emergency units for electricity supply

Item	*Cost*
Five 1100 kW gas-turbine alternators complete (5500 kW) at £50/kW	£275 000
Five waste-heat boilers with supplementary firing at 20 000 lb/h each (100 000 lb/h)	£120 000
Oil-storage and handling plant for use on interruptable gas tariff	£10 000
Builders' work associated with engineering, including overhead crane etc.	£13 000
Insulation and ventilation in plant areas	£8000
Two dual-fuel engine/alternator sets complete (750 kW each) for auxiliary and emergency supplies	£63 000
Contribution to Gas Board for gas service	£3500
	£492 500
Additional building provision (6000 ft²)	£54 000
Additional for ducts and flues to chimney	£13 000
	£67 000

Table 16 Operating costs: conventional system, 1200-bed hospital

Steam—annual consumption = 3·74 therm
Electricity—annual consumption = $23{\cdot}18\times10^6$ kWh
= $0{\cdot}79\times10^6$ therm

Assuming 75% efficiency for boiler plant, and 1·45d/kWh for electricity charge since the annual electrical load factor is 59%.

Item	*Cost*
Cost of heavy oil (3500 s) at 4·5d/therm	
$3{\cdot}75\times10^6\times\frac{100}{75}\times\frac{4{\cdot}5}{240}$	£93 500
Electricity at 1·45d/kWh	
$23{\cdot}18\times10^6\times\frac{1{\cdot}45}{240}$	£140 045
Maintenance charges (2% capital)	£1940
Operating labour (five shift engineers at £1300 p.a. each)	£6500
Total	£241 985
Say	£242 000

Table 17 Operating costs: dual-fuel system, 1200-bed hospital

Natural gas will be used for both engines and for supplementary boiler plant, but 35 s oil is required for pilots and start-up of the engines

Oil-supply energy is estimated at 8% of the total energy supplied to the engines

High and low efficiencies have been taken for the engines as 70% and 60%, respectively

Under low-efficiency conditions proportion of fuel to engines

$$\frac{2{\cdot}26}{7{\cdot}55}=0{\cdot}3$$

Under high-efficiency conditions proportion of fuel to engines

$$\frac{1{\cdot}975}{6{\cdot}48}=0{\cdot}305$$

Total energy from gas under low-efficiency conditions = $7{\cdot}369\times10^6$ therm
Energy from pilot oil = $0{\cdot}181\times10^6$ therm
Total energy from gas under high-efficiency conditions = 6·322 therm
Energy from oil = $0{\cdot}158\times10^6$ Btu

Item	*Cost*
Cost of gas (low-efficiency)	
$7{\cdot}369\times10^6\times\frac{5}{240}=153\,520$	
Cost of oil (low-efficiency)	
$0{\cdot}181\times10^6\times\frac{7}{240}=5280$	£158 800
Cost of gas (high-efficiency)	
$6{\cdot}322\times10^6\times\frac{5}{240}=118\,583$	
Cost of oil (high-efficiency)	
$0{\cdot}158\times10^6\times\frac{7}{240}=4608$	£136 316
Maintenance charges	
3% capital on engines (8040)+boilers (1940) ..	£9980
Operating labour (as for diesels)..	£10 500
Total (low-efficiency)	£176 580
Total (high-efficiency)	£157 190

Table 18 Operating costs: diesel plant, 1200-bed hospital

Diesel oil (35 s) will be used for the engines and heavy (3500 s) oil for the supplementary boiler plant.

High and low efficiencies have been taken for the engines and boiler plant (75% and 65%, respectively).

Under low-efficiency conditions: proportion of fuel to engines

$$\frac{2{\cdot}19}{7{\cdot}0}=0{\cdot}312$$

Under high-efficiency conditions: proportion of fuel to engines

$$\frac{2{\cdot}08}{6{\cdot}05}=0{\cdot}344$$

Total diesel fuel (low efficiency) = $2{\cdot}19\times10^6$ therm
Total heavy oil (low efficiency) = $4{\cdot}81\times10^6$ therm
Under high-efficiency conditions
Total diesel fuel = 2·08 therm
Total heavy oil = 3·97 therm

Item	*Cost*
Diesel fuel (35 s) low-efficiency $2{\cdot}19\times10^6\times\frac{7}{240}$ ..	
Heavy fuel oil (3500 s)	
low-efficiency $4{\cdot}8\times10^6\times\frac{4{\cdot}5}{240}$	£154 062
Diesel fuel (35 s)	
high-efficiency $2{\cdot}08\times10^6\times\frac{7}{240}$	
Heavy fuel oil (3500 s)	
high-efficiency $3{\cdot}97\times10^6\times\frac{4{\cdot}5}{240}$	£134 670
Maintenance (as for dual fuel)	£9980
Lubricating oil	£2040
Operating labour (five shift engineers and fitters) as for dual fuel	£10 500
Total (low-efficiency)	£176 582
Total (high-efficiency)	£157 190

Table 19 Operating costs: gas-turbine plant, 1200-bed hospital

High and low efficiencies have been taken in calculating the total energy-input requirements, and it has been assumed that natural gas at 5d/therm is available as the fuel for engines and for auxiliary firing.

Low efficiency for gas turboalternators = 65%
High efficiency for gas turboalternators = 90%
Heat input at 65% efficiency = $7{\cdot}0\times10^6$ therm
Heat input at 90% efficiency = $5{\cdot}04\times10^6$ therm

Item	*Cost*
Cost of fuel (low-efficiency)	
$7{\cdot}0\times10^6\times\frac{5}{240}$	£145 833
Cost of fuel (high-efficiency)	
$5{\cdot}04\times10^6\times\frac{5}{240}$	£105 000
Maintenance charges (1·5% capital)	£6000
Operating labour (five shift engineers) five at £1300	£6500
Total (low-efficiency)	£158 333
Total (high-efficiency)	£117 500

factors which must be considered on top of the economic case: first, the security of the engineering services—in particular the security of the electricity supply—and secondly the necessary staffing levels. I repeat that any proposal must be demonstrably as good as, or better than, the existing normal arrangements of public supply backed up by standby generators. At this point one should pay tribute to the supply authorities which, while not regarding hospitals as favoured consumers, clearly make every effort on the rare occasions when there are interruptions. Interruptions in the public supply to hospitals are normally measured in hours at worst.

The statistical treatment of the probability of breakdown is obviously extremely difficult. For diesel engines the very minimum which would be considered acceptable is for maximum demand to be carried with one set out of action on maintenance, and essential load to be carried comfortably with a second set out due to unplanned maintenance. This is the absolute minimum, and I am by no means stating that such a scheme would necessarily be acceptable to the Department. Gas turbines are much more difficult to appraise because their record to date is extremely good. The Department would probably be most happy with a design based on gas turbines with an outside electricity supply available, at suitable tariff rates, to cover breakdowns. This is particularly so because an engineering design based on a highly reliable prime mover could conceivably run into grave difficulty in the event of a low-risk major breakdown, even though this might not be the fault of the prime mover. For instance, if there were a major fire in the generator room of the hospital damage might well be done to a gas-turbine generator installation, which, unlike damage to a public-supply transformer, would require a very significant plant-replacement time.

The other major factor is that of staffing. One could

Table 20 Summary of costs, 1200-bed hospital

Plant type	Cost	Present worth factor	Present worth	Equivalent annual value	Capital difference	Annual savings	Years to recover capital
	£		£	£			
Conventional							
Buildings etc.	—	—					
Plant	197 000	1·17	230 490				
Operation—annual	242 000	9·97	2 412 010	265 124	Datum	—	—
Dual-fuel							
Buildings etc.	39 000	1·00	39 000		229 000		
Plant	387 000	1·17	452 790				
Operation—annual 60% efficiency	179 280	9·97	1 786 890	228 622		36 502	6·3
Operation—annual 70% efficiency	156 796	9·97	1 562 795	206 137		58 987	4·5
Gas-turbine							
Buildings etc.	67 000	1·00	67 000		362 500		
Plant	492 500	1·17	576 200				
Operation—annual 65% efficiency	158 333	9·97	1 578 112	222 866		42 258	8·6
Operation—annual 90% efficiency	117 500	9·97	1 171 122	182 032		83 092	4·3
Diesel (35 s oil)							
Buildings etc.	40 000	1·00	40 000		250 000		
Plant	407 000	1·17	476 190				
Operation—annual 65% efficiency	176 582	9·97	1 759 992	278 537		Negative	—
Operation—annual 75% efficiency	157 190	9·97	1 566 712	259 145		5979	42·0
Diesel (950 s oil)							
Buildings etc.	40 000	1·0	40 000		250 000		
Plant	407 000	1·17	476 190				
Operation—annual 65% efficiency	156 507	9·97	1 559 905	208 296		56 828	4·3
Operation—annual 75% efficiency	138 457	9·97	1 380 000	190 246		74 878	3·3

Assumptions
Interest rate 10%
Life of all plant taken as 20 years
Life of all buildings taken as 60 years
Life of project taken as 60 years

say that hospital engineers are in hospital engineering and not in supply generation. However, we clearly aim to make every pound available to the Health Service go as far as possible—there are plenty of claims on any monies which we can save on the engineering while providing the necessary service. But staffing is in itself one of our major worries. We have simultaneously a constant increase in the amount and complexity of the engineering services in hospitals, and an ever more difficult labour market for the responsible engineers needed to run the hospitals. This is a very great worry, and the Department has recently set up a school for training and refresher courses particularly aimed at easing this situation. We can state quite definitely, then, that any change of technique which increases the requirement for technical labour is unpopular, and really substantial advantages must be shown to justify it.

Security and labour are the major extra considerations, and after these we have to consider the rather less tangible ones. The fact is that the economic cases considered do actually represent the best case which can be made for total energy. In other words, the only factor which can effect improvement is a drop in the primary-fuel cost; this is just as likely to improve the conventional plant economics as is the total cost. In contrast, any untoward happening, such as breakdown or wage award, is likely to shift the balance away from total energy towards the conventional plant. Total energy at best uses the same staffing levels, in some systems significantly more, and clearly the trend in staff wages and salaries is upwards. Similarly, maintenance costs will probably increase since they reflect labour costs. Fuel costs might go either way, but the figures quoted are extremely low, and in any case reduction of fuel costs is unlikely to affect the differentials between conventional and total-energy schemes significantly. Thus, cruel though it may sound to the advocates of total energy, the intangibles all point towards the conventional treatment.

The overall view

You may recall that right at the beginning of this paper I remarked on the resurgence of interest in total energy due to the shifting balance of fuel availability and costs, and in particular to the availability of natural gas at rates competitive with heavy oil. From the point of view of the Department, it is not sufficient merely to say, 'What about total energy?' We must say, 'Can we use natural gas to simplify the conventional approach?' If we are to build hospitals with separate industrial complexes, and there are signs in our planning appraisals that this may well be the most economic and flexible line of attack in the future, then in cases where natural gas can be negotiated at competitive rates we must clearly consider multiple fully automatic boiler houses, and we must also look at roof-top siting. In other words, the advent of natural gas as a competitive fuel may enable us to produce economies in conventional installations which could well match the marginal economies predicted for total energy. I am not claiming that multiple roof-top boiler houses are necessarily an economy for new designs, but they do clearly have advantages. For example, in the phased construction of large schemes, the initial heavy commitment of a large boiler house for the full planned capacity of the ultimate size is avoided. Again, in the very large horizontal layouts which are now being considered they may well give rise to a reduction in standing losses and in unwanted summer heat gains in long tunnels running through the spines of long low buildings. In other words, as far as possible the Department's engineers look at the whole picture, rather than merely a narrow section of it.

Future possibilities

It would appear from our figures, though these may be disputed, that total energy has now become competitive, though it is debatable whether it can show a true saving except in particularly favourable circumstances. Other factors, and some of the intangibles, tend to point away from total energy, favouring the known security and lower staffing requirements of more traditional approaches. Finally, prospective total-energy schemes must also stand scrutiny against the use of the more easily piped fuels lending themselves to reduced costs by changed design techniques.

In case I have given you the impression of a Department of reactionaries, I could perhaps make a prediction. This is my personal view and not that of the Department. I draw a very sharp distinction between probabilities and policy because I am not acting as a spokesman for the Department's policy, and also because individual cases are reviewed carefully, each in its own right—a blanket policy would not be appropriate to this sort of decision. As a matter of probability, then, I think it unlikely that the Department would approve a total-energy scheme for a 600-bed hospital built with natural ventilation. I think it possible that the Department will approve at some point in the future a total-energy scheme for a large, say 1000-bed, deep-planned hospital with significant air conditioning. In this case I would expect the refrigeration to use absorption plant, and I think the prime movers would be industrial gas turbines. For the first installation I think it possible that the Department would require a supply available for emergencies from a public supply authority and a slight premium might be allowed for this extra security. I select the gas-turbine installation because of its negligible impact on the staffing levels required, and also because, if the gas turbine continues with its excellent record for long uninterrupted runs, the maintenance needs should be low. Factors which the Department would be very interested in would be the overall effect of the part-load efficiency of the gas turbine, and of the necessity for spinning reserve to prevent cascade failure. Perhaps I should further mention that the Department has in fact approved in certain cases extra consultants' fees to investigate the feasibility of total energy in projects which are now on the drawing board.

Acknowledgments

I would like to make acknowledgment first to the Department, for permission to allow me to give this paper, and secondly to my colleagues who have assisted in its preparation. Mr. Worsley, of the costing section, has been particularly helpful.

While it is officially accepted that coke is liable to be in short supply this winter, and notwithstanding the aggressive campaigns of other fuel industries, those installations still using coke need not necessarily abandon solid fuel.

Conversion of coke-fired boilers to coal

BY NORMAN GLENSY

Many of the smaller hospitals, nurses' homes, and ancillary buildings under the care of hospital engineers are still heated by hand-fired coke boilers. Now, with the increasing shortage of coke, and the prospect of supplies of gas coke for this winter even bleaker, their conversion to coal firing merits serious consideration, and perhaps immediate action.

The two main kinds of coal-conversion unit most suited to the types of boiler involved are gravity feed and the underfeed stoker. Both of these systems are equally effective for firing all types of sectional boiler; i.e. those normally found in coke-fired heating plants. The choice of underfeed or gravity feed is nearly always determined by local conditions and the prevailing boiler-house design. It is hoped that the following description of the systems will help hospital engineers when making their choice, and will give them some idea of what is available and how it operates.

Mr. Glensy is the Technical Press Officer, National Coal Board

Gravity feed

Though the gravity-feed device is not truly a form of mechanical stoker (defined in BS 1846:1952 as 'an apparatus for delivering the fuel mechanically to the grate or furnace'), it nevertheless fully deserves to be called automatic.

Gravity-feed firing for both water heating and steam raising is firmly established on the Continent. Its growing use in our schools, churches, hotels and cinemas—all with a difficult heat load to follow—and in our public buildings, hospitals, office blocks and factories suggests that the system is now as acceptable in British heating practice on the large scale as it has long been in the kitchen.

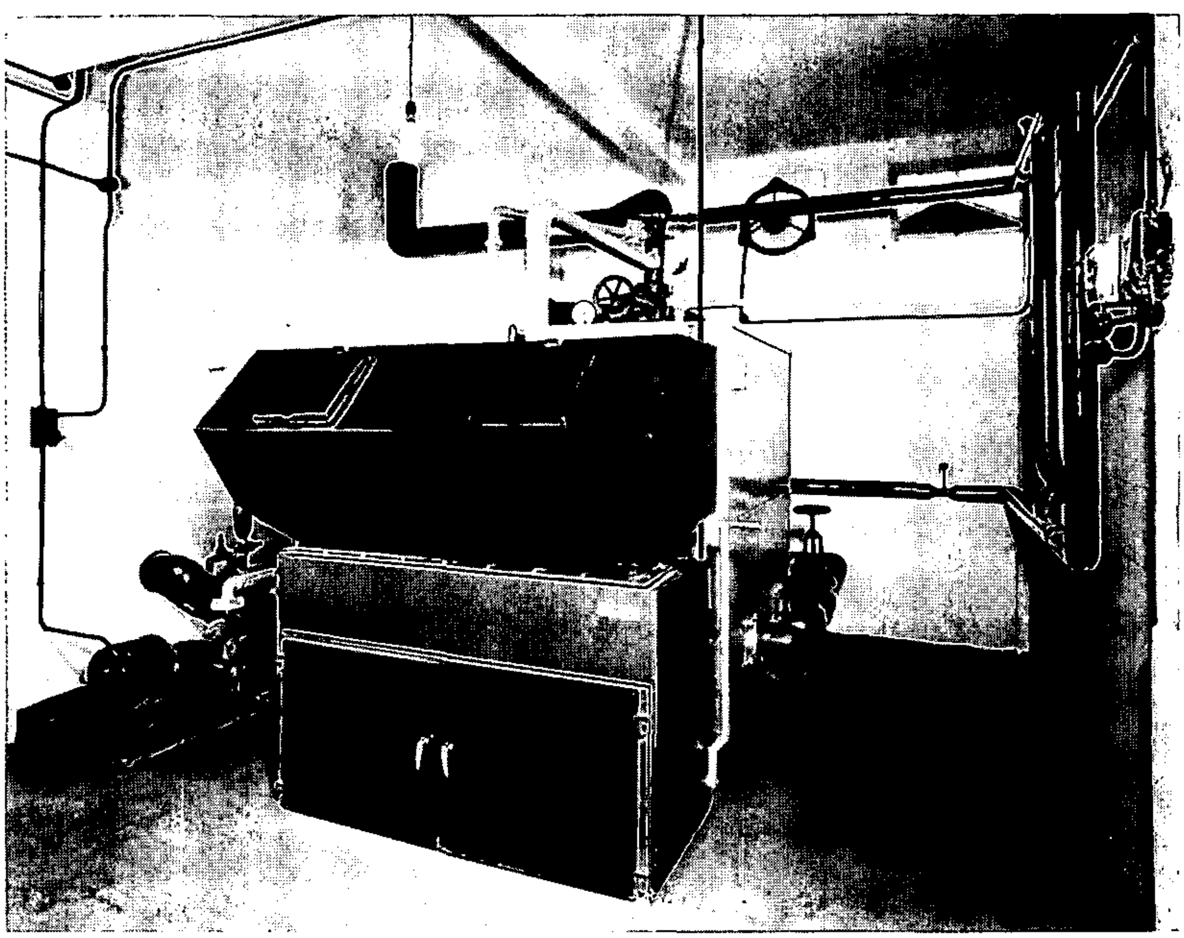


Fig. 1 Small boiler house with a single sectional boiler fired by the new 'Trianco' gravity-feed unit

Gravity-fed units are an effective and inexpensive means of converting most types of sectional boiler to automatic gravity-fed firing. Such conversions are mainly for boilers already in operation, but they are equally applicable to new boilers about to be installed. The units are not mechanical stokers; fuel simply gravitates from a hopper to the firebed, and combustion air is supplied by a forced-draught fan (Figs. 1 and 2).

In the typical gravity-feed unit, fuel flow down the feed chute from the hopper can be interrupted by a shutter. The fuel forms a fire bed over a cone on the fire base, both the cone and the base being water cooled. Primary air is distributed from the periphery of the cone, and the remainder of the air supply is emitted as secondary air from a perforated ring above the fire. Fuel feeds at the rate needed to replace the fuel consumed, and combustion is regulated by thermostatic control of the fan. Time switches can also be incorporated for programme and kindling control. The fuel used in gravity-feed units is anthracite, a naturally smokeless fuel, and this is burnt to a clinker. Removing the clinker and refuelling the hopper are simple operations usually done together once a day.

All gravity-feed equipment has the merit of few moving parts, and shares the natural advantage, essential in smoke-control areas, of smokeless combustion through burning smokeless solid fuels.

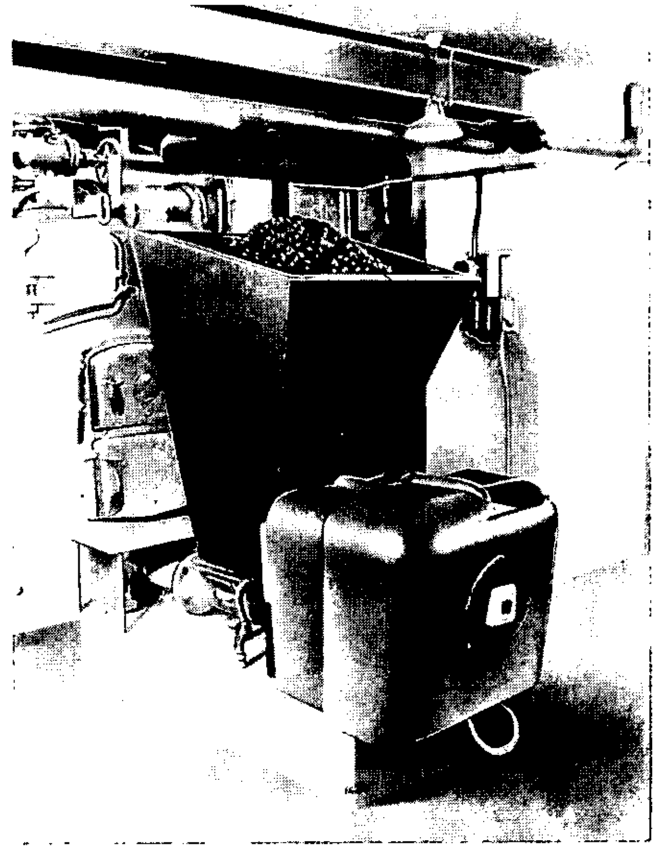


Fig. 3 Hopper-type underfeed stoker

Underfeed stoker

The principle of underfeed stoking has been understood and applied to the firing of sectional boilers for many years. In this type of stoker the coal is burned in a retort into which it is fed by means of a screw or ram which takes its supply from a hopper or bunker (Fig. 3). Air for combustion is supplied through tuyeres located around the top of the retort. As the coal is fed into the retort the volatile matter is given off, and, since it must pass through the incandescent mass of burning coal, is completely consumed without smoke. As the coal is burnt the ashes and clinker collect around the periphery of the retort and are removed by hand from time to time.

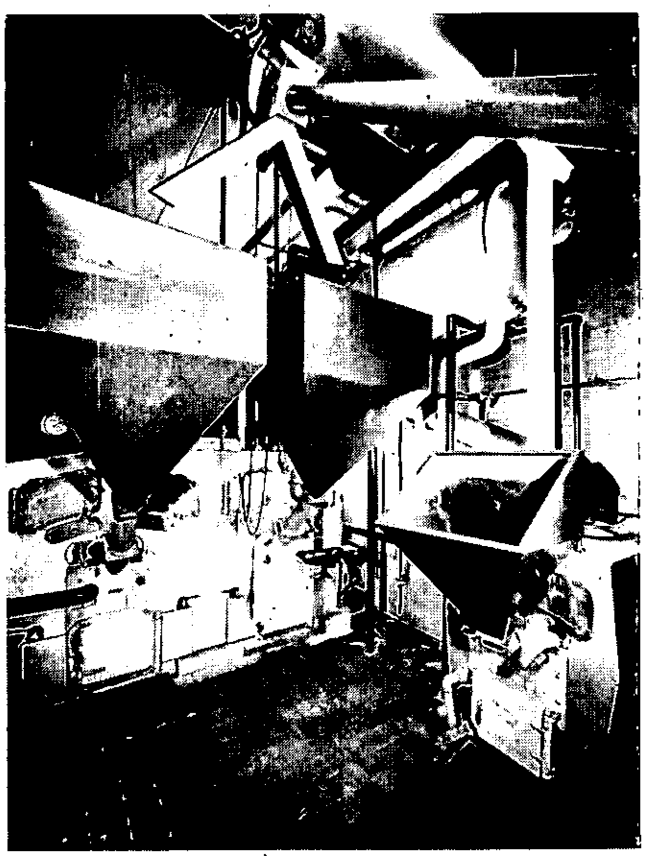


Fig. 2 Typical small-hospital installation; three sectional boilers converted from coke to gravity-feed coal firing

Depending on the choice of stoker, coal can be fed into single or double retorts, or by twin screws into double retorts. In all cases air is forced via ducting into the wind box, and thence by tuyeres into the fuel bed near the top of the retorts. Further air is fed through the side bars, which range in design from flat terraced segments to standard sections closely resembling those of normal forced-draught grates. In some stokers of unit design separate self-contained air boxes are fitted; in these stokers it is usual for the unit to be completely assembled at the works. Usually the air supply is regulated either at the fan inlet or by a damper in the forced-draught duct. In several cases the air control is linked directly to that of the coal feed, and in this way a correct coal/air ratio is maintained at all times.

The underfeed stoker is a fully approved appliance within the terms of the Clean Air Act, and can operate in all smoke-control areas. To ensure the absolute minimum of smoke when starting or stopping the coal feed, various measures have been introduced by the manufacturers, some since the Act came into force. One of these arrangements comprises the fitting of a number of secondary air jets set in brickwork, so designed to direct streams of hot secondary air over the fire. The secondary air supply can either be hand controlled, or operated automatically by a switch or a smoke-measuring device. In other cases the forced-draught fan is automatically controlled so as to operate for a period after the coal has stopped feeding to the grate, and to start before the coal feeding starts. Both of these systems undoubtedly result in a positive degree of control which prevents smoke emission, and with underfeed stokers grit arresters will not normally be necessary to comply with provisions of the Clean Air Act.

The underfeed stoker is usually supplied with automatic control as an integral part of the equipment. This will include a kindling control which keeps the fire alight during long periods at no load, for example during the night. Because the only moving parts are far from the heat of the fire, underfed stoking usually results in relatively low running costs, and the simple maintenance can be carried out by unskilled staff, which also helps to reduce costs to the very minimum.

This stoker is easily operated to give efficient performance with a minimum of manual attention, provided that the correct coal is used. Banking and starting up are also very easy, while in the event of a mechanical or electrical breakdown hand firing can be resorted to, provided that firebricks are put inside the retort to protect it and the exposed part of the coal-feed worm.

The underfeed lends itself admirably to small installations such as heating, as no full-time attendant is required; coal trimming and clinkering only occupy a small proportion of a man's time.

The bunker-to-boiler type of stoker is very convenient, eliminating any hand filling of hoppers.

NCB technical services

Free advice to hospital engineers on both systems, and on all matters relating to the use of solid fuel, can be readily obtained from any NCB Regional Sales Office, where a member of the Board's technical service will be on call. In some cases it may be possible for the Board to arrange financial assistance as an added incentive to convert a coke-fired boiler to coal.

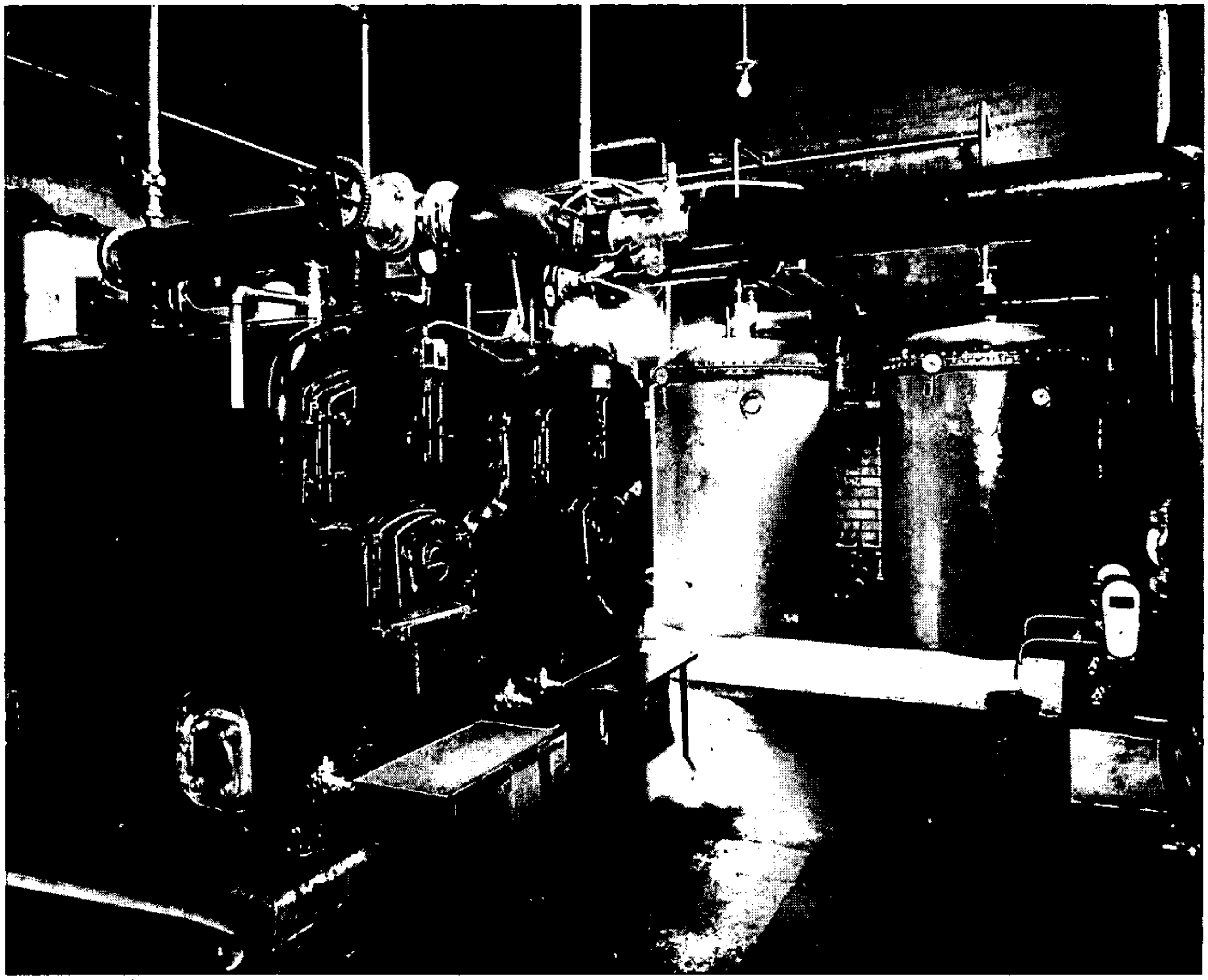


Fig. 4 Boiler house with two boilers fired from the rear by bunker-to-boiler underfeed stokers

National Post-experience courses—University of Keele

Two courses were again held at the University of Keele this year. The first, in July, was attended by 70 assistant engineers, and, as usual, the programme embraced both management and technical content, dealing with such subjects as the nature of management, communications, planning, inspection, productivity and staff relations and committee work. It also included visits to two hospitals in Liverpool.

As with all of these Keele courses, the great majority of the work was done in small groups of about 10 students; it is felt that the most benefit can be achieved from the programme using this approach. The course moved towards a climax when each Group presented a verbal report to all delegates on a different aspect of the week's work. The level of enthusiasm and performance was high, and certainly pointed to the value of the courses.

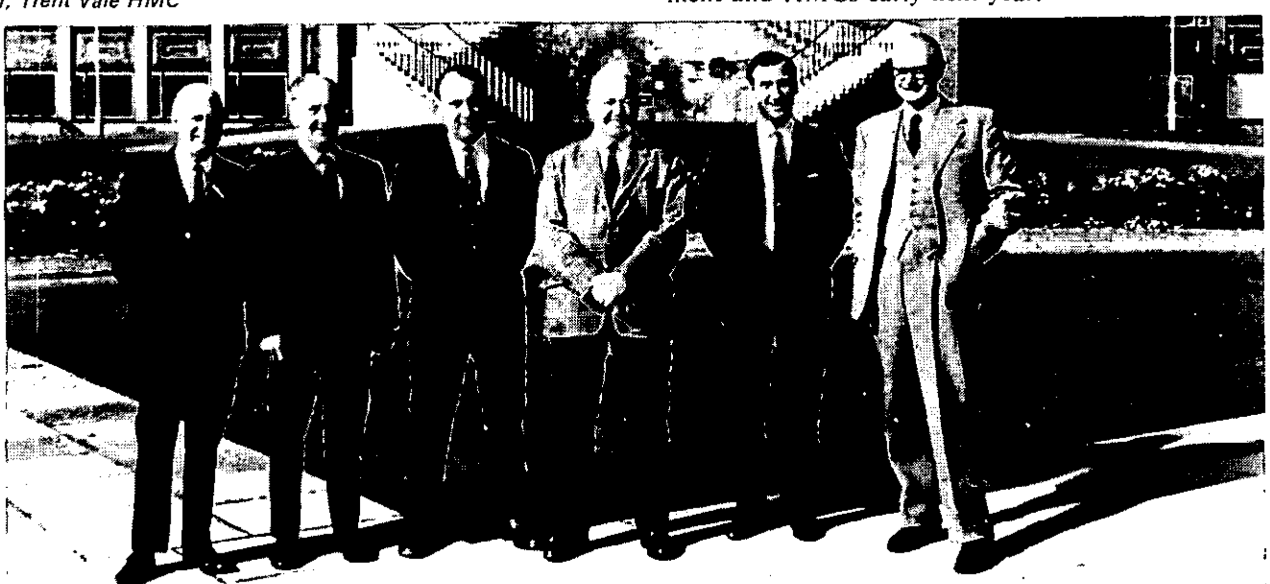
Keeping up with the Parkers! Three brothers who, without collusion, met each other at a Keele course—and for the second time! Left to right: J. A. Parker, Group Engineer, Norwich, Lowestoft & Gt. Yarmouth HMC; E. Parker, Hospital Engineer, Royal Victoria Infirmary, Edinburgh; G. Parker, Hospital Engineer, Trent Vale HMC

The second course, in September, was attended by 100 group and hospital engineers. Again, both management and technical subjects were studied, this time with the emphasis on the former. Technical subjects included approach to design, small capital works, productivity and maintenance and public-health engineering. As well as a number of management tutorials, other subjects dealt with were public speaking, the art of decision making, working situations and relationships and staff management.

This course had a rather more sophisticated pattern in that each day involved the carrying out of certain practical exercises, and ended with a course council at which small groups of students presented verbal reports to all delegates on certain tasks which had been allotted to them. Again, high standards of performance were attained.

There were a number of visitors to the courses. These included Mrs. P. M. Williamson, Assistant Secretary, Department of Health & Social Security, Mr. G. A. Rooley, President of the Institute, and Mr. John Bolton, Chief Engineer, and Mr. R. Manser, Assistant Chief Engineer, of the Department of Health & Social Security.

The dates of the 1971 courses are already fixed for the 18th–23rd July and the 19th–24th September. Details of the courses, nominations and registration will be circulated to RHBs, Boards of Governors, Boards of Management and HMCs early next year.



Pictured at Keele: (left to right) M. J. Burke; G. S. Gillard, Chairman, Keele Courses Committee; J. E. Furness, Secretary, I.Hosp.E. and Keele Courses Committee; E. L. Taylor, Regional Engineer, Eastern RHB Scotland; J. Knipe, DHSS; R. Manser, Assistant Chief Engineer, DHSS

★ Among the Branches ★

EAST-ANGLIAN BRANCH

Two speakers from the British Oxygen Co. visited Fulbourne Hospital, Cambridge, on the 12th September to give the branch a talk on piped medical gases and 'Entonox'. As there was a new British standard almost ready for issue, BOC had redesigned some of its equipment and a marketing campaign was due to start in about a month. Members were therefore treated to advance information, anticipating the issue of new BOC manuals. The reasons for the widening use of 'Entonox' were given; one of the most important being that accident patients are more easily able to describe their symptoms. The 50 : 50 O_2 : N_2O mixture cannot lead to hyperoxy. The disadvantages were also covered, including the need for particularly careful storage. A discussion of economics, with a comparison of piped and portable units, followed, and the talk concluded with a description of liquid-oxygen and medical-suction systems.

At the Branch Committee meeting which followed the talk the dates of branch meetings until September 1971 were agreed, and part of the programme decided. This was to include talks on fire prevention and on 'best-buy' hospitals.

NEW FACES

Two active members of the Institute have recently taken up new appointments. **Mr. Duncan MacMillan** has been appointed Group Engineer to the South Worcestershire HMC, and has been succeeded as Group Engineer to the Inverness Hospitals Board of Management by **Mr. G. Doherty**, who, until taking up his new post, was Honorary Secretary of the Glasgow & West of Scotland Branch of the Institute. Good wishes go with them both in their new surroundings.

★ Market News ★

For further details, simply encircle the relevant numbers on the reply-paid postcard

Motorised cardiovascular table

A new cardiovascular table has a powered vertical-lift base and motor-driven patient-rotating device, in addition to a wide variety of standard accessories. The base incorporates a motor system providing a top-height adjustment from 32 to 47 in. This accommodates any stretcher height for transferring the patient, and provides a comfortable " working " level for the surgeon. The patient-rotating system is attached to the table top, and allows the patient to remain flat (anterior-posterior) on the table top. There are no protrusions or drive systems sticking up or out from the surface; a thin Mylar sheet is used to rotate the patient. **HE74**

Westinghouse Electric International Co., PO Box 1133, Grand Central Station, New York, 10017, USA

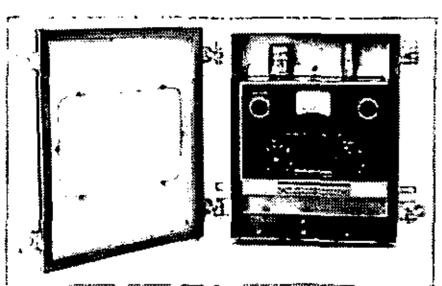
Water softeners

Denco Engineering Services has extended its range of water-treatment plant by the introduction of two new base-exchange water softeners. Maximum service flow rates for the SSD range are from 540 to 2160 gal/h, and for the LSD range from 2800 to 21 600 gal/h. The two ranges total 18 softeners, including both manual and automatic regeneration models. In the SSD range a pilot-operated multiport valve is mounted on top of the mild-steel cylinder, and this is used to control regeneration. It is hydraulically operated by the untreated water, or may be electrically remote controlled. Each unit is provided with a salt saturator and brine tank.

Denco Engineering Services Ltd., Holmer Rd., Hereford **HE75**

Smoke-density monitor

The Hird–Brown smoke-density indicating equipment fulfils all requirements for a unit enabling compliance with the Clean Air Act. The equipment comprises a control unit, a light-beam projector unit and a photocell receiver unit together with suitable mounting flanges. Projector and receiver units can be mounted on a chimney or flue (in a negative-pressure region) so that the smoke interrupts the beam of light, and will then emit a varying current as the smoke density varies. Additional equipment includes alarm bells, meters, a voltage stabiliser and a roll-chart recorder. When used as an



alarm the equipment operates within 1% of the set point when smoke density increases.

Hird-Brown Ltd., Lever Street, Bolton, Lancs. **HE76**

Electronic pacemaker tester

Significant reductions in the incidence of unexpected heart-pacemaker failures have been achieved by the use of a simple combination of standard Hewlett-Packard equipment. An American heart surgeon has reduced the failure rate from one or two incidences a week to one or two a year. To establish whether an implanted pacemaker requires a new battery or complete replacement, an oscilloscope is attached directly to the electrocardiograph electrodes on the patient's chest. The pacemaker output is then photographed by a camera mounted on the oscilloscope itself to obtain a permanent record for analysis. The condition of the pacemaker is established by measurements of the rise and fall times, height and width of the pulse. These measurements are then compared with the outputs of similar units known to be in good operating condition. A low pulse height will indicate a weak pacemaker battery. A further check is carried out by measuring the exact time interval between pulses. As properly functioning pacemakers have an almost constant time interval between each pulse, irregularity indicates a defective unit. Units which operate 'on demand'—triggered by the patient's heart rate—are checked in a similar manner. However, if the demand unit is not operating because its set rate is below the rate of the heart, an r.f. stimulus is applied to the pacemaker, and the output waveforms are then analysed.

Hewlett-Packard, 224 Bath Road, Slough, Bucks. **HE77**

Bench power supply

The Mark 2 version of the TSV 70 has a continuously variable output capable of 0–70 V, 5 A or 0–35 V, 10 A with line and load stability (over ±10% mains change and zero-full load) of 10 000 : 1. Ripple and noise content is less than 1 mV peak–peak at full load (measured at 80 kHz bandwidth). Overload protection is afforded by adjustable constant-current limiting circuitry, and remote-sensing facilities are provided to ensure high stability even when feeding distant loads. Separate meters enable precise monitoring of both output voltage and current levels. The use of forced air cooling has led to a considerable reduction in size, thus increasing the portability and resulting in a clean attractive style. The unit's dimensions are 43 cm wide × 18 cm high × 41 cm deep, and it costs £165.

Farnell Instruments Ltd., Sandbeck Way, Wetherby, Yorks. **HE78**

Laboratory service trunking

For all laboratory work, a new trunking from Climpex places electrical outlets conveniently above bench-top level. Gas and hot- and cold-water services can also be supported on the trunking fixing brackets, and double- and single-sided trunking is available to enclose the pipes. The box trunking is supported above the bench on steel scaffolding, which leaves the maximum bench space and saves time in fitting and assembly. It is supplied with cables already installed; the basic unit is a 62·5 cm length with four 13A flush-mounted switched socket outlets, the cabling and sockets can be varied to customers' specifications. The trunking is all metal; steel parts are zinc plated except for the faceplate which is finished in white.

Climpex Ltd., Hammers Lane, Mill Hill, London NW7 **HE79**

Disposable ashtrays

A shortage of ashtrays, whether due to cost, theft or breakage, always represents a fire risk. Disposable heavy-foil ashtrays which could provide a solution to the problem are available from Food Containers Ltd., at a price of £6 15*s*. per thousand (minimum order) with reductions for larger quantities.

Food Containers Ltd., 153 High Street, Aldershot, Hants. **HE80**

Grease-filter units

A new range of grease-filter units for use in kitchen and canteen extractor hoods is to be marketed by Davis Industrial Ltd. The filters have the galvanised or aluminium mesh formed in rolls and packed into a galvanised or aluminium frame with holes at both ends. They can be easily cleaned either by washing in the normal way or by inserting a steam hose into an end hole. The filter units may be used to replace any standard units now being marketed.

Davis Industrial (Filters) Ltd., Mead Works, 29–31 Parsons Mead, Croydon, Surrey **HE81**

Literature available

Cisterns and traps
Two 4-page leaflets, one describing 'Osmaglass' and 'Osmathene' cisterns, the other 'Variform' h.d. polythene traps, which can be used in almost any existing plastics or metal plumbing layout. *Osma Plastics Ltd., Hayes, Middx.* **HE82**

Chimneys
Glossy booklet covering research, multi-boiler installations, dealing with oversized chimneys, delivery and erection and choice of insulation. A useful introduction to the wide range of chimneys available. *F. E. Beaumont Ltd., Rathgar Road, London SW9* **HE83**

Fin tubes
10-page booklet describing five types of fin tube available for heat-exchanger applications. *Howell & Co. Ltd., PO Box 100, Wincobank, Sheffield 9* **HE84**

Oils journal
New quarterly publication to be circulated free to any company etc. where lubricants and allied products are used. Intended to increase the awareness of users to the activities of Burmah-Castrol, and also as an information source on tribology. *Burmah-Castrol Industrial Ltd., Marylebone Road, London, NW1* **HE85**

Gas cylinders
Useful booklet, covering in 24 pages not only details of seamless steel cylinders available from Chesterfield, but also sections on maintenance, fittings and accessories. *The Chesterfield Tube Co. Ltd., Chesterfield, Derby.* **HE86**

Power-control wall chart
Contains information on all Zenith equipment, including the well known 'Variac'. A metric conversion table is included. *Zenith Electric Co. Ltd., Cranfield Road, Wavendon, Bletchley, Bucks.* **HE87**

Heating elements
Exhaustive 43-page booklet covering Eltron's range of standard heating elements and custom-design services. Includes flame-proof immersion heaters, air heaters, defrosting elements and special-purpose units. *Eltron (London) Ltd., Accrington Works, Strathmore Road, Croydon, Surrey* **HE88**

Gas catering equipment
Appliance list comprising only equipment approved for operation with both towns and natural gas. Divided into Category 1 (requiring a change of jets for conversion) and Category 2 (requiring only a change of injector) appliances. *Commercial Gas Centre, 139 Tottenham Court Road, London W1* **HE89**

Aluminium roofing
Designed to assist in the selection of aluminium building-sheet profiles for roofing and cladding specifications, an 8-page metric booklet. *Alcan Booth Industries Ltd., Southam Road, Banbury, Oxon.* **HE90**

Gas sterilisation
News sheet on a steriliser using ethylene oxide, controlled by fluidic techniques to avoid the risk of explosion. *Norgren Fluidics, Shipston-on-Stour, War.* **HE91**

Air conditioning
4-page leaflet that describes the 'Satair' wet-duct air-conditioning system. *A & A Industrial Equipment Ltd., Sandleas Way, Manston Lane, Cross Gates, Leeds 15* **HE92**

Noise measurement
Very informative 18-page booklet on noise-measurement techniques; the second edition of a publication used by 15 000 people. *Dawe Instruments Ltd., Concord Road, Western Avenue, London W3* **HE93**

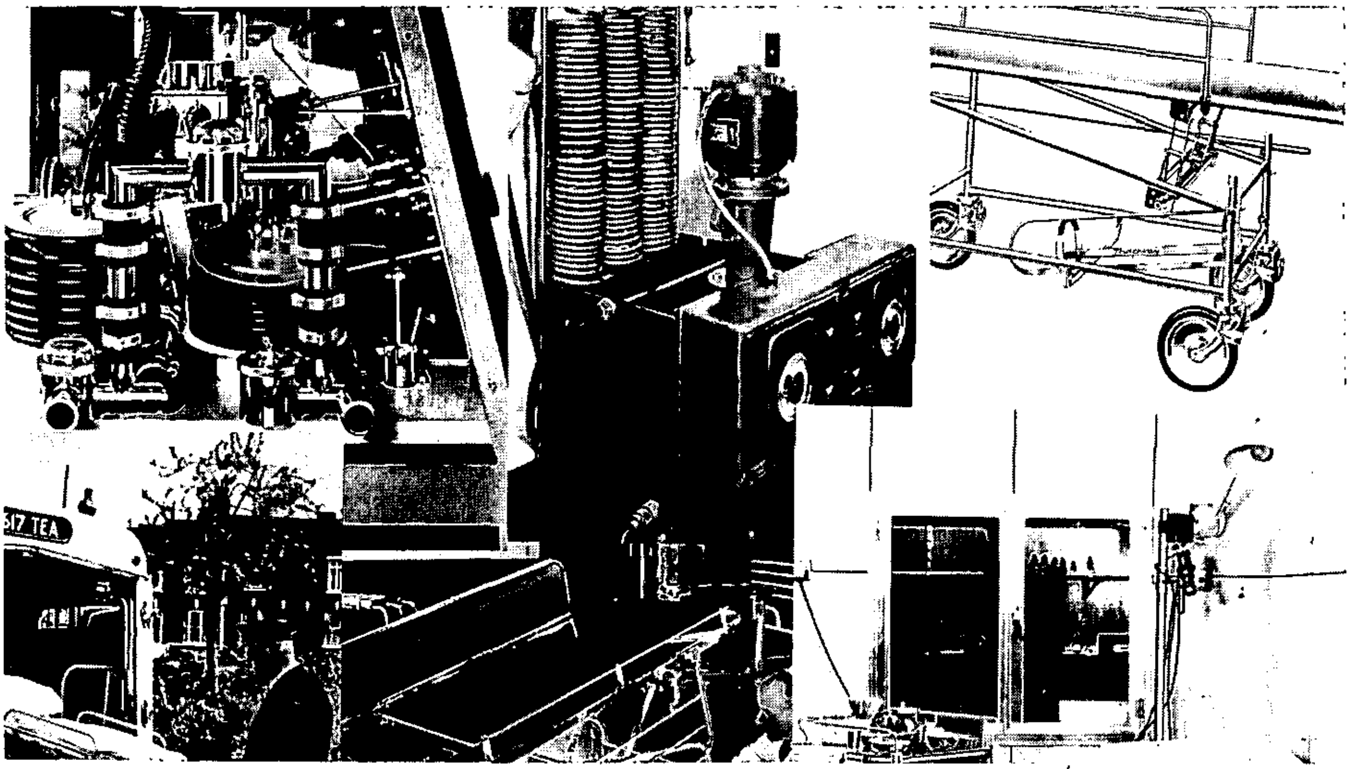
Liquid-phase heating
Leaflet covering the use of thermal fluids and a range of equipment for steam raising. *Wanson Co. Ltd., 7 Elstree Way, Borehamwood, Herts.* **HE94**

Heating equipment
Comprehensive 52-page catalogue of heating, ventilating and air-conditioning equipment and components. *Perfection Parts Ltd., 59 Union Street, London SE1* **HE95**

Instrumentation and control
Booklet giving brief descriptions of the instruments manufactured by N & Z. *Negretti & Zambra Ltd., Stocklake, Aylesbury, Bucks.* **HE96**

Fire-protection posters
Four striking posters on security, night fires, store fires and extinguishers. 14s. a set or 4s. each. *Fire Protection Association, Aldermary House, Queen Street, London EC4* **HE97**

Fan systems
Well produced 6-page brochure on the range of activities of the Fan Systems Group. *Fan Systems Group Ltd., 35 Dale Street, Manchester M1 2HF* **HE98**



Existing and potential uses for stainless-steel tube in hospitals

BY
COLIN B. EDMONDS

In an environment where even the slightest possibility of infection from bacteria cannot be tolerated, the prime essential is meticulous attention to cleanliness. Where that environment is a hospital complex, such attention must be given to the kitchens, cloakrooms and offices no less than to the operating theatres, dispensaries and wards. Every piece of equipment exposed to contamination must be easy to sterilise—and by equipment is meant not only the delicate instruments for diagnosis, surgery and therapeutics, but also the more mundane furniture like stretcher trolleys, meal trolleys, beds, tables and chairs. And to be easy to sterilise, the exposed surfaces need to be smooth and free from crevices, so that they can readily be wiped down and disinfected. If these surfaces are prone to corrode they will gradually roughen with small pits and craters where bacteria spores can find a harbour in which to proliferate.

This is where stainless steel comes in; in the form of a whole series of iron–chromium–nickel alloys which all have the characteristic of excellent resistance to atmospheric and chemical attack. Chromium is the element mainly responsible for this corrosion resistance, and all stainless steels contain upwards of 12% of the metal. The reason for stainless steel's ability to withstand attack is the hard, tenacious and transparent oxide skin that forms on the metal surface as soon as it is exposed to the atmosphere; a film that will reform immediately if the original coating is scratched or abraded. This hard, smooth surface is permanent and does not deteriorate with time, so that cleaning is never more difficult even after many years of wear and tear. The chemical composition of the protective oxide film varies with that of the stainless steel, and while there is no one grade that will effectively resist every type of corrosive medium, a specific grade can always be selected to provide satisfactory resistance

Mr. Edmonds is Marketing Manager, TI Stainless Tubes Ltd., Walsall, Staffs.

to particular forms of corrosive attack. For example, the addition of molybdenum to a basic 18/10 chromium-nickel steel increases its resistance to sulphuric-acid attack and to pitting corrosion by chlorides.

What this means in the context of stainless-steel tube is that both the outside surface and the bore will remain smooth and crevice-free. Even at welded joints the same smooth contours are maintained, thanks to sophisticated welding techniques that have been developed and perfected over a number of years. Several British Standards relate specifically to hospital equipment, and many of these refer to stainless steel either as the sole material for fabrication or as one of the materials recommended.

In considering the applications of stainless-steel tube in hospitals the obvious starting point is the intricate area of surgery, with its complex demands for precision instruments. However, there are many more conventional applications. Tubes are not solely destined to convey fluids—they need not convey anything at all. The hollow section that makes up a tube provides an immediate weight saving over its solid counterpart. And in a hospital any means of reducing manual effort is a means of getting more of the essential work done. Steel tubes, with their high strength/weight ratio, can form the integral structures of bedsteads, trolleys, movable screens, stools and tables. And if the steel tubes are stainless, the weight saving is reinforced by the nontoxic surface finish that makes cleaning and maintenance a simple matter. Naturally, stainless steel is not the only material that has a smooth corrosion-resistant finish. Plated or vitreous enamelled surfaces are equally immune to attack, nontoxic and free from crevices. But they do have disadvantages. Chromium plating, for instance, however perfect, is inherently porous. Hence, over a period of time there tends to be a gradual penetration of water and disinfecting solutions which, sooner or later, leads to a lifting of the plated coating. Peeling plate, in addition to providing the ideal breeding ground for bacteria spores, can also cause physical injury. Enamelled coatings, again, while being entirely free of surface flaws, are not capable of withstanding too rough a treatment, and once they start to chip the damaged areas are difficult to disinfect so that germ-breeding dirt will tend to accumulate.

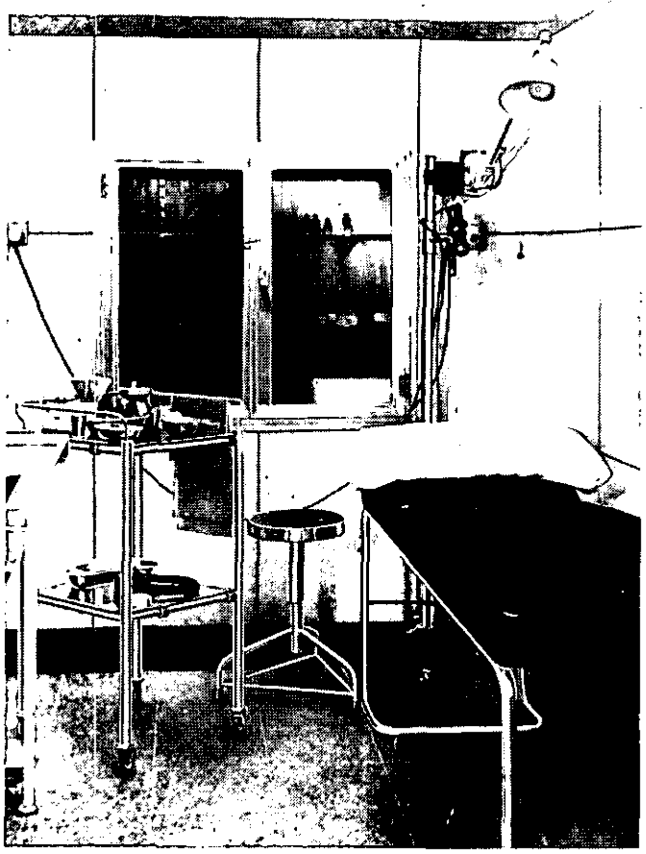


Fig. 1 This view of the medical centre at ICI's Wilton works, Middlesborough, shows some of the many applications of stainless-steel tubing

Stainless steel, without any applied coating, cannot peel and cannot chip. It can therefore be subjected to rough handling without in any way detracting from the ease with which it can be washed down.

One of the obstacles to a greater use of stainless steel as structural members in hospital furniture, taking again bedsteads as a typical example, is its relatively high initial cost. There can be no argument against the fact that an enamelled mild-steel tubular frame, is, in terms of initial cost, cheaper than stainless steel. On the other hand, cost-saving automatic welding processes, coupled with the thinner gauge of tube that goes with the higher strength of stainless steel, makes the margin extremely narrow. And in the long run the extra capital investment is more than refunded in terms of longer life and easier maintenance. Unfortunately, budgets for new equipment in hospitals remain tight. Decisions on spending money are still dominated by the short-term economics of what can be bought this year, rather than what will not need to be replaced in five years' time. More emphasis on long-term investment would inevitably reap its rewards in the course of time.

While still on the subject of beds there is a widely held viewpoint that the glare and reflection from a ward full of gleaming stainless-steel bedsteads has a tiring effect on both patients and ward staff. This viewpoint can hardly be challenged. But while the usual image that stainless steel conjures up is its shining appearance, it need not be in this highly polished condition. Stainless steel is available, just as readily, and at no difference in cost, in a satin or matt finish—equally corrosion resistant, and equally easy to clean, but without the capacity to dazzle—at least not visually! In fact, BS 2563:1967, one of a series of standards relating to tubular-framed equipment, specifies that the simple trolley for use with stretchers within the hospital should have a satin finish.

Reference to some of the relevant British Standards will substantiate the extent to which stainless steel is accepted for the tubular construction of hospital furniture by illustrating the fine detail in which processing directions are given. For example, referring again to BS 2563:1967, while the main trolley framework is specified as either mild or stainless steel, if welded it must be welded tube Grade 2 (BS 3014). Even the method of welding is laid down in that, if the material is stainless steel, the tube has to be either oxyacetylene, inert-gas arc or resistance welded. Further, the filler rod for inert-gas arc welding must comply with specification A8 Nb or A8 Ti, as appropriate, as detailed in BS 2901, part I. In specifying welded joints, BS 2563 states that ' there shall be no exposed edges on the trolley or unsealed formations which may harbour dirt or foreign matter '—a condition that does not present stainless-steel tube with any problems. And the tube need not be of circular cross-section; there are a number of kidney-machine trolleys in service contructed of square-section tube.

Apart from various types of trolleys, tables and stools, stainless-steel tube can find useful applications behind closed doors; i.e. in the form of wardrobe hanger rails, tubular handles and toilet accessories such as towel rails and shower-curtain rails. Perforated tube can be used in shower units. And moving slightly away from the main hub of hospital life, hollow-tube section provides attractive balustrading on the main staircases, particularly leading to and from the reception areas. Here a cheerful decor can offset the gloomy atmosphere traditionally associated with hospital entrance halls. The keynote once more is ease of maintenance, freedom from germ traps and the overall pleasing effect of the surface finish.

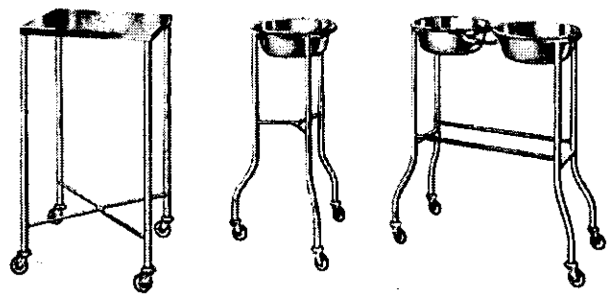


Fig. 2 Single and double bowl stands and an instrument trolley in stainless steel

Coming on to tubes that carry fluids, one use of stainless steel that has yet to be fully exploited in hospitals is for water-supply services. The corrosion resistance of the outside surface, as has already been said, is equally effective in the bore. Stainless steel, well proven as an alternative to copper, has twice the strength of conventional water-pipe materials and can be cut, bent and soldered with standard plumbers' tools. And, because of its strength, a lighter gauge of tube can be used, so making stainless steel competitive in price with alternative materials.

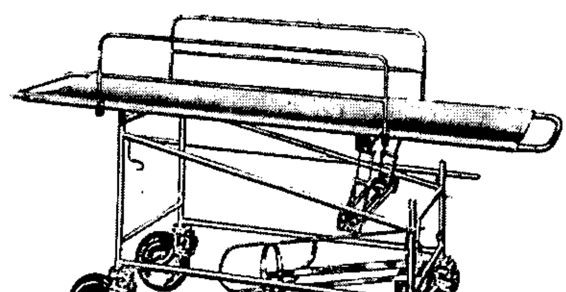


Fig. 3 Stainless-steel recovery trolley

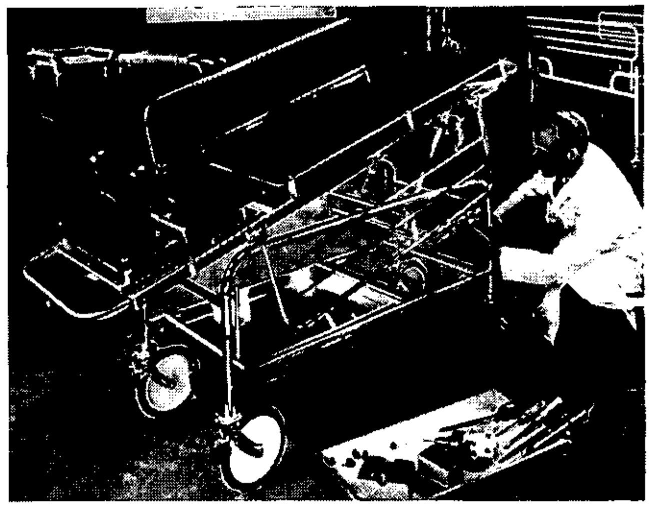


Fig. 4 X ray trolley whose entire frame is in stainless-steel tube, chosen for its inherent cleanliness and ease of maintenance and high strength/weight ratio. The trolley is designed to convey a patient from an ambulance, through X ray and on to the operating theatre

Fig. 5 Stainless-steel stretcher trolleys in use in West Bromwich, Staffs.

Acknowledging its penetration into the water-supply service field, BS 4127:1967 quotes nominal sizes of $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$ and $1\frac{1}{2}$ in diameter, but accepts that other sizes will be added as necessary. The Standard specifies that the tube may be welded or seamless, but the generally adopted process is welding, the tube being formed from strip and seam welded by the TIG process. Mandatory requirements include tensile drift and flattening tests, as well as hydraulic and pneumatic tests which ensure that no possibility of leakage will exist in service.

There is absolutely no danger of the water supplied being contaminated; for example 'Supatube', manufactured by TI Stainless Tubes Ltd. for above-ground water-supplies services, has the approval of the British Waterworks Association. Stainless-steel tube can be connected to copper, brass or gun-metal fittings, and can form part of circuits containing copper hot-water cylinders or a galvanised steel tank without any risk of intermetallic electrolytic action at the joints.

Again, the corrosion-resistant properties of stainless steel means that building materials will not attack the outside of the tubes, which can thus be embedded in brickwork or concrete or covered with plastics with no ill effects.

From large bores to small bores; in fact to tubes whose inside diameter is only of the order of thousandths of an inch—hypodermic needles. Tube for these needles is manufactured from AISI type 304 austenitic stainless steel, a composition that, in addition to having the inherent corrosion resistance of all the stainless types, has the additional strength and hardness essential for such a delicate application. In accordance with BS 3522, hypodermic needles must meet a stringent stiffness test, involving both deflection through an arc without acquiring an appreciable permanent set, and bending a number of times to right and left without breaking. To meet corrosion-resistance requirements the needles must be capable of immersion in 10% aqueous citric-acid solution at room temperature for 5 h, followed by distilled water at boiling point for 30 min and finally at room temperature for 48 h without showing any signs of corrosion.

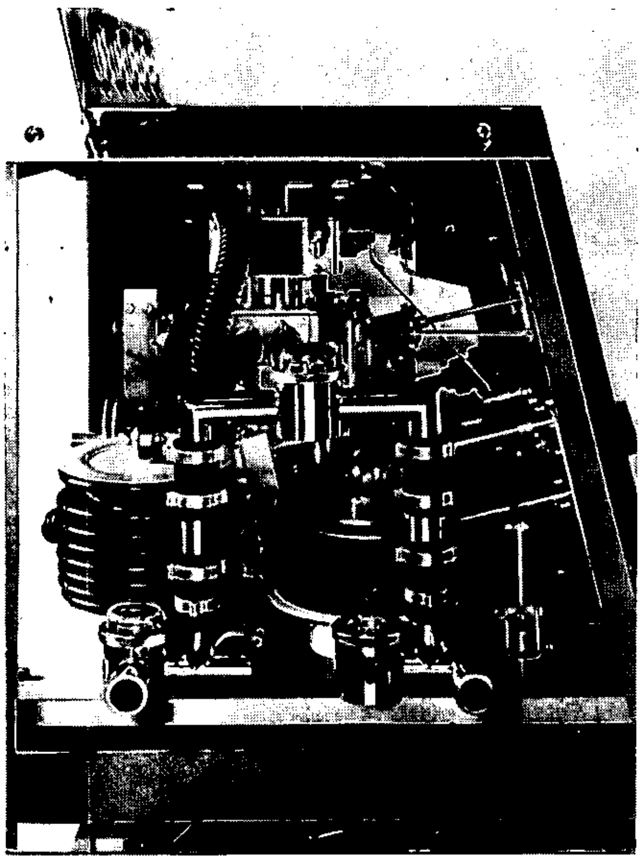


Fig. 6 Stainless-steel tubing, with its resistance to the corrosive effects of anaesthetic gases and its ease of sterilisation, is put to good use in the Cape-Waine anaesthetic ventilator

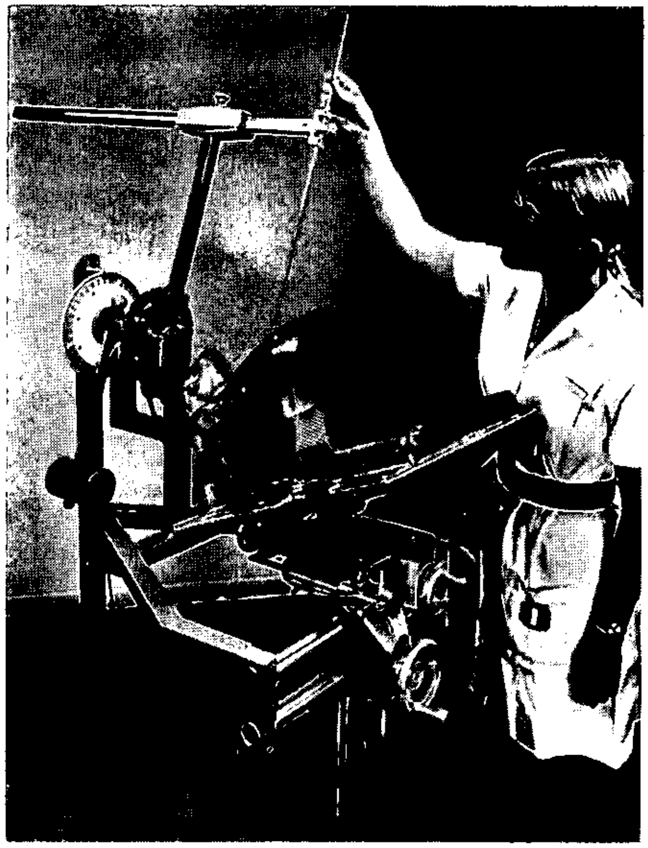


Fig. 7 The microplotter built by the Radiotherapy Physics Department of the Queen Elizabeth Hospital, Birmingham, incorporates stainless-steel tubing, both for ease of cleaning and to provide the essential robust construction

Since the abandonment some four years ago of conventional steam sterilising of hypodermic needles, the needles are now used once only, and then thrown away. Risk of infection is obviously minimised, and although the cost of a new stainless-steel needle for every injection

Fig. 8 Ancillary equipment at the Queen Elizabeth Hospital, using stainless-steel tube for the calibrated rise and fall

puts up the cost, this is actually only very slightly more than that of maintaining the steam-sterlising unit.

On the subject of sterilisers, the bulbs of the thermometers fitted in the steam-heating lines of automatic sterilisers are best protected by a stainless-tube sheath. Buchanan Bros., of Glasgow, is one manufacturer of hospital thermometers that makes good use of stainless steel's capability of withstanding the effects of superheated steam at temperatures up to 275°F.

Equally resistant to anaesthetic gases, stainless-steel tube is extensively used in the Cape-Waine Anaesthetic Ventilator, replacing the more difficult-to-maintain plated-brass components fitted to earlier models. Ease of sterilisation is again a major reason governing the choice of stainless steel, which in this application is an 18/10 chromium–nickel alloy containing molybdenum.

Illustrating the dual attributes of good strength/weight ratio and corrosion resistance is the incorporation of stainless-steel tube in a microplotter in use at the Queen Elizabeth Hospital, Birmingham. Designed and built by the physics department of the hospital, the machine, which is used to plan the contours of the treatment area of a patient undergoing radiotherapy treatment, has to be robust in construction and readily cleaned. Other applications in radiotherapy departments include the component parts of calibrated rise-and-fall equipment.

An interesting and vitally important use of stainless-steel tube is for the heat-exchanger coils in the newer designs of artificial-kidney machines. The renal unit of St Paul's Hospital, London, has a heat exchanger as an essential part of the installation. Designed and engineered by G. & J. Weir Ltd. of Glasgow, the heat exchanger incorporates coils of stainless-steel tube whose function is to ensure that the dialysis-fluid temperature is consistent with that of the patient's blood. Two series of three tubular coils are immersed in a large tank of distilled water whose temperature is very accurately controlled and safeguarded by automatic standby equipment. The sets of coils are connected in parallel with twin supply lines feeding two Travenol coil kidneys with saline solution from a bulk-storage tank. As the dialysis fluid flows through the coils it is heated by the surrounding water, the total coil length having been calculated to provide excess heat-exchange surface so that the final temperature of the fluid is very close to that of the surrounding water. The inherent resistance of the stainless-steel tube to scaling guarantees that no impurities are introduced into the fluid during the heating cycle.

Another life-saving piece of electromedical apparatus incorporating stainless-steel tube is the heart–lung machine, and metal surgical implants, all in austenitic stainless steel, can often include drawn tube. BS 3531: 1968, Part 1, covering materials for metal implants in bone surgery, specifically mentions the need for the internal surface of the tube to be free from carburisation. The internal surface of a test specimen, split longitudinally, has to comply with the requirements of an intercrystalline corrosion test—a requirement that only austenitic stainless steel can satisfy.

These typical examples are just a few of the ways in which stainless-steel tube is contributing to the efficiency of worldwide medical services, but they illustrate the characteristics that make this metal, in this form, an essential ingredient of hospital equipment. Its nontoxic properties, and the ease with which it can be wiped, cleaned and disinfected, make it a first contender for hospital furniture, both static and mobile. Its corrosion resistance makes it an ideal carrier for aggressive liquids, with no scaling problems even at high temperatures, water-supply services being an ideal application. Finally, its attractive appearance gives it decorative appeal. All in all, there can be no doubt that more and more uses will be found for stainless tube in hospitals, even though the initial costs may sometimes be higher. The expenditure will usually be recovered in lower maintenance costs and longer life.

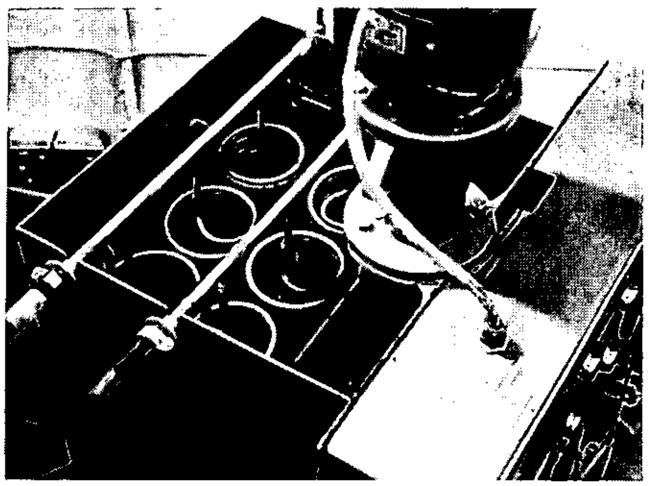


Fig. 9 Two views of the stainless-steel heat-exchanger coils in the artificial-kidney installation at the Renal Unit of St. Paul's Hospital, London

Operating-theatre air conditioning

BY
R. A. BROOM,
Assoc. I. Hosp.E.

Enormous progress has been made in the field of bacteria control, and the risk of a patient being infected from any of the operating-theatre equipment is now almost negligible. Equally, the principles behind the protection of the patient from airborne infection are now well known—but their application is perhaps not as widespread.

The ventilation of hospital operating theatres varies enormously. Some still rely on the opening or closing of a window, while others have systems ranging from simple propeller fans to the newest fully refrigerated air-conditioning systems.

It is of immense importance that the one area in a hospital where a patient has the biggest risk of infection, i.e. during an operation, should be the area where the most efficient means of bacteria control is performed. It is also the area where the best possible environmental conditions should exist. Bacteria control is normally carried out by sterilisation of all instruments, blankets, clothing and dressings, and of all furniture, floors, walls and ceilings. Having gone this far, it is quite pointless to open a window and allow untreated air to enter the theatre, carrying with it airborne bacteria to recontaminate the area and possibly infect the patient.

It is, therefore, vital that all air entering an operating theatre should be treated to eliminate the carrying of airborne bacteria, by filtering the air to such a degree that the minute particles of dust on which bacteria normally reside are removed from the air with the bacteria carried. It is also essential that no air from adjoining areas can find its way into the theatre, as this could well be contaminated, particularly if it came from, say, a sluice area. This is prevented by slightly pressurising the operating theatre so that any air leakage is outward and not inward.

In spite of all precautions, bacteria may still be released into the theatre area. For example, during surgery, bacteria may be released from the patient as a result of the actual operation, or possibly from the staff by an accidentally torn mask or clothing. In any event the bacteria count must be reduced to a minimum, and this can only be done if an efficient ventilation system is employed, and if the designer has taken into account the recommended number of air changes (15–25 in England) and the speed and direction of the general air movement.

This last-named point is of extreme importance, as bad siting of the discharge grilles can cause stagnant areas and turbulence in which eddy currents containing bacteria

Mr. Broom is the Managing Director of Myron (Air Conditioning) Ltd.

can be re-entrained into the clean air as it comes into the theatre, contaminating it before it has even reached the patient.

A typical example is the type of ventilating system which has the supply grilles mounted in the ceiling over the operating table and discharging downwards over the patient. This provides the patient with a constant supply of fresh, clean air and, supposedly, an air movement which is outwards from the patient at all times. However, to obtain such an air movement it is essential to have extract grilles equally spaced in all the peripherial walls; if one wall has no extract, then the area from the patient to the wall will become a dead-air zone and bacteria trap (see Fig. 1).

In addition, even when all walls have their requisite extract points, there is still a design fault which has not been previously recognised. Any bacteria which are carried into a dead-air zone by aerosol action, convection currents or other eddy currents can be re-entrained into the clean air and passed over the patient (see Fig. 2). If they come into contact with an open wound, infection or reinfection can occur.

Air movement, both speed and direction of flow, is among the most important factors in operating-theatre air-conditioning design. The ideal would be a discharge terminal occupying the whole surface area of one complete wall and an extract terminal occupying the entire area of the opposing wall, so that air passed through the theatre in a straight line (or nearly so) from one wall to the other over the whole theatre cross-section. There would then be no dead areas or areas of reverse turbulation, and all liberated bacteria would be carried away from the patient and rapidly extracted with practically no danger of contaminated air passing back over the patient.

Note, however, that there is a very slight risk of this latter happening, as whenever air is passed over a stationary (or moving) object a pressure depression is formed on the downstream side, and turbulent air results for a short distance behind the object. Thus, oxygen bottles, trollies and all operating-theatre staff can carry bacteria in the air depression behind them, and these can be liberated by air turbulence and possibly moved in the direction of the patient. As previously mentioned, this risk is very slight. Nevertheless, it can be further minimised by careful positioning of objects and staff within the theatre, and by, as far as possible, restricting the movement of staff so that, when the direction of air flow is from the head to the foot of the operating table, which is the normally recommended flow path, they pass around the foot of the table and not round the head.

Comfort conditions

The second important point is comfort, which involves temperature and humidity. The problem is to maintain comfortable conditions for the patient which are not too uncomfortable for the surgeons and staff.

In America the tendency is towards high temperatures—sometimes as high as 80°F, and in France a temperature of 64°F has been used with no apparent ill effects to the patient. In England the generally accepted temperature is 72°F, but there is now a general tendency towards using slightly lower temperatures, in the range 65–70°F.

Control of temperature alone cannot give comfortable conditions, as a great deal depends on the humidity of the air. This affects the rate of evaporation of perspiration from the body; at any particular dry-bulb temperature dry air causes rapid evaporation, which cools the skin and makes us feel cool, while moist or humid air retards evaporation, tending to make us feel hot and depressed. From the point of view of staff comfort, it is therefore of advantage to have as low a humidity as possible.

Unfortunately there is another controlling factor, which is that low humidities are conducive to the build-up of static electricity on the equipment and fabrics used in the operating theatre, so that with flammable anaesthetic gas there is a definite risk of an explosion caused by static-electricity discharge. With the use of more modern anaesthetics this danger has been minimised, but it nevertheless still does exist.

At a relative humidity of about 50% a very thin invisible film of moisture forms on equipment and other surfaces, and this conducts static electricity harmlessly to earth before it can build up to a spark-producing potential. Equipment that generates heat in any way, such as lamps, motors, pumps etc., naturally require a higher humidity before this film is formed. It therefore follows that a higher relative humidity of 55–65% must be maintained, in order that the required film-forming r.h. of the air in contact with the equipment is present. A further advantage gained from this higher r.h. is that the drying out of exposed tissue is retarded.

In the winter a system using only heating and humidifying equipment is adequate to provide comfort conditions on most days, but there will be a fair number of days when, owing to high external humidity, the humidity inside cannot be brought low enough. Dehumidification equipment must then be used. In dehumidification the air is cooled to dew point and beyond, so that it gives up a certain amount of its moisture, and then reheated to the desired temperature. Clearly, to carry out this cooling refrigeration equipment must be used.

In the summer humidity varies quite considerably, so that both humidification and dehumidification equipment must be available to obtain accurate control of the air condition. Cooling equipment is required when the outside air rises beyond a certain temperature, which may be as low as 65°F. The need for cooling appears at first sight to be fairly obvious, particularly when the outside temperature in summer soars to 85–90°F. Air being brought into an operating theatre at that temperature is too hot for the comfort of both patient and staff, and therefore it has to be cooled. However, there are other sources of heat within the theatre itself.

People at rest liberate about 300 Btu/h, and about 400 Btu/h when working lightly, so that with 20 people in an operating theatre at least 8000 Btu/h would be liberated—which is sufficient heat to boil 5½ gal of water. Heat is also liberated from lamps, sterilisers and all other electrical apparatus. It is gained from solar radiation through exterior walls and the roof, and also through walls from any adjoining areas which are at higher ambient temperatures. All of this additional heat must be absorbed by the incoming cooled air so that the

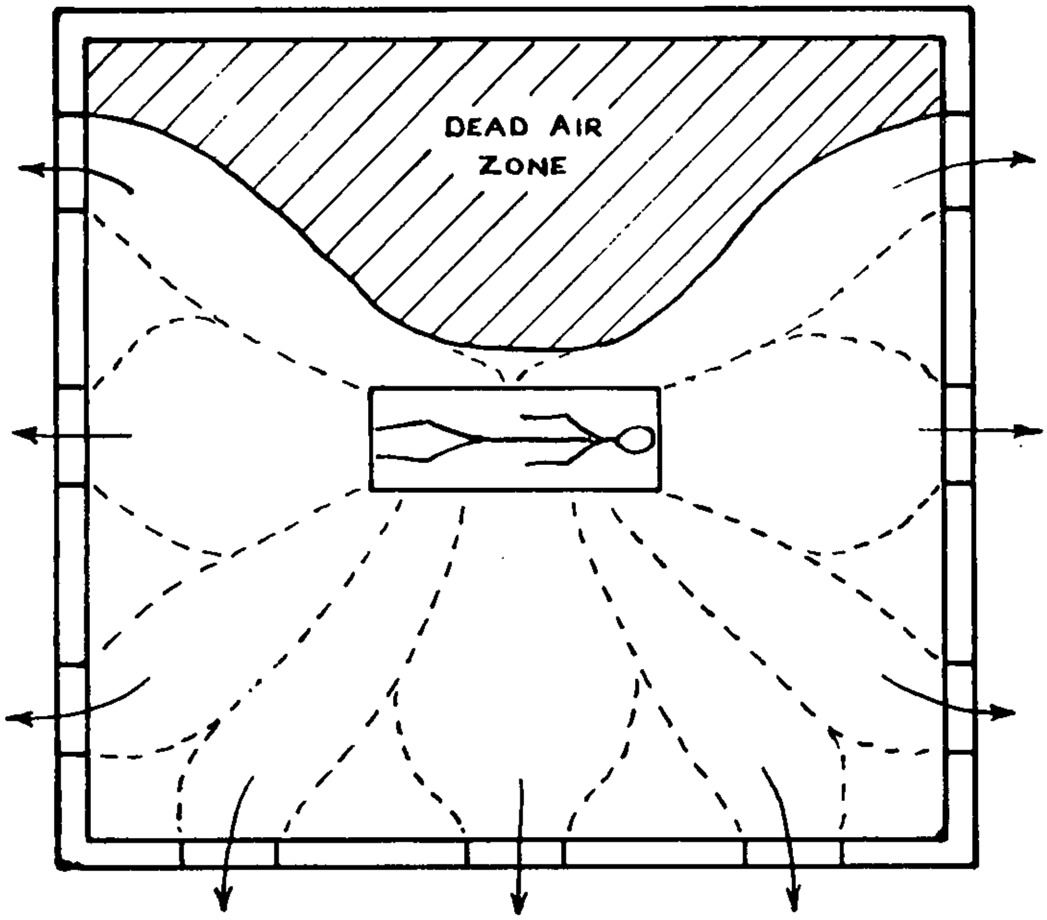


Fig. 1 Effect of extraction in only three walls with overhead air supply

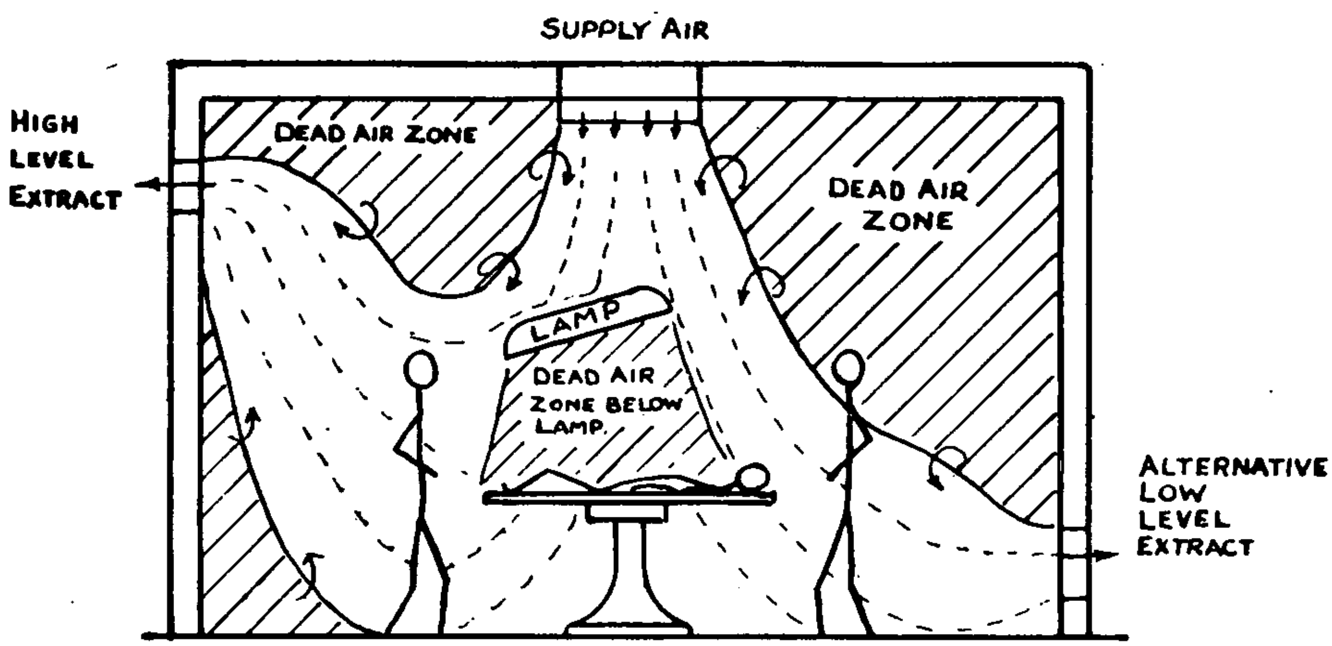


Fig. 2 Obstacles can strongly interfere with the air-flow pattern, and the clean air can be infected by entrainment from dead-air zones before it reaches the patient

temperature within the theatre does not rise above the desired limit; this is why cooling may have to begin when the outside air is at 65°F when the inside conditions are set for 72°F.

In the northernmost parts of the country, heat gains can, in the main, be counteracted by increasing the quantity of air passing into the theatre. Ignoring dehumidification, this eliminates the cost of refrigeration equipment, but does increase the cost of the fan, heater, filters and ducting. In southern areas no such saving can be made; refrigeration equipment must form an essential part of any well designed air-conditioning system.

'Air conditioning' is a much abused term. Some people speak about an air-conditioned room when they only have a fan fitted in a window. If we take matters in their correct progression, then opening a window or fitting a fan to replace stale air within a room with fresh air from outside is purely ventilation. If the replacement air is first filtered, then one can say that the air has been 'conditioned' or 'treated' to contain less atmospheric dust, and likewise when the air is heated, humidified, dehumidified or cooled it is further 'conditioned' or 'treated'. To avoid confusion the following classification could, with advantage, be used:

Ventilation: replacement of air from within a room with untreated air from an outside source, by either natural or mechanical means. (Fume and dust extraction would, very broadly, also come under this classification.)

Air treatment: this would denote that the replacement air is to be filtered only, or filtered and heated.

Air conditioning: the air may be filtered, heated, humidified or dehumidified, and cooled.

Full air conditioning: the supply air would be conditioned as under the previous heading, with the addition of an extract system. The whole would be fully automated so that any preset room condition would be automatically maintained irrespective of outside atmospheric conditions.

Old traditions (and systems) die hard, but it is becoming increasingly apparent that hospital authorities are appreciating the definite need of full air-conditioning for operating theatres. As an example of this thinking, Barnet General Hospital now has a most up-to-date full air-conditioning system serving the orthopaedic operating theatre.

When the existing air-treatment plant began to malfunction owing to certain main items of plant requiring replacement, and bearing in mind complaints which had been received about the environmental working conditions for the theatre staff, particularly in the summer months, the group engineer decided that the time had arrived when the question of full air conditioning must be seriously considered.

Of the firms tendering, Fan Application & Engineering Ltd. [now Myron (Air Conditioning) Ltd.] was successful in securing the contract, and at various meetings with the group engineer the final design was agreed. Various problems had to be overcome, paramount of which were particular difficulties with the building construction and layout.. As a result of these, the ideal wall-to-wall airflow pattern could not be used, and an alternative method, creating a similar pattern, was employed (see Fig. 3).

Air-flow pattern

Discharge grilles with blades adjustable for both horizontal and vertical throw were installed high up in one end wall. The blades were adjusted so that the discharged

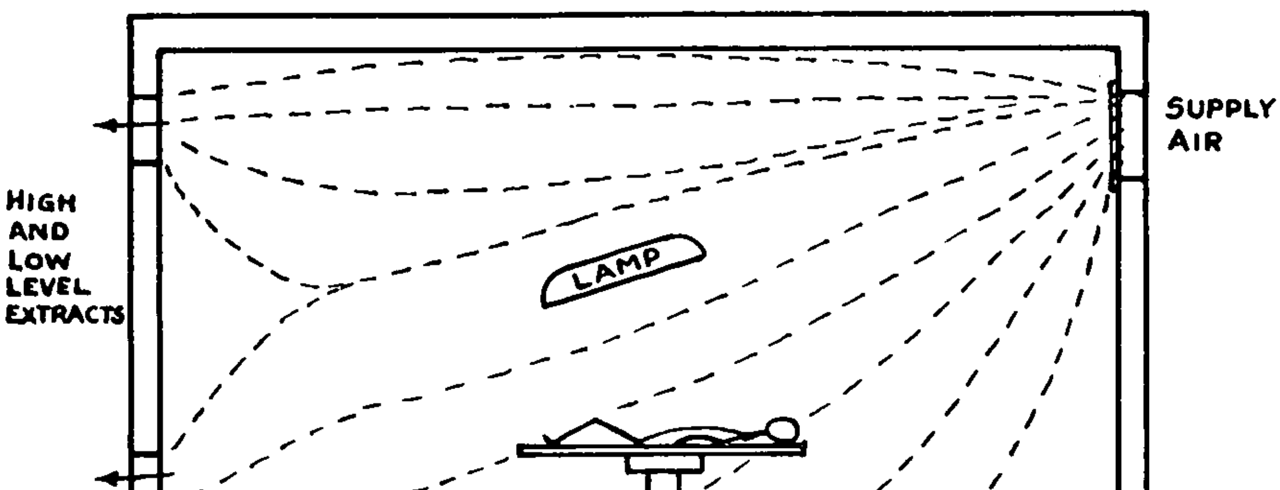


Fig. 3 Wall-to-wall downward air-flow pattern created at Barnet

air streams diverged and, midway between the grille and the operating table, occupied the whole cross-sectional area of the theatre. The air then passed over the operating table in a slightly downward direction with the minimum of turbulence. At the far end of the theatre extraction grilles were set, and connected by ducting to an extract fan. The larger grilles, at low level, extracted 60% of the equivalent supply volume, and the smaller grilles at high level extracted 20%. Thus, with the total extract at 80%, the theatre was pressurised, so that the excess air leaked outwards from the theatre.

The larger extract grilles were fitted low down to maintain the slightly downward flow pattern of the air past the operating table, so that any liberated bacteria would be carried downward towards the extract, and, apart from tubulence caused by staff or objects, could not return to the higher table level. The smaller high-level extract grilles maintained a semihorizontal air flow higher above the table to eliminate turbulence and remove the air warmed by various heat sources.

Air filters

In order to arrest the bacteria-carrying dust particles, main filters of the Vokes ' Absolute ' type were employed. The ones chosen had an efficiency of 99·995% on sodium-chloride test and were capable of operating at up to 100% r.h. To obtain the maximum life from the absolute filters, Vokes ' Super Vee ' prefilters, having an efficiency of 96%, were fitted.

Heating

The system was fitted with a steam-operated air-heater battery which could fulfill all winter heating demands, and therefore the existing panel-type heating system became redundant. It was not, however, disconnected, but merely shut off, as it could then still be operational for emergency use.

Humidity

To provide the moisture to increase the relative humidity of the supply air the Armstrong ' Dry steam humidifier ' was used. This injects completely sterile dry steam into the air stream, with the result that the moisture is rapidly absorbed, and no drop in air temperature, as would happen with a spinning-disc type using cold water, occurs. Other problems, such as scale in the evaporative-pan types, are also eliminated. The quantity of moisture injected is controlled by a fully modulating motorised valve fitted to the unit.

Cooling

The air-cooling equipment is of the direct-expansion type, and consists of a compressor, cooling coil, evaporator and controls. The compressor is of the semi-hermetic-sealed type with antivibration spring mountings fitted onto a concrete plinth, which is itself seated on a rubberised cork insulation pad to eliminate the possibility of any vibration being transmitted to the building structure.

The cooling coil is a normal refrigeration unit, and the evaporator is air-cooled with two cooling fans. As quiet is very important, the cooling fans are arranged to reduce speed at the lower cooling loads; hence for most of the time they are running at 50–75% of their full speed.

Controls

The complete system is controlled by Billman Electromation automatic controls. The heart of the system is the ' Ventonik ' electronic controller, essentially a Wheatstone bridge, which is capable of detecting quite small changes in temperature and humidity. Acting upon the measured information the controller will automatically reset various controls until the preset conditions are attained.

The detecting elements are located in the operating theatre, and comprise variable potentiometers so that, within a range of 65–75°F d.b. and 55–70% r.h., any conditions can be preset.

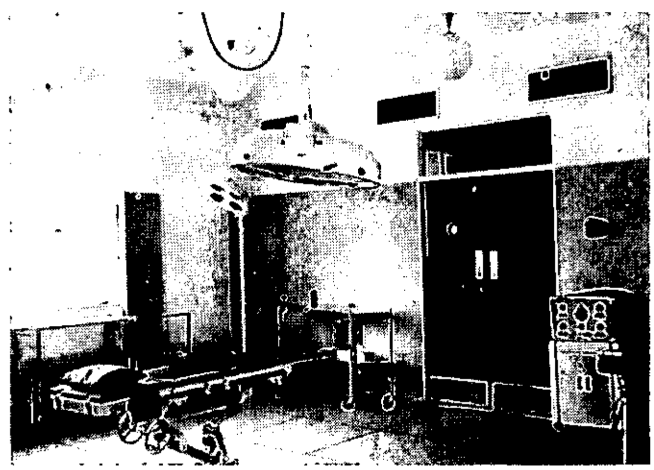


Fig. 4 Interior of the operating theatre, showing the high-level air-supply grilles

The extract fans are electrically interconnected with the supply fan so that they cannot be operated on their own, as this would create a pressure depression within the theatre and air would be drawn in from adjoining rooms.

There are just two push buttons in the theatre: ' start ' and ' stop '. On operating the start button all items of equipment operate fully automatically. A duplicate set of buttons are provided in the plant room, with manual changeover switches, so that in an emergency the system can be operated by hand.

Noise attenuation

To keep the noise level in the theatre to a minimum, the whole of the air-supply ducting was internally lined with acoustic material (it was also externally lagged to prevent heat losses or gains to the air carried). The extract ducting was lined internally with acoustic material only. All items of plant were fitted with antivibration mountings to prevent any mechanical disturbance from being transmitted to the building structure.

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Applicants must have completed an apprenticeship in mechanical or electrical engineering, or have a thorough practical training, be experienced in management of mechanical and electrical engineering plant, in control of maintenance and operational staff, in preparation of maintenance estimates and reports, and in carrying out directly or by contract, small works of engineering construction or renewal.

Applicants should have one of:

- HNC or HND in electrical or mechanical engineering (preferably electrical) with appropriate endorsement in mechanical engineering, and preferably with endorsement in industrial organisation and management
- City & Guilds mechanical engineering technicians Full Technological Certificate (Part III) which must include plant maintenance and works service.

Persons with suitable experience who do not possess the full qualifications also considered.

Salary on scale commencing at £1734 rising to maximum of £2037 per annum, plus allowance of £153 per annum for special responsibilities and London weighting of £90 per annum. (A 10% allowance is paid for additional overtime duties.)

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WYTHENSHAWE AND NORTH CHESHIRE HMC

Assistant engineer required at Baguley and Wythenshawe Hospitals (one site) to assist hospital engineer in operation and maintenance of hospital engineering services. Initially he will be required to assist in commissioning and setting up a planned - preventive - maintenance scheme for a new hospital.

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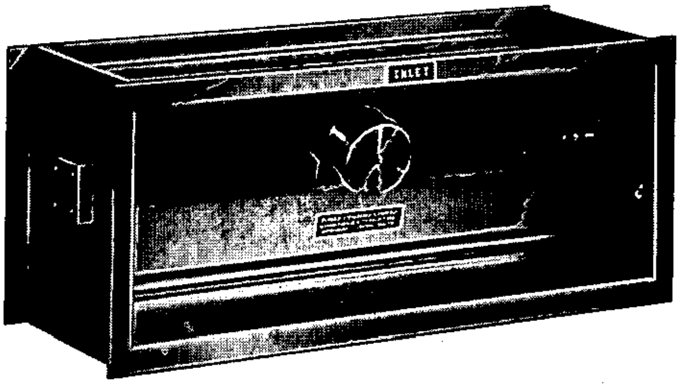

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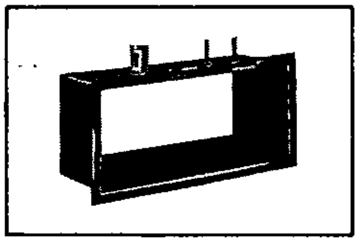

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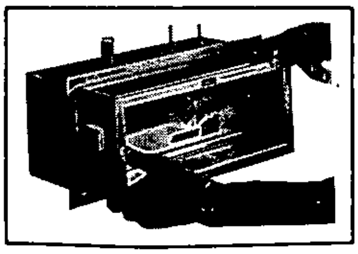

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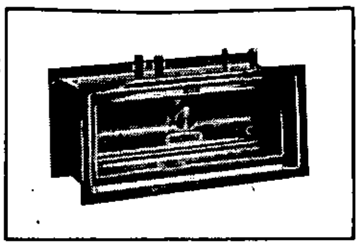

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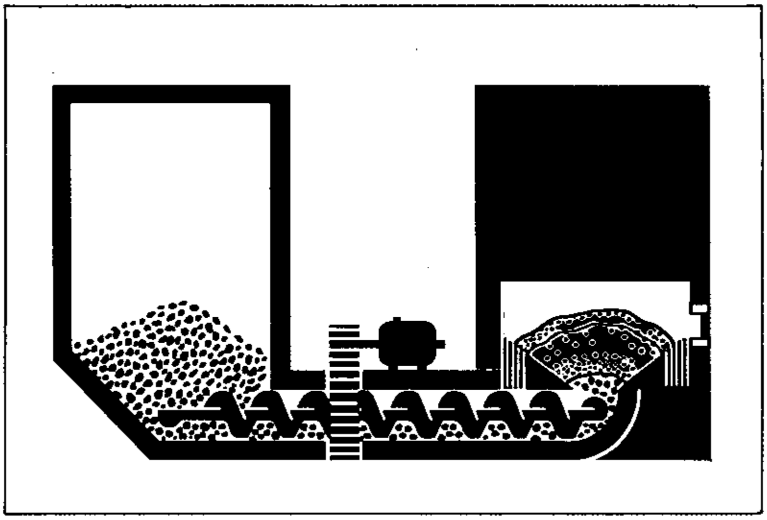
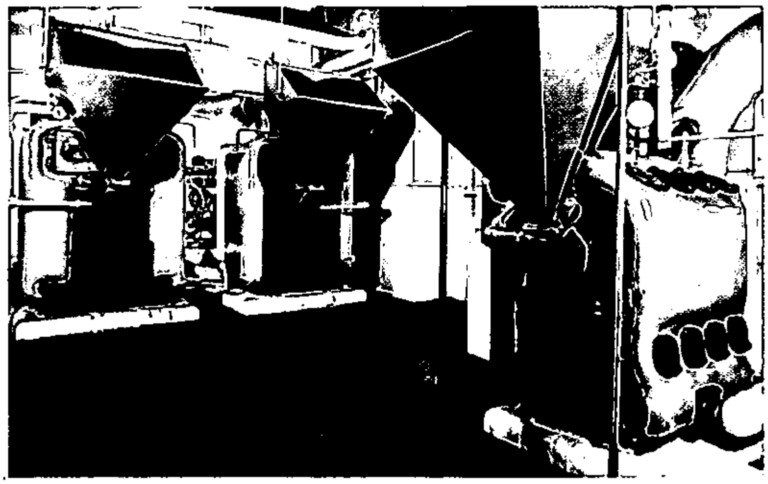


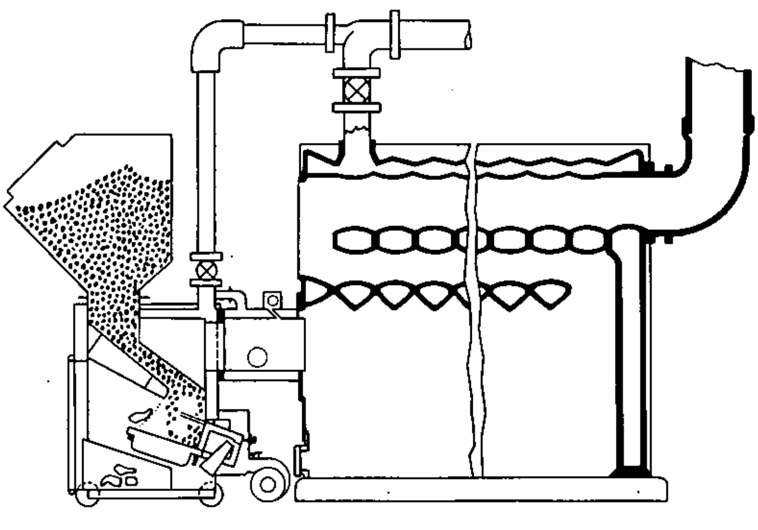
Underfeed Stoker

This method feeds fuel to the firebed from below, enabling the cheapest variety of bituminous coal to be burned smokelessly. The volatile gases which are released pass through the incandescent firebed and are almost totally consumed to give maximum heat with minimum smoke emission. A secondary air supply can be introduced over the firebed to make doubly certain of smokeless combustion, which has the added advantage of allowing a wider range of coal to be burned. Automatic controls ensure the regulation of hot water flow and automatically operate the underfeed stoker thus controlling combustion and the rate of coal feed from the bunker to the boiler. Hence minimum labour.

Earleymil Gravity Feed

The Earleymil unit consists of a fuel hopper, a feed tube, a conical water-cooled firebed through which primary air is supplied, and a secondary air supply ring at the crown of the firebed. The hopper holds fuel for up to 24 hours combustion —or more, according to heat demanded. Fuel is automatically fed to the firebed, where almost complete combustion takes place, leaving only a small quantity of clinker for removal. This, and hopper refilling, take only a few minutes a day. For boilerhouses with three or more boilers, Earleymil have an automatic system for delivering fuel to the hopper.





Trianco Pre-burner

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Coke-to-coal conversion solved the fuel cost problem for Ingersoll

Millions of people all over the world rely on Ingersoll watches and clocks for accurate time-keeping. The attractiveness of their design is another important factor in their popularity. The international reputation of this long-established company for accuracy and reliability in time-keeping is well-deserved. It also carries right through their production processes.

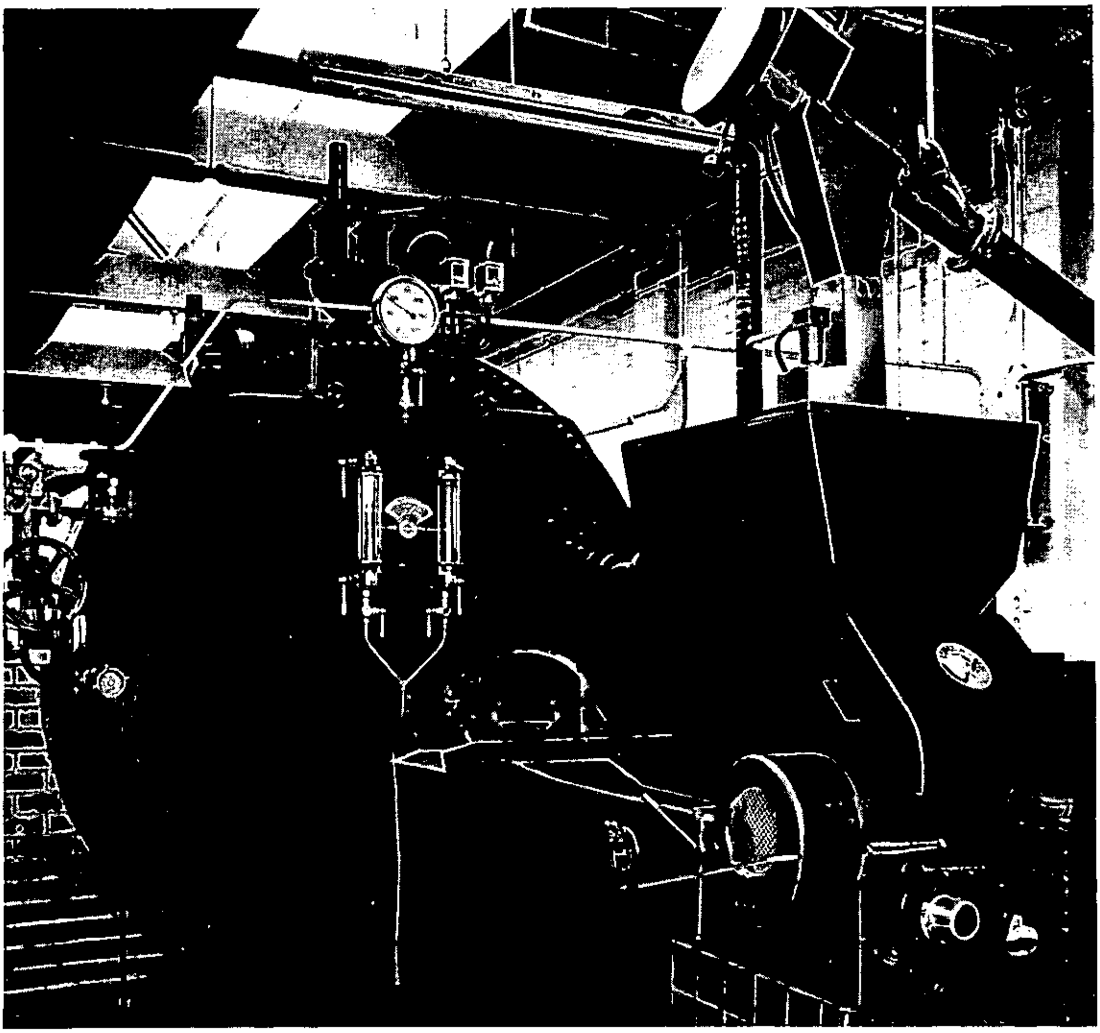
Five years ago, Ingersoll decided that the boilerhouse at their plant in North London was not ticking over as precisely as it should be. The hand-fired coke boilers gave only 40% thermal efficiency. Fuel bills were around £1,300 a year, with labour costs on top of that. The Works Manager called for estimates for new boiler systems using oil and gas.

He didn't consider coal until he was invited by one of the local team of NCB fuel technologists to see a modern coal-fired plant in action. The cleanliness and automatic operation impressed him so much that he asked for an estimate to weigh against the others he was getting. It proved to be lower, in both capital and running costs, and coal got the vote.

A new Potterton boiler was installed, with the practical help of NCB experts – a cast-iron sectional design with a special convection heating surface and built-in induced draught fan. Coal handling, feeding and firing are automatically controlled. Underfeed stoking ensures smokeless burning that complies fully with the Clean Air Act.

The efficiency of Ingersoll's new boiler averages 80% – exactly double what their coke-fired plant produced, and after five years of trouble-free operation, annual fuel costs are down by over £600. And that includes an additional winter load of 500,000 Btu/hr to provide the works canteen with continuous hot water!

y for Britain's Hospitals.



AT KETTERING
Hospital eliminates smoke nuisance—with coal

The Oxford Regional Hospital Board approached the NCB Technical Service with a problem – how to eliminate heavy smoke from the chimney of the St. Mary's Hospital boiler-house, Kettering. A look at the two Lancashire boilers used to produce steam for the laundry and kitchen found the cause – large coal being hand-stoked. The answer was a 5-pass unit conversion for the larger boiler, to be mechanically-fired by a hopper type underfeed stoker.

A 40-ton vertical coal storage silo sited adjacent to the boilerhouse, to be filled pneumatically, was also recommended, together with a heavy duty spiral coal elevator to transfer the coal from the silo into the stoker hopper under automatic controls.

The recommendations were accepted and the improvements carried out. Now, with the use of South Leicestershire Washed Singles and the highly efficient delivery, storage and feeding of the fuel to the boilers, the laundry and kitchen requirements are supplied satisfactorily from the one much-improved boiler, and savings made in fuel costs and labour.

Most importantly, the smoke emission has been eliminated to the satisfaction of the local Public Health Inspector.

These facts prove it, Coal saves money

AT BOURNE
Coal the best treatment for hospital heating

A new boiler was installed and commissioned by the Sheffield Regional Hospital Board at St. Peters Hospital, Bourne, Lincs. in 1965 following consultations with the NCB Technical Service. This replaced an existing steam installation, for having closed the hospital laundry, steam was no longer required.

Three new low-pressure hot water boilers were installed, two Potterton MEG cast iron sectional boilers type MU7-KR7 each rated at 1,240,000 Btu/h. and one Potterton MEG type MU5-KR4 rated at 720,000 Btu/h.

These boilers, under normal conditions, are capable of operating efficiency at excess of 75%—giving greater economy in fuel consumption. All three units are fired by Riley 'Direkto' bunker type underfeed mechanical stokers, and the coal (Washed Singles) is delivered pneumatically into the 50-ton bunker, cutting labour costs considerably.

For economy and efficiency, the Sheffield Regional Hospital Board have discovered that they were right to choose coal for St. Peters, where – as with many consumers large and small – it will continue to be used for years to come.

Ingersoll
keep things ticking
with Coal