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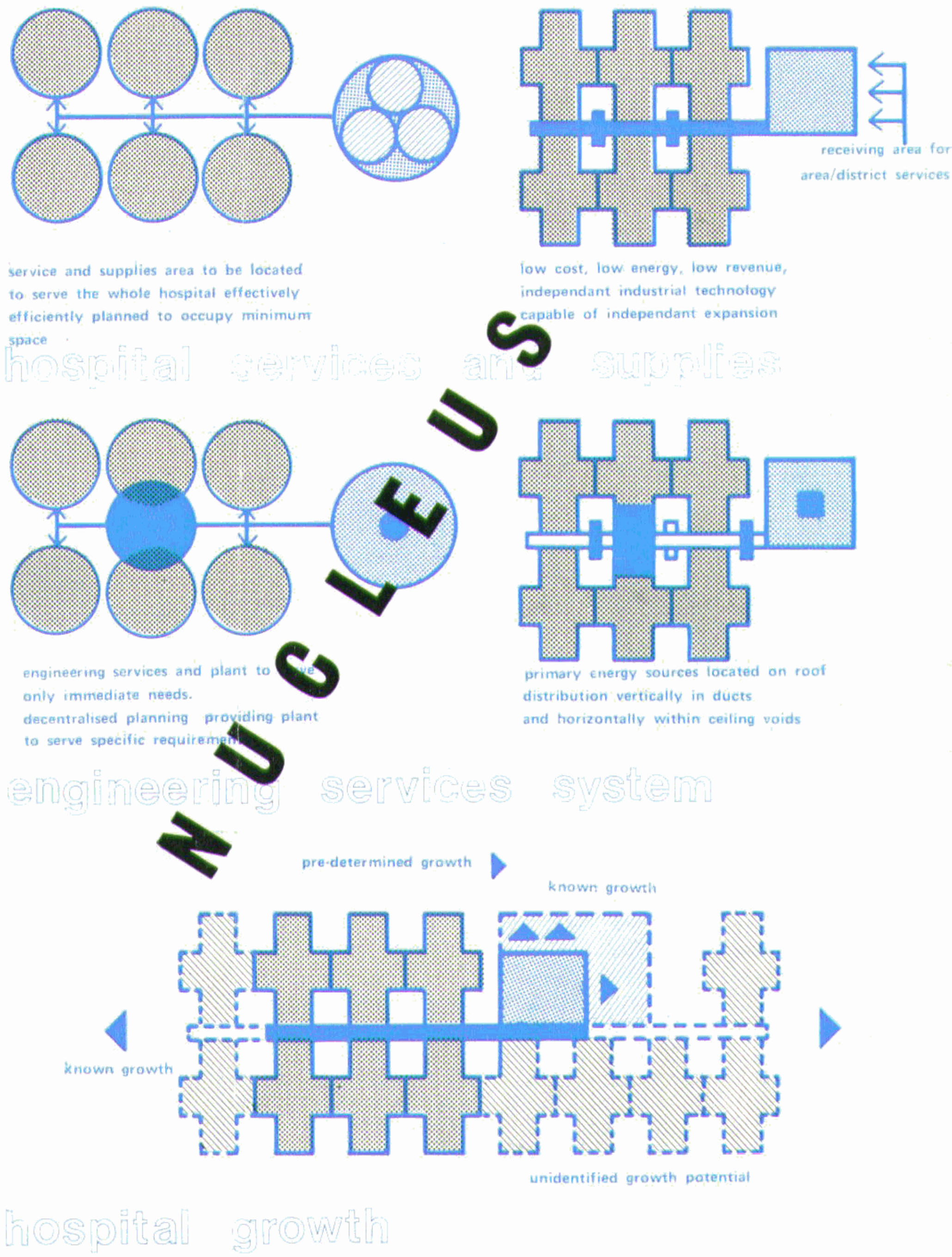

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Contents

Special features

News features

Departments

Front cover: An illustration of the design strategy for nucleus hospitals (from a paper by the Architects Division of the DHSS)

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No. 17

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Hospital Engineering

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Nucleus Hospitals

A statement from Dr David Owen, Minister of State for Health

In recent months there has been some controversy over the Government's plans for building new hospitals. We reproduce here the text of a speech given by Dr. Owen to the Medical Practitioners' Union (ASTMS) on Community Hospitals on the 6th December 1975.

The general and acute hospital services account for about 40% of total health and personal social services revenue expenditure and are therefore by far the largest element in expenditure terms of health and personal social services as a whole. These services include all specialist services, other than maternity services, and those provided specifically for the elderly, the chronic sick and the mentally ill and the mentally handicapped. The services are mainly hospital based but include specialist services provided outside hospitals. There has been a considerable increase in the use of most of the services as measured by the number of patients who have been treated between 1970 and 1973: hospital discharges up by 3½% and out-patient attendances by about 4%. This increase in demand was considerably larger than the increase in the population as a whole, which was about 1%. During that same period there was an increase in the cost of the acute services of about 9% at constant prices. There was an increase in the number of doctors and hospital dentists by 13% and in the number of nurses estimated to be working in this sector by 10%. Nevertheless, during that same period, there was a decrease in the number of in-patient beds by something under 2%. There has been a decrease during this period in the average length of in-patient stay by about 7½% and an increase in the average cost of treatment per in-patient of 6%.

It must, however, be stressed that since 1973 hospital costs have, if anything, risen more sharply. There has been a quite unprecedented increase in relative salaries for most of the health-service workers during the fiscal year 1974/75. There has been a growing tendency for more health-care workers to be paid realistic overtime rates in comparison with other industrial workers and there has been a tendency amongst doctors, whether consultants or junior hospital doctors, to demand new contracts reflecting an industrial wage structure rather than a professional wage structure. Wages and salaries in the hospital and community health services rose by 43% between November 1973 and November 1974, compared with a rise of 26% in all earnings. For example, since April 1974, an average nurse's income has risen by 60%. This increase in the remuneration of health-care workers was long overdue. In the past one of the reasons why the National Health Service, in most international comparisons, has been able to get away with paying a lower percentage of the gross national product to health and yet achieve a relatively high standard of health care was the low level of wages we were paying. In 1974/75, as a deliberate act of policy, and mainly because of a decision to give the pay of health-care workers the first call on extra resources, the percentage of the gross national product devoted to the NHS rose from the average 4·9% of the previous two years to 5·4%. This was the largest increase ever recorded in health service expenditure in any one year, and 5·4% of the g.n.p. represents the highest percentage ever devoted to the health service.

The total expected health and personal social services expenditure in 1975/76 is £5447 million. The largest proportion of the health budget (69%, or some £3143 million) is accounted for by current expenditure on hospitals. If we look at the split of the 1975/76 budget it reads as follows:

Hospital and community health services doctors and dentists pay	6%

Hospital and community health services nurses pay	17%
Hospital and community health services ancillaries pay	18%
Hospital and community health services other expenditure	18%
Family practitioner services	15%
Personal and social services expenditure	13%
All capital expenditure	10%
Other health services including central and miscellaneous expenses	3%

It must, however, be stressed that in 1974 and 1975, although these were years that there was a substantial increase in revenue expenditure, even allowing for inflation, it was a period of severe capital restriction in the health service. In December 1973 the then Chancellor *announced a 20% cut in capital expenditure for the* forthcoming year 1974/75 and for future years. If such a cutback had been continued in 1975/76 it would have meant a virtual moratorium on all new hospital starts for at least two and probably three years. Although having the virtue of simplicity, it would have had a devastating and unacceptable effect on the future. The present Government felt it very important to ease the position and was able to find some new capital resources. Effectively, the cut in the health building programme was reduced to 17% in 1975/76. The number of new hospital major projects started in 1974/75 and 1975/76 were 22 and 14, respectively. The personal social services have also been cut back. In 1976/77, faced by a £40 million overspend on revenue and to preserve services, it has been necessary to make an additional £20 million cut in capital. One consequence of sharply reducing the forward capital building programme has been to put at risk the whole movement towards greater care in the community. It also increases the demands made on existing buildings in terms of maintenance costs and means that more money has to be spent on old buildings, which had previously been left to deteriorate because of promised new capital buildings. This switch from capital to revenue necessary to maintain the essential revenue to fund existing levels of services in the Health Service and personal social services has, however, now reached a level which is rightly causing concern.

There is no prospect in the next three to four years of any substantial injection of extra money into capital building. Indeed the capital building programme for these years will be at a level substantially lower than that obtaining in the preceding few years. I am sure we must continue to give the utmost priority to the expansion of the medical-student intake, but this inevitably then means that capital for pressing service needs will be further reduced if we are to give priority to teaching-hospital projects whose service priority may not be the highest in their region. The Government has already taken some very tough decisions affecting teaching hospitals. In London, St. Mary's Hospital, Paddington, which had a forward capital rebuilding programme over the next 10 years of some £60 million has had to be postponed. Many other teaching hospitals —the London, Charing Cross—all have desirable building programmes, but where they are not absolutely linked to medical-student expansion they have had to face postponement. Outside London, the Northern General Teaching Hospital at Sheffield and the Leeds General Infirmary have suffered. We have continued to give priority to the planned build up of the new medical schools at Southampton, Leicester and Nottingham.

The National Health Service has an appalling legacy of old buildings. Roughly half of our schools in Britain and nearly half of our housing has been built since 1948, but less than a quarter of our hospitals have been built since 1948. 48% of the hospitals in England and Wales have been built before 1918, some 6·5% before 1850, whereas only 16% of secondary schools and 42% of primary schools in England and Wales were built prior to 1918. Capital restriction, which is being felt in all areas of public expenditure, poses serious problems for the health service and in no field is this more clearly demonstrated than in the future hospital building programme. There is still a large gap in trends of relative deprivation between North and South in Health Service buildings. The regional inequalities of provision that have been allowed to continue since 1945 are well known. This Government has already started a systematic attempt to allocate resources on the basis of need. The recent report of the Resource Allocation Working Party is an important development in trying to provide objective criteria for allocating resources within the NHS.

Poor primary-care facilities

We do, of course, also face the problem that hospital provision in the inner parts of our big cities exceeds that required to serve the declining population in these areas. Nowehere is this more true than in London. But, at the same time, we must recognise that primary care facilities in these areas are relatively poor. We therefore need to ensure that the hospital stock in our cities is used efficiently in the light of changes of this sort.

For 10 years after the creation of the National Health Service there was virtually no new hospital building in Britain. The hospital plan of 1962 (Cmnd. 1604) envisaged that the number of beds in new district general hospitals would normally be between 600 and 800 and serve a population of 10 000 to 150 000. A ratio of 3·3 acute beds per thousand total population was proposed. The hospital plan of 1966 (Cmnd. 3000) made no change in bed ratios and largely reiterated the earlier hospital plan, although it admitted that the closure of many hospitals would be delayed longer than had previously been foreshadowed although they might be retained for different purposes.

Currently, the ratio of acute beds per thousand of population requires justification for more than 2·5 plus 0·3 for regional specialties, yet the best-buy hospitals at Frimley and Bury St. Edmunds were planned on a ratio of 2 per thousand. In 1969, the Committee of the Central Health Services Council on 'The Functions of the District General Hospital' (the Bonham Carter Committee as it came to be called) recommended that there should be a complete integration of the psychiatric and geriatric services in the d.g.h. It recommended that d.g.h.s should normally serve a population of between 200 and 300 000, and that this implied a d.g.h. of between 1200 and 1800 beds. The prime reason for choosing a district general size of 1200 to 1800 beds was the Bonham Carter Committee's view that these hospitals should be planned around teams of not less than two consultants in each of the major in-patient specialties with all their in-patients at the one d.g.h. This has since been considered to be a very narrow base on which to determine the size of hospitals and anyhow has been changed since 1969 by the planned increase in the number of consultants.

Public opinion does not always have the same priorities as health-service planners. The concept of the very large district general hospital has been increasingly, and in my view rightly, criticised. Large hospitals frequently have to be sited on the outskirts of towns and cities and are difficult to reach by public transport. There has been criticism about large hospitals because of their impersonal institutional nature for both staff and patients. Even economists have not been convinced by the arguments relating to economies of scale, some people claiming there are certain diseconomies of scale which operate in large hospitals. In 1970/71 the DHSS decided to conduct operational research on the optimum size of district general hospitals. Its finding have not yet been published but the study points clearly to a smaller size range of district general hospitals than was foreseen in the Bonham Carter report. The Department in 1970/71 anticipated to some extent these findings and asked regional health authorities not to plan d.g.h.s larger than 750 to 1100 beds and said that this size was only to be exceeded in special cases. In August 1974 a guidance memorandum on the role and the concept of the community hospital was published. Yet hospital design in 1974 began to be influenced by stronger factors than the conceptual wish to bring hospital size down from the massive hospitals; increasingly the main determinant was becoming one of financial restriction. From December 1973 onwards, when severe financial capital restraint was imposed on the health-service building programme, it became obvious that capital projects which could not be split up into phases and involved sums of £12 million and above would seriously distort future hospital building programmes. Yet the best-buy hospital of 600 beds was designed to be built all in one phase and its total cost would now be over £10 million. The Harness design for large hospitals could be built in phases, but hospitals of this size could not possibly be justified in the financial climate following the December 1973 cuts and had to be abandoned. Harness has been an expensive project although there has been some valuable spinoff from the programme.

The plain fact was that the hospital building programme in 1972/73, like so much of public expenditure in this country at that time, was completely out of control. Even if Britain had been able to sustain its then rate of economic expansion, the forward planning of hospitals was completely unrealistic. There was hardly a town of any size or city in the country that was not encouraged to believe that a new district general hospital was soon to be built. Hospital planning in the early 1970s was bedevilled by optimism, wholly unjustified optimism in terms of the track record of British economic history and in terms of future demands that would inevitably arise within the health service. It was quite unrealistic to continue to plan forward for the health service without recognising the marked imbalance that was occurring between the priority given to hospital-staff remuneration as against the increased hospital-staff manpower projections and the capital building programme. The decision to pay hospital staff more reasonable rates meant that the capital building programme with its revenue consequences obviously had to be restrained.

In the absence of steady growth and the presence of high inflation, capital restriction will be greater than anyone would wish over the next few years. I fully accept, albeit reluctantly, the over-riding need for public expenditure constraint over the next few years. But those who publicly advocate swingeing cuts rarely face up to their consequences, either in terms of creating unemployment or their effect on services to the community. It is now my sad duty to tour the country telling numerous people that their much needed and much desired district general hospital cannot be built. It is also my sad lot to inspect large holes in the ground where a new hospital was hoped to be built and to write-off very large sums of money spent in consulting fees and staff effort designing hospitals which will never leave the drawing boards. The Public Accounts Committee has also made a number of criticisms of past hospital projects. We must now face up to the future and some very difficult choices will have to be made.

Realistic planning

We must all learn from this period. We must never again in future plan on the basis of optimism; we must plan instead on the basis of realism. It is better in terms of morale and the wise use of scarce resources to be able to expand a sensible and realistic hospital building programme within the capacity of the building industry than to be forced to contract quickly an over-optimistic programme. We need a new attitude to hospital design. The health service in many areas has not achieved sufficient benefits from being a national centralised service. Nowhere is this more obvious than in hospital design. Up and down the country, regional health authorities have been designing their own one-off hospitals. The best-buy is a notable exception.

The first thing that will have to be accepted is that large district general hospitals built in one phase are no longer a feasible policy. We need to plan our future hospital development on the basis of making essential provision for acute services in a way that will not prejudge the eventual size of the district general hospital. Fashions change: what is the conventional wisdom today may not be the wisdom of tomorrow. By building for the essential, not the desirable, number of beds one can spread the limited capital resources and start more new hospital developments.

The community-hospital concept offers a way of meeting many of the wishes that have often been expressed about hospitals by patients and consumers generally. Most patients or their relatives would like hospitals to be as local as possible. The old hospital in the centre of a large city or town is often the most convenient for patients and relatives. However, since it is almost always cheaper to build a new hospital on a green field site, the temptation is to close the inner city hospital and plan the large hospital on the outskirts of the town or city. If we decide to build, at least initially, a small, acute hospital on the outskirts of the city and cannot afford to embark on a large hospital, then the opportunity of retaining the inner city hospital need not be a cause for despair. The problem is that while we know what we want of a community hospital in a rural environment, there is nowhere near the same consensus of opinion as to what is expected or wanted of a community hospital in an urban environment.

A strong commitment already exists amongst g.p.s in a rural environment to work within the present cottage hospitals, which I hope will be transferred to the community hospital. It is easy to assume that there is no such commitment amongst urban g.p.s. Yet there is no evidence that they are any more reluctant to work in community hospitals than their rural counterparts, and indeed may well find it a satisfying addition to their general practice. There is also clearly a danger that geriatric provision, being a very large part of the community hospital, may alter basic attitudes towards a community hospital. A lot will therefore depend on the extent of the rehabilitation services offered in the hospital. If community hospitals are not to become long-stay geriatric hospitals under another name, then they must be given, right from the outset, proper facilities for rehabilitation. They must feel that they are an active part of total hospital provision in the acute sector, not just the long-stay sector. This means frequent contact and interchange between staff at every level. Of course this means incurring the considerable disadvantage of increased travelling time between hospitals. This is certainly one of the major disadvantages of choosing small hospitals, and it also carries costs. To reduce such costs, duplication needs to be cut to the minimum. Smaller hospitals also require a greater flexibility over patient transfer. Whereas, traditionally, we tend to think of a hospital as being a place where one goes when one is acutely ill, where one is diagnosed and where one stays until one is better. In future, we may well need a fundamental rethink of how we conduct hospital practice. Just as we have been forced to concentrate and rationalise accident and emergency services, so we may have to develop a more formalised system of acute diagnosis and acute care in one hospital followed by transfer to a community hospital. One advantage may mean one being transferred closer to one's relatives and ensure easier visiting, but the community hospital must be able to give active rehabilitation and convalescence. Such a policy would mean a more active hospital in that there would be movement of patients in and out of the community hospital. It would, of course, have the disadvantage of a continuity of care and the problems for both patient and doctor that can come with this should not be underestimated. A dynamic active community hospital, albeit not having expensive diagnostic equipment and, for example, piped oxygen to every bed, can still provide a stimulating therapeutic environment.

The size of community hospitals will normally be expected to be between 50 to 150 beds for a population of from 30 000 to 100 000. But the Department has no intention of setting rigid limits to the size of community hospitals. They must be allowed to develop flexibly, and particularly so in urban areas. I think it is too early to form any definite view of size or of scope. Similarly I do not think it is possible to predict the exact mix. What is important is that we should hold on to the concept of the community hospital as being an active hospital closely integrated with other acute hospitals in the district and forming part of a district-general-hospital complex. Instead of the large district general hospital, we are being forced, by financial and other restraints, to plan for a d.g.h. complex using a number of hospitals to cover many district needs. They must, however, be planned as a cohesive whole and their development must be seen as being complementary to each other. As we develop a challenging task for the community hospitals, it is clearly necessary to think afresh the role of the acute hospital. The new nucleus hospital design offers an opportunity for such a rethink.

The concept of the nucleus hospital emerged early this year and is now being quickly developed. Its basis is that one makes no definite decision on the eventual size of a hospital. The start is a standardised, but flexible, basic hospital design for around 300 beds at a cost, from May 1975 prices, no higher than £6 million. It will be the first phase of a district general hospital which could develop to, say, 600 or very exceptionally 900 beds. There will be a choice, but a limited choice, of content. In most cases it will contain accident and emergency services. It is a hospital that is specifically designed to be built in phases that are also flexible in content. This change of design ethos reflects a necessary change in attitude to the way such a hospital can be used. Not only should it be a hospital primarily focusing on acute services, it must also be a hospital that is used intensively. In this way, the very high capital equipment and revenue costs of 24 hours a day, seven days a week cover can be concentrated and justified. Intensive diagnosis and intensive care will mean a high turnover, but all the evidence shows that higher bed utilisation is an obvious area for economy. Bed-utilisation figures already show extraordinary variations between different consultants, different specialties, different hospitals and different areas and regions.

First nucleus hospital

A nucleus hospital with 300 beds used intensively should provide a much greater service than would normally be provided by a hospital of this size, if it was complemented by other hospitals, such as community hospitals or small general hospitals within the district. We may, for example, have to adapt an existing well-situated small hospital to form a psychiatric unit away from the nucleus hospital, but clearly related to it.

The first nucleus hospital will be at Newham and this was announced in the summer. Site preparations at Newham are expected to start in 1975/76, with the main building contract to start in the autumn of 1977. At the moment the Department thinks it will be able to offer a nucleus design which other regions could plan on starting in the financial year 1978/79. A great deal of effort is being made to try and bring this forward to allow a start date in the year 1977/78. A lot will depend on the enthusiasm of Regions up and down the country for nucleus and on our joint ability to ensure that the results of the detailed design effort are made available for use by all regional design teams, for this could cut time and save money. I am well aware that regional works staff face difficult times. It is not easy to see all their efforts on designing hospitals scrapped. I am determined to ensure that in the next few years we use their expertise and design capacity to the full and before any Region uses outside consultants they should first check that there is not available capacity within the NHS. Even if this capacity is outside their own region, in many cases it should be possible to make sensible arrangements to share the workload between them.

We must realise as a country that we face make and mend years. The desirable will not always be obtainable. In designing for the ideal hospital we can, and often have, missed the opportunity to make any new provisions at all. Complete standardisation has never been very popular with professionals and it must be admitted that mistakes have been made. The DHSS does not wish to impose detailed designs. With the 14 regional health authorities we need a genuine partnership to ensure that the department's lead in the design work reaps its full rewards. We need to learn from each other but one thing is certain: we cannot continue as in the past the record speaks for itself. We need a new, more realistic and less ambitious approach.

Institute news

WEST OF SCOTLAND BRANCH

At the meeting on the 30th October 1975 in the offices of the Greater Glasgow Health Board the branch was honoured to have the attendance of J. Hunter who presented a paper entitled 'Coal's contribution to the efficient use of energy'. Mr. Hunter is Head of Technical Services with the Scottish Area of the National Coal Board Marketing Department.

Mr. Hunter began by giving a detailed explanation of the principles behind the concept of fluidised-bed combustion and illustrated this with a short film. He continued with details of the research programme that has taken place in recent years into the subject and listed the various organisations that have been involved. Referring to the advantages of the system, he drew attention to the facility with which such a system can deal with either coal, gas or oil and the additional benefits of sulphur retention of the bed material by the addition of quantities of limestone or dolomite.

The talk continued with details of some recent developments in conventional modern coal-fired industrial boiler plant. This section was supported by colour slides. Some examples of these developments included a system of ash extraction from a boiler with an underfeed stoker, whereby the boiler might run for up to five days without attendance and a system of electrical ignition for a coal-fired boiler with chain grate stokers.

Mr. Hunter concluded by relating some case histories from the work of the board's technical services in Scotland.

After a short break for coffee the branch chairman Allan Gray invited the audience to present questions to Mr. Hunter. A very lively discussion then ensued with questions dealing with the chemical, metallurgical and mechanical details of fluidised combustion and with various other installations to which Mr. Hunter had referred.

At the Branch meeting held on the 27th November 1975, members were given a talk by James Brown, a senior lecturer specialising in dynamics and control, with the Department of Mechanical Engineering of the University of Strathclyde.

Dr. Brown's talk was entitled 'Recent developments in measurement and control'. He began by dealing with the basic primary elements of temperature and pressure measurement such as direct volume/pressure systems and bridge circuits and developed the theme to cover modern transducer technology.

Attention was drawn to the importance of correct screening of signal leads in high-sensitivity amplifier installations in order to minimise electrical interference. He then outlined the advantages of operational amplifiers and dealt at length with their use. The final section of the talk dealt with the methods of processing and conveying signal information over distances and the recording of the information using pulse-width modulation, f.m. carriers and digital methods using binary code.

WELSH BRANCH

The Institute of Fuel invited members of the Institute of Hospital Engineering to a lecture at the University Hospital of Wales, Cardiff, on the 7th November 1975.

The subject was 'The utilisation of energy in the hospital', and the speakers were R. Kensett, Principal Engineer, WHTSO, and D. Samuels, Fuel Efficiency Officer, WHTSO.

The first part of the paper was presented by Mr. Samuels, who drew attention to the fact that nearly all the nation's energy requirement was obtained from fossil fuels which were irreplacable and being exhausted at an alarming rate. In the past the capital cost of plant was of prime importance and hospitals were no exception to this at the time, but, along with industry, hospital authorities are now very conscious of the need to use fuel economically and efficiently, especially as fuel costs absorb a large part of budgets provided from public funds.

Mr. Samuels then showed a number of colour slides depicting efforts being made in the health service in Wales to bring boiler houses up to high standards.

Mr. Kensett devoted his part of the lecture to the areas where heat is recoverable and the means by which it could be recovered.

Heat sources on which Mr. Kensett provided interesting facts and figures included heat recovered wastes from buildings, absorption refrigeration, heat pipes, heat pumps, solar heating, thermal wheels and total-energy systems.

There followed a short but interesting discussion period, after which the chairman of the Institute of Fuel branch warmly thanked the speakers for their paper and all the supporting facts and figures they had provided.

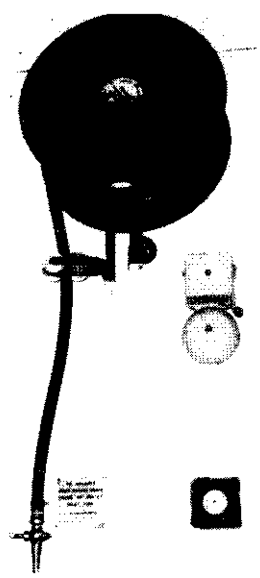
H. H. Provan

We are most sorry to report the death, at the early age of 50, of Mr. Provan after only a short illness. Hugh Provan was a Clerk of Works with the Scottish Health Service Common Service Agency. Prior to this, he had been a Contractor's supervisor and over the years he made a contribution to many health service projects.

R. Wellby

Mr. R. Wellby has retired, on 31st December, 1975.

Mr. Wellby was one of the 'founder members' of the Institute being involved in that very first meeting in Nottingham back in 1943. He has the proud record, too, of 36 years' service at St. Francis Hospital, Haywards Heath.



Fire-alarm systems in hospitals

by
R. B. WHITEHOUSE

Considerable care must be exercised in the siting of smoke/combustion detectors if false alarms are to be avoided. This article gives some guidance on the siting of detectors for use with open-circuit-monitored systems. The terms of reference of some relevant rules and standards, which have led to some confusion in the past, are outlined.

Introduction

It is not surprising, in the present difficult financial situation, to find that considerable thought, and time, are being given to the problem of finding alternative types of fire-alarm systems that provide the facilities required in hospitals, and at the same time effect some economy in the overall cost of installations.

In the past, open-circuit, simple or more sophisticated closed-circuit systems, embodying 'line-fault' monitoring facilities, were able to fulfil the requirements for manual systems, or systems with automatic heat detectors incorporated and these could be provided at a reasonably economical figure. With the introduction of smoke/products-of-combustion detectors over wide areas of hospital premises, the costs of installing the systems mentioned above have increased, since additional conductors are usually required for line-fault-monitoring purposes. This is now resulting in considerable interest being shown in 'open-circuit-monitored systems', which only require two conductors per signal zone.

With systems of this type, any manual contacts, heat detectors, or smoke/combustion detectors in a zone can be incorporated in one parallel circuit, this being fitted with a diode at the farthest point of the wiring. (No spur wiring is permitted on this system.)

One such system employs both 24 V d.c. and 28 V a.c. supplies on the initiating circuits: the end-of-line diode allows one half cycle of the a.c. supply to be passed, maintaining a relay in the indicator/control panel in an energised condition, the other half cycle provides the energy to power any smoke detectors included in the circuit. A break in the external wiring of the initiating circuits gives an audible and visual 'line-break-fault' signal (Fig. 1).

When any contact or detector operates, a circuit is established between the two conductors, the d.c. supply bypasses the end-of-line diode, energising a second relay which gives an audible and visual 'fire' signal. A benefit provided by this relatively inexpensive open-circuit monitored system, which is not provided by simple closed-circuit installations, is that 'short circuits' on the initiating circuit wiring will give a signal; a short circuit having the same effect as the operation of a contact or detector and, although a fire signal is given, it does ensure that no line fault will go undetected.

This system will operate over a direct-voltage range of 22·5 to 30 V, the constant current drain on the battery being only 0·035 A plus 1 mA for each smoke/combustion detector, this rises to approximately 0·2 A (excluding the alarm load and detectors) during alarm conditions. This low d.c. consumption and the use of a.c. for monitoring enables a much smaller battery and charger to be provided than would be required for closed-circuit d.c. systems. In the event of mains failure, the system operates on the 24 V d.c. supply, and only the line-monitoring feature is lost. An audible and visible fault signal is incorporated in the system to cover either an a.c. or d.c. supply failure. The current drain on the battery increases to 0·25 A during the period of mains failure.

All the usual extra facilities for sectionalising the alarm circuits, 2-stage warnings, repeat indicators, etc. can be provided, also an additional unit is available to provide line monitoring on the audible-alarm circuits.

Siting of alarms

Whichever system is selected, great care must be exercised in siting the equipment this applies particularly to automatic smoke detectors. It is a source of embarrassment to the manufacturers and suppliers of fire-alarm systems that, in many cases, requests are made in specifications for smoke detectors to be fitted in locations where false alarms will be certain to occur, or where incorrect siting or excessive heights will place great doubt on their ability to give prompt and early warning of an outbreak.

It is therefore deemed advisable to give some information on this subject.

Table 1

Maximum floor area for each detector	Maximum distance apart between centres		Maximum distance of centres from walls and partitions	
	In general	In corridors	In general	In corridors
93m²	12m	18m	6m	9m

It must be remembered that the correct siting of smoke/combustion detectors is dependent upon many important factors that would not be taken into account if thermal detectors were being used.

The early warning that smoke/combustion detectors are capable of giving is provided by convection currents which are less vigorous than those required to actuate a thermal detector, and they are thus influenced to a greater extent by the normal air currents prevailing in the area to be protected.

Some do's and don't's

(*a*) Ionisation/smoke/products-of-combustion detectors should not be fitted in any area in which the following are likely to be used:
open gas fires or cooking rings
ovens or toasters
electrical switchgear (ionised air particles prevail)
any naked flame or burner
welding equipment
any process which produces dust
Neither should they be fitted (if it can possibly be avoided) in:
garages
kitchens
linen stores (floating lint)
'standby' supply stores (long term) (where dust accumulates)
laundry premises (steam and lint)
roofs with heights exceeding 10·5 m.

(*b*) Take great care, and the advice of the manufacturer, before deciding the cover required in areas where the environmental conditions can change rapidly, e.g. detectors in the proximity of doors and windows, fast-flowing air streams etc.

(*c*) Where flat ceilings are intersected by deep beams, or other architectural features, these will have a considerable bearing on the siting of detectors. An area of ceiling enclosed by beams which is immediately above a fire will have to be filled with combustion gases or smoke before there is any overspill into other compartments of the ceiling, therefore, logically, one smoke detector will be required in each such confined area.

(*d*) Air in the corners of rooms, in the angles between wall and ceiling or beam and ceiling will tend to be static and not so readily affected by air flows, in consequence no detector should be fitted at less than 75 cm from such corners.

(*e*) Pitched or north-light roofs enhance the performance of combustion detectors, since they tend to concentrate the combustion gases along the apex. Each pitched roof bay should be considered as an enclosed area and be provided with at least one detector in the apex. The tendency of pitched roofs is for a 'heat barrier' to be built up in the apex of a greater depth than would be found on a flat ceiling, although processes, or equipment which generate heat can also create an appreciable heat barrier on a flat ceiling. Detectors should therefore be fitted as indicated in Table 2.

(*f*) In rooms which are divided into sections by partitions, storage racks, or stacks of goods, it is necessary to establish if there is free air space above any of these features. If this air space is less than 30 cm it will interrupt the free flow of combustion products to the extent that each partition or rack must be considered as a wall, and a detector should be fitted in each section so formed.

(*g*) Detectors in ventilation plants. This is a feature that should only be included in a specification after discussions with the manufacture of the equipment.

(*h*) When assessing the siting of detectors in dormitory areas or sleeping quarters, it must be borne in mind that the primary function of the system is to protect life. The greatest hazard is therefore likely to occur during the late evening and night. The environment that will exist during this period must be taken into account rather than that which exists during daytime.

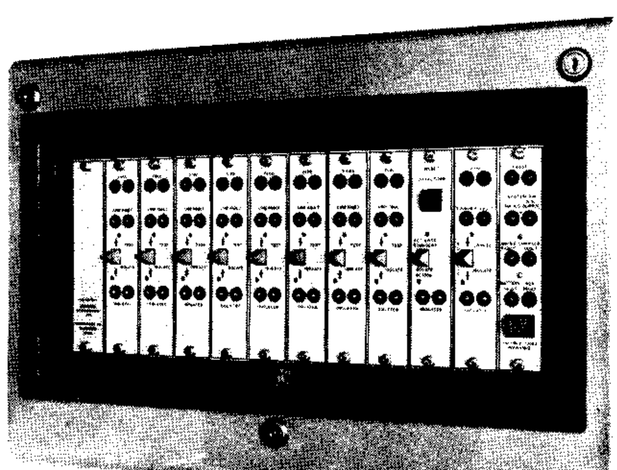
From the above information it will be seen that careful planning and system engineering is essential if undue false alarms are to be eliminated from automatic detector systems. This also places considerable responsibility on the shoulders of any engineer, consultant, or fire prevention officer who prepares specifications for automatic detector systems. Unfortunately, all too often, specifications are issued which are confusing and impossible to comply with and also of far too complicated a nature.

Rules and standards

Considerable concern is felt in many quarters at the wide variation in equipment and facilities being specified in different parts of the country for fire-

Table 2

Height above floor level of apex of pitched or north light roofs or of flat ceilings	Distance of detectors below flat ceiling	Distance of detectors below apex
m	cm	cm
6	0	46
7·5	0	64
9	23	76
10·5	35·5	92



This control panel from Shorrock Security systems conforms with BS3116 part 4

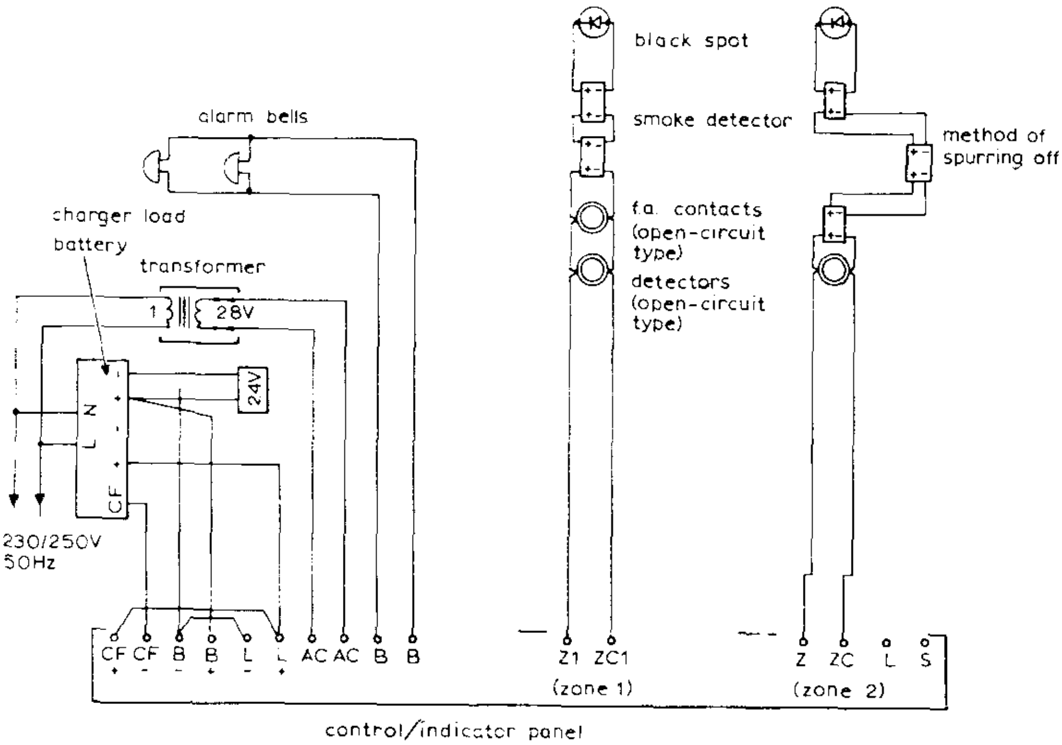


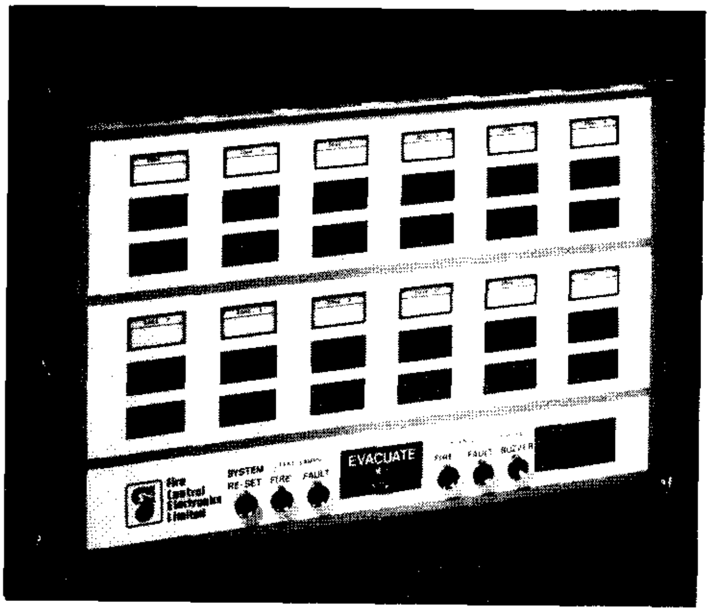
Fig. 1 An open-circuit-monitored system

alarm systems in hospitals and other premises responsible for the care of the sick, handicapped or aged. The information given below will, it is hoped, be of assistance to planners and engineers in bringing about a greater degree of uniformity in the approach to these problems.

There are some points which require clarification. The first is that FOC stands for *Fire Offices'* Committee and not *Fire Officers'* Committee, as often quoted. Another is the incorrect manner in which Fire Offices' Committee Rules are quoted in respect of individual items of equipment. FOC approval has never been granted to a single piece of equipment, and therefore such items as heat or smoke detectors only receive approval when they form part of a full FOC system, which has been planned, installed and certified by an FOC-approved designer and installer, and then checked and approved by a fire surveyor of a tariff insurance company, the correct siting being of paramount importance.

The rules of the FOC are primarily designed for systems which protect property, therefore all parts of the premises must be covered, the only exception being areas which are separated from the protected area by double fire-stop doors. The planning and installation of the system must be carried out by an FOC-approved fire protection company, and not by the client. The only permissible sounders are one bell on the outside of the building, fitted near the access door nearest to the indicator/control panel, and one within the building. All FOC systems must include facilities to call the Fire Brigade automatically, by direct line or through an approved means of communication; 999 units are not acceptable.

Any additional facilities which are required that are not covered by the FOC Rules must have relays included in the system to segregate the additional



Fire Control Electronics Ltd. has designed this panel to comply with BS3116 part 4

equipment. A separate and independent battery and charger must be provided to power any additions to the approved system controlled by the relays.

From the foregoing it will be appreciated that it is a serious embarrassment for a reputable fire-alarm company to be faced with a specification which states that the heat or smoke detectors are to be FOC-approved and then details a system which does not in any way comply with the FOC Rules—alternatively, for the client to closely tie up their requirements in a detailed specification and then state that the system must comply with the Rules of the FOC and BS3116 Pt4. Under the Trades Description Act, the more responsible companies have no option but to state that they cannot meet the specification and are therefore unable to submit a quotation, and, in so doing, lose business.

BS3116 Pt.4 is also being regularly quoted out of context. The title reads 'Specification for automatic fire alarm systems in buildings'. 'Part 4. Control and indicating equipment'. The strict interpretations of this title is stated, under 'Definitions' in 'CP327.404/402.501 Automatic system or circuit', 'A system or circuit in which the alarm is originated without manual intervention'. This clearly infers that this is a standard designed principally for the protection of property. For this specification to be quoted for systems, the main function of which is protecting life, would appear to be somewhat illogical.

Where there is a need for a client to prepare a specification (or instruct a consultant to do so) which is outside the precise requirements of BS3116 Pt.4 of the FOC Rules, Code of Practice CP1019 1972 should be specified. This is a code covering all types of electrical fire-alarm systems.

One further point on the subject of standards. Specifications are being put out calling for equipment to comply with BS3116 Pt.2 or Pt.3 which have not yet been completed (nor their contents generally made known), which renders it impossible to comply with these specifications. Considerable confusion has recently been caused by a premature quoting of a standard. When CP1019 1972 was prepared, reference was made on page 21 paragraph 2.11.1 to the effect that:
'Any control and indicating equipment should comply with BS3116 Pt.4. Since Part 4 was not completed until 1974, it was not appreciated that this standard only covered automatic systems. An amendent to this paragraph of CP1019 has recently been agreed and will be published shortly. The text will now read:
2.11.1 General. Any control and indicating equipment for automatic systems should comply with BS3116 part 4.
This amendment clearly indicates that it was never intended that BS3116 Pt. 4. should be applied to manual or partly automatic systems designed for the protection of life.

Systèmes d'alerte à l'incendie dans les hôpitaux

Il s'agit de choisir l'emplacement des détecteurs de fumée et d'incendie avec une grande prudence afin d'éviter les fausses alertes. Cet article donne quelques informations utiles concernant le positionnement des détecteurs utilisés avec des systèmes de surveillance par circuit ouvert. Il traite aussi de la validité de certaines règles et normes qui ont donné lieu à des malentendus dans le passé.

Feueralarmanlagen in Krankenhäusern

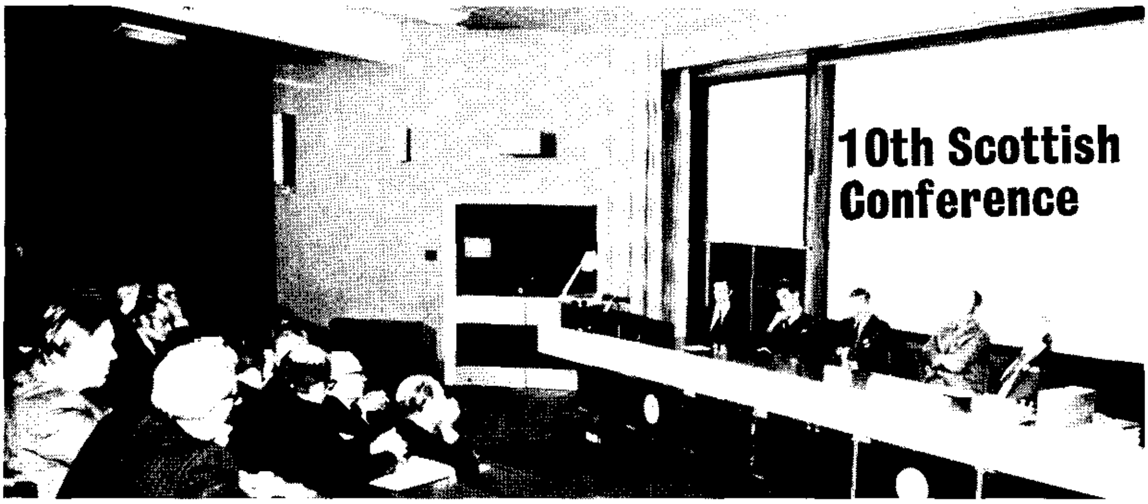
Bei der Entscheidung, wo Rauch-/Verbrennungsdetektoren anzubringen sind, muß sehr sorgfältig vorgegangen werden, wenn ein falscher Alarm vermieden werden soll. Dieser Artikel enthält einige Hinweise, die bei der richtigen Placierung von Detektoren für arbeitsstromüberwachte einschlägiger Vorschriften und Normen eingegangen, die schon öfter Verwirrung angestiftet haben.

Avvisatori d'incendio negli ospedali

I rivelatori di fumo/principi d'incendio debbono venir situati ai punti prescritti, per evitare falsi allarmi. Questo articolo fornisce indicazioni sul posizionamento dei rivelatori da utilizzarsi con sistemi a circuito aperto con monitor. Tracciamo i termini di riferimento di alcuni regolamenti e norme a questo riguardo che, in passato, hanno destato confusione.

10th Scottish Conference

The 10th Scottish Conference was held in the Walton Conference Suite of the Southern General Hospital in Glasgow. The conference suite, which comprises a 250-seat lecture theatre with television studio and seminar rooms, was provided by the Isidore & David Walton Trust to meet the increasing demands of health service training and education and is widely used by all sections of the health service, especially in undergraduate and post graduate teaching.



Southern General Hospital, Walton Conference Centre 23rd–25th October 1975

The Conference was opened by Simpson Stevenson, Chairman of the Greater Glasgow Health Board. In extending a welcome to members and visitors on behalf of the Greater Glasgow Board Mr. Stevenson commented on the sophisticated electrical and mechanical plant now being installed in hospitals and the increasing responsibility placed upon engineers in the health service. There was an ever increasing demand for the services of hospital engineers and their contribution to the health service was not unrecognised.

F. Hugh Howorth, President of the Institute, in reply thanked Mr. Stevenson for granting the use of the Walton Conference Centre. Mr. Howorth then took over as chairman of the first conference session and introduced Mr. Hornby, Technical Director of Howorth Air Conditioning Ltd., who delivered a lecture on 'Air technology in medicine'. A film, 'Thermal boundary layer of man and prevention of airborne infection' was shown and later on, a short film dealing with the development of the air bed. The lecture and films were well received by members and visitors and a lively question time followed.

Session 2 of the conference was chaired by T. D. W. Astorga, Director of the Scottish Health Service Common Services Agency Building Division. Mr. Astorga introduced a 3-man team from the Building Services Research Unit, University of Glasgow, Messrs. Rae, Robertson and Smith. Mr. Robertson gave the paper entitled 'Energy conservation in hospital ventilation systems' and supported by his two colleagues answered questions from the body of the hall. John Bolton, Chief Engineer, DHSS, questioned the validity of some of the figures quoted and an interesting discussion ensued. The question of hospital odour (smells both unpleasant and thoroughly repugnant) was raised and was treated in both a serious and humorous vein.

The paper was well received and the chairman (an architect), despite some pointed remarks about building designs, remained in good humour and conducted the discussion with excellent control.

Session 3 was chaired by John Bolton, who introduced Cameron Weymes, Medical Director of the Greater Glasgow Health Board Sterile Supply Service who gave a lecture on 'Research into sterilisation with steam at sub-atmospheric pressure'. Dr. Weymes related the history of the development of this type of sterilisation, commenting on the problems still to be resolved in this field. He was joined on the platform for the discussion period by Mr. Harris, an engineer and Mr. Pickerill of British Sterilisers. This was a most interesting paper and question time indicated how closely the talk had been followed by members and visitors alike.

Session 4 was chaired by A. Wotherspoon, Assistant Chief Engineer, Scottish Development Department, who introduced A. H. Christer who delivered a paper entitled 'The quantitative approach to maintenance' which dealt with the computerisation of maintenance data. Dr. Christer is Senior Lecturer in Operational Research at the University of Strathclyde, and his paper was delivered with expertise and enjoyed by all those in attendance.

The Saturday morning session (Session 5) was chaired by K. W. Wilson, Assistant Director, Maintenance, Scottish Health Service, Common Services Agency who introduced L. Munro, HM District Inspector of Factories (Glasgow South District). Mr. Munro spoke on 'Some implications of the Health & Safety at Work Act 1974'. The serious topic was lightened by Mr. Munro's wit and humour and concluded with considerable audience participation in discussion.

The Chairman thanked Mr. Munro for a most interesting talk and declared the Tenth Scottish Conference closed.

THE INSTITUTE OF HOSPITAL ENGINEERING
in conjunction with
THE CHIEF ENGINEER,
DEPARTMENT OF HEALTH AND SOCIAL SECURITY
ONE-DAY SYMPOSIUM
'THE HEALTH AND SAFETY AT WORK ACT, 1974'
at The Institution of Electrical Engineers,
2, Savoy Place, Victoria Embankment, London, WC2R 0BL
on Wednesday, 3rd March, 1976

PROGRAMME

1000-1030	Assembly and Coffee
1030-1035	Official Opening by F. H. HOWORTH Esq., F.R.S.A., F. Inst P.I., F.I.I.C., F.I.Hosp E., President, The Institute of Hospital Engineering
1035-1130	'THE LEGAL STRUCTURE OF THE ACT' Speaker: DR. VINCENT POWELL-SMITH, LL.B(Hons), LL.M., M.Sc., D.Lit, F.F.B., F.Ph.S. Commandure de l'Education Sociale (France) Lecturer in Law, University of Aston Management Centre, Member of Joint Advisory Committee for Safety and Health in the Construction Industries Chairman: JOHN BOLTON Esq., LL.B., C.Eng., F.I.C.E., F.I.Mech E., F.Inst F., Hon. M.I. Hosp E., FRSH., F.I.Arb., Chief Engineer, Department of Health and Social Security
1130-1220	Questions and Discussion
LUNCH	
1400-1500	'THE FUNCTIONS OF THE HEALTH AND SAFETY COMMISSION AND EXECUTIVE' A Speaker from the Health and Safety Executive Chairman: JOHN BOLTON Esq., LL.B., C.Eng., F.I.C.E., F.I. Mech E., F.Inst F., Hon. M.I. Hosp E., FRSH, F.I.Arb.
1500-1600	Questions and Discussion
1600	OFFICIAL CLOSURE

TICKETS for the Symposium, cost £6 (SIX POUNDS) each, can be obtained ONLY from: The Secretary, The Institute of Hospital Engineering, 20, Landport Terrace, Southsea, PO1 2RG.

N.B. *LUNCH*. Unfortunately, only a limited number of Buffet lunches can be provided at the Institution of Electrical Engineers. These will be allocated on a 'first come first served' basis to those who purchase a lunch ticket from the Institute of Hospital Engineering 'Stewards' on duty on the doors of the Lecture Theatre prior to the Opening.

Other snack lunches can be obtained within I.E.E. and there are numerous eating establishments in the immediate vicinity.

An application form for tickets for this symposium is provided at the bottom of page 16.

News

IHF events

The International Hospital Federation has three major events planned for the 1976–77 session. The 5th IHF Regional Conference will be held in Mexico City on the 7th–12th March 1976. Topics covered will include hospital and health service planning and management. The conference is open to members and non-members of the IHF.

For further details contact Dr. José Gonzalez, Secretary of the IHF Pan American Office, 1 Farragut Square South, Washington DC 20006, USA.

The 14th IHF study tour of hsoptials will be held in Denmark on the 13th–24th June 1976 and will include visits to hospitals at Copenhagen, Odeuse, Aarhus and Aalborg. The tour is open to members of the IHF only and is limited to 200 people.

The 20th International Hospital Congress will be held in Tokyo on the 22nd–27th May 1977, and is open to non-members of the IHF. The main topics to be discussed are health care in big cities, health auxiliaries, epidemology and health services, modernisation of hospitals and the supply and maintenance of electronic equipment.

Non-members of the IHF can receive further information on the study tour and the International congress from Miss Dorothy Maitland, Assistant Director, IHF, 24 Nutford Place, London W1H 6AN, England.

Laundry exhibition

One of the first exhibitions housed by the new National Exhibition Centre at Birmingham will be the International Laundry Cleaning Equipment and Services Exhibition which is being held on the 17th–24th June 1976. To date 120 companies have taken stand space totalling 6460 m^2 and negotiations are in progress with a further twenty.

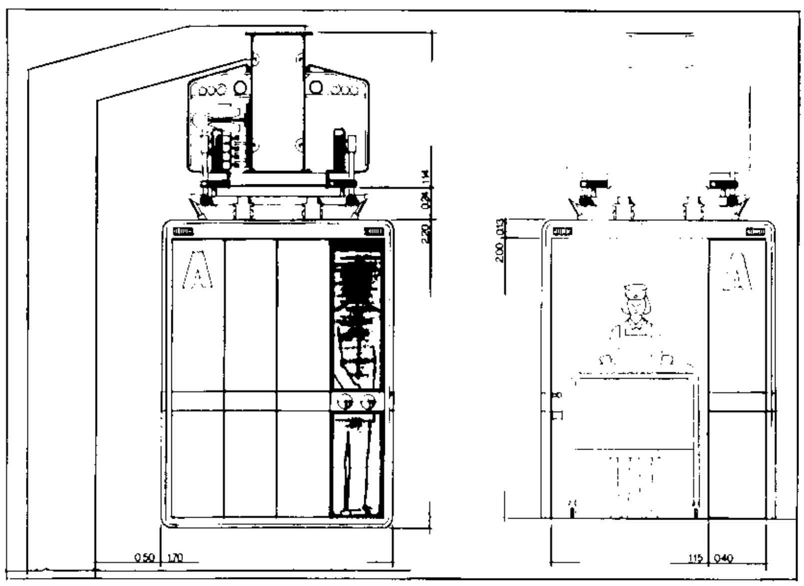
Companies from Switzerland, Sweden, Italy, West Germany, Belgium, Denmark and the USA will be among those exhibiting. In honour of the many overseas visitors expected, the Association of British Launderers and Cleaners will hold a dinner-dance at the Hilton Hotel, Stratford on Avon. The ALBC will hold its annual conference at the Stratford Hilton during the exhibition.

Suspension system eases communication

Common to hospitals old and new is the problem of rapid, silent communication between separate buildings. A West German hospital has overcome these problems with the installation of the Cabinenlift system by Demag Material Handling. This link lift, based on an inverted crane suspension system, connects the hospital's main clinic and follow-up care block, 600 m apart.

Advantages of the Cabinenlift include silent running due to linear-motor drive and rubber-tyred wheels, absence of exhaust gases and pliable braking and acceleration in all weathers.

Demag Material Handling Ltd., Beaumont Road, Banbury, Oxon. OX16 7QZ are handling enquiries on this lift system for the UK.



To: The Secretary, The Institute of Hospital Engineering, 20 Landport Terrace, Southsea, PO1 2RG.

Please send to me........ticket(s) for the ONE-DAY SYMPOSIUM on 'HEALTH AND SAFETY AT WORK ACT, 1974' to be held on 3rd March, 1976.

I enclose £........to cover cost at SIX POUNDS each.

NAME (in capitals, please)..

ADDRESS..

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Instrumentation for hospitals in India

a planned approach

by T. G. KRISHNA MURTHY

The establishment of a health-care system in a developing country, such as India, is limited by many financial, social and economic parameters. This article outlines the problems encountered in equipping a hospital, be it in a rural or urban environment, and gives a guide to the instruments that should be purchased to meet the requirements of the area.

The role of instruments in the diagnosis and treatment of diseases is an accepted fact. Some of them have become an inevitable part of a hospital, nursing home or polyclinic. Instruments greatly assist and enhance the human capabilities, which are, of course, limited. There is some apprehension in developing nations about automation of certain hospital procedures using computers, autoanalysers etc. Proper briefing on the economic use of these methods in hospitals having beds of over 750–1000 and a heavy work load of outpatient services will go a long way towards convincing medical administrators. Recurring and nonrecurring expenditure to cover the cost of the equipment, personnel and maintenance have to be planned in advance for the best utilisation of the facilities.

Approximately 30 to 50 medical institutions in the country; appear to be suitable for being upgraded. These must be given funds for the additional expenditure involved.

Some of the medical institutions, established by the central government, may be specially selected. Each state must have one such institution. Such a step will be an incentive and a morale booster to research-minded interdisciplinary scientists all over the country. Looking at the location of such centres already established in the country, it will be fair to upgrade some of the medical colleges located in Assam, Orissa, Bihar, Madhya Pradesh, Rajasthan and other states of the country; at least one institution, equipped with the latest instrumentation and competent personnel, is already functioning.

Problems

Instruments can be broadly classified under three headings; namely diagnostic, therapeutic and bioanalytical. Medical-college departments obviously utilise a fair amount of instruments; certain instruments can be termed essential and others optional, while some may not be needed at all. Although planning, location, number of beds, inpatient and outpatient work-load are the most important criteria, there appear to be two types among the medical profession; the first group, having well-established nursing homes and polyclinics, are inclined to maintain the *status quo* and are not keen to use or change over to modern methods; the other group intend to equip their institutions with the latest techniques. The cost effectiveness of clinical engineering analyses varied aspects including the cost of equipment, personnel and maintenance. This is of utmost importance in nations like India, where funds for health care are rather meagre compared to nations like the USA, Japan, Sweden etc. It is rather futile to attempt to imitate those nations. Technology in health care has to be harnessed to the fullest extent practicable, depending on the socioeconomic conditions prevalent in the country. The situation varies from nation to nation, even among developing nations.

The adoption of new methods primarily depends on the medical profession of that country, but public

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acceptance is another very important aspect. Educating the public in a country like India is a challenging and formidable task, a nation of 600 million people of various religions speaking 14 languages presents a totally different and unique task. Various media, such as the newspapers, journals, radio and television have to be used in the local languages to propagate the advantages of new techniques. To achieve positive results, dedication and perseverance are essential.

From a long-range view, such planned efforts will be of immense value. Both the product and the user benefit, besides the all important main purpose of providing better health care for the masses being achieved. Governmental efforts in this gigantic task have to be substantially supported by the society in the form of hospitals, nursing homes and polyclinics, particularly in the rural areas. The enlightened and affluent in the countryside have an important and vital role to play.

Planning

With the above background, the scene in India has to be analysed and planning done for the future. Over 80 % of the 600 million live in the rural areas. Currently the ratios of population to hospital beds and patients to physician is in the range of 2000:1 and 5000:1, respectively. Over 70 % of modern practitioners are settled in cities and towns. The reasons for this state of affairs are obvious, the reluctance of a modern medical practitioner to move into the rural areas is understandable. But the rural scene in India has undergone a rapid transformation in the last few years. Rural areas are now being provided with basic amenities, e.g. a power supply, sanitation, water supply etc., besides being linked by better transport and communication. 1500 out of the 6000 primary health centres are being converted into 30-bed rural hospitals. These are to be provided with essential diagnostic and therapeutic instruments, besides the other hospital prerequisites. It is certainly a laudable move. In the planning itself, provision had to be made for recurring expenditure on equipment maintenance, technicians, e.c.g. paper, X-ray films etc.

From a humanitarian angle, the rural rich can make a positive contribution by donating equipment etc. Large undertakings, irrespective of their location

Table 1. Suggested equipment

Name of instrument	30–250 beds Rural hospital	20–100 beds Nursing home	500–1000 beds Urban hospitals
Diagnostic X-ray unit	×	×	×
Electrocardiograph	×	×	×
Surgical diathermy	×	×	×
Nerve muscle stimulator	×	×	×
Foetus monitor	×	optional	×
Premature baby incubator	×	optional	×
Ultrasonic therapy unit	×	×	×
Clinical audiometer	×	—	×
P.E. colorimeter	×	×	×
Incubator	×	×	×
Centrifuge	×	×	×
Respirator	×	×	×
Cardioscope	×	×	×
D.C. defibrillator	×	optional	×
Pacemaker	×	optional	×
Electromyograph	×	×	×
Electroencephalograph	—	—	×
Flame photometer	—	—	×
Electrophoreses	—	—	×
Gas chromatograph		—	×
Convulsive stimulator	—	optional	×
Closed circuit t.v.		—	×
Ion-therapy unit	×	×	×
E. aerosol unit	×	×	×
E. sleep therapy unit	×	×	×
Medical spectrometer	—	optional	×
Nuclear scanner	—	—	×
Renograph	—	—	×
Deep X-ray units	—	—	×
Cobalt-60 units	—	—	×
Short-wave diathermy	×	×	×
Cryoprobe	—	×	×
Fibroscope	—	—	×
Electronic cell counter	—	—	×
Autoanalyser	—	—	×
pH meter	—	—	×
Artificial kidney	—	—	×
Heart/lung machine	—	—	×
Laser coagulator	—	—	×
Ultraviolet/infrared lamps	×	×	×

(urban or rural), now have really well equipped hospitals whose bed strengths range from 50 to 200. Voluntary organisations are also doing a highly commendable job, accounting for about 80 000 beds, and remote rural areas have benefitted from their service. Highly competent specialists from abroad also work in these hospitals sacrificing personal comforts.

Hospitals and nursing homes in major cities, numbering about 300, are well equipped besides having the services of highly competent specialists. In general, major hospitals, numbering about 300–500 and having bed strengths varying from 500–1000, are reasonably well equipped. Practically all the 105 medical colleges have hospitals attached. Hospitals and colleges in the state capitals are comparatively better equipped than those in the interior. Some private medical colleges may be exceptions. Colleges in States like Assam, Bihar Orrisa, West-Bengal, Madhya Pradesh and Rajasthan are not so well equipped compared to those in Punjab, Haryana, Tamilnad and Kerala. Paucity of funds is the reason. The same applies to district hospitals in the country. A positive and realistic approach, taking account of the financial limitations for health care, by proper scientific planning of hospital instrumentation may yet lead to better care using modern resources.

The success of such planned effort mainly rests on the co-ordination between the administrator, medical specialist and engineer (full time, part time or honorary). Equipping a hospital with essentials like drugs, surgical instruments, beds etc., consumes a great proportion of the funds allotted, and a great amount of discretion has to be exercised in the proper selection of equipment using the remaining funds. It is always advisable to buy from firms which are well established and value customer goodwill.

Equipping a hospital

As regards instruments, some can be termed 'absolutely essential'. Under this category come: (*a*) diagnostic X-ray unit; (*b*) electrocardiograph; (*c*) p.e. colorimeter; (*d*) incubator; (*e*) centrifuge; (*f*) surgical diathermy; (*g*) stimulators; (*h*) respirator; (*i*) diathermy, pacemaker cardioscope on a mobile trolley. For any hospital, polyclinic or nursing home, irrespective of the location, the above instruments are basic.

Under the catogory of 'useful', come (*a*) convulsive stimulator (where psychiatric consultancy is available); (*b*) ultrasonic therapy; (*c*) clinical audiometer; (*d*) foetus monitor. (*e*) premature baby incubator; (*f*) flame photometer; (*g*) pH meter. District level hospitals and nursing homes can progressively buy the 'useful' instruments after the 'essential' ones. Some other useful devices, e.g. an electrosleep unit, an ion-therapy unit, an aerosol unit, a speech-correction unit, a medical spectrometer and a chromatograph may be 'optional'.

Major hospitals with neurological facilities may purchase e.e.g., e.m.g., photic stimulator equipment and relevant accessories. Closed-circuit television systems are essential for all medical colleges, teaching hospitals and for medical-research institutions. The remaining equipment cited in the Table 1 may be procured by major hospitals, depending on the recurring and nonrecurring funds available.

Full-time engineers and trained technicians will be a necessity as more instruments are obtained. An annually recurring amount has to be specifically kept for spares and maintenance if one is genuinely interested in utilising the equipment. Some spares can be procured along with the instruments and, wherever possible, at least two units must be procured by the nursing homes and city hospitals. This particularly applies to 'essential' and 'useful' instruments whose unit cost is under Rs.5 000. At least two electrocardiographs are needed to have uninterrupted service in any polyclinic or nursing home. Although the X-ray unit is essential, it may not be practicable to have a standby unit. But certain essential spares must be kept handy for replacement when needed. A planned approach to modernise the hospital or nursing-home instrumentation will be an economically viable proposition. The financial resources available, whether from government or a voluntary agency, has to be judiciously used to provide fullest health care for the patient at reasonable cost.

The cost aspect is important. The approximate cost of procurement of 'essential' and 'useful' instruments comes to about Rs.200 000, out of which the diagnostic X-ray unit with accessories alone consumes about Rs.100 000. The useful life of these instruments ranges from five to fifteen years, with occasional attention for replacement of a part. Under present conditions, frequent investment in instruments is not possible. It is advisable to contact a competent bioengineer to advise on instrumentation. A group of dedicated engineers are available to guide and advise, if called upon to, at nominal costs. (They will not demand professional charges or consultation fees etc., as in some nursing homes!) One hopes that the medical specialists and institutions will utilise the services of such dedicated engineers who are interested in health care.

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14 KRISHNA MURTHY, T. G.: Electronics and medical sciences, S. J. SOUVENIR, MIT, February 1975

Technique au service de la santé—Inde

La mise en place de services de la santé dans des pays en voie de développement tel que l'Inde est limitée par de nombreux paramètres financiers, sociologiques et économiques. Cet article expose les problèmes rencontrés dans l'équipement d'un hôpital, que ce soit dans un endroit rural ou urbain, et donne des exemples d'instruments qu'il convient d'acheter en fonction des besoins localisés.

Die Technik in der Gesundheitspflege—Indien

Der Errichtung eines Gesundheitspflegesystems in einem Entwicklungsland wie Indien sind durch viele finanzielle, soziale und wirtschaftliche Parameter Grenzen gesetzt. Dieser Artikel geht auf die Probleme ein, die bei der Ausstattung eines Krankenhauses—ob in ländlicher oder städtischer Umgebung—auftreten. Er enthält ferner Hinweise in bezug auf die Instrumente, die man im Hinblick auf die in diesem Gebiet herrschenden Bedürfnisse anschaffen sollte.

La tecnica nel campo medico-sanitario—India

L'istituzione di un sistema medico-sanitario in un Paese in fase di sviluppo, come l'India, è limitata da molti parametri finanziari, sociali ed economici. Questo articolo delinea i problemi che si incontrano nell'attrezzare un ospedale, in campagna o in città, e fornisce una guida sugli strumenti che si dovrebbero acquistare per soddisfare le necessità locali.

Institute news

32nd Annual Conference Royal Hotel, Norwich

April 28th-30th, 1976

Membership of conference

The Conference is arranged, primarily, for members of the Institute of Hospital Engineering.

There will be a Registration Fee of £18 (eighteen pounds) permitting attendance at the entire Conference, with a daily fee of £9 (nine pounds) allowing attendance at the two sessions on any one day and a sessional fee of £5 (five pounds) which allows attendance at any one session. Lunch is included in these fees.

Visitors from other societies and organisations, and from the hospital service, are welcome to attend any session of the Conference, Registration fees as above.

Payment of expenses—Hospital Service Members. In accordance with the authority given in Circular HM (54) 55, officers may be granted special leave with pay to attend conferences on work with which they are concerned. Travelling and subsistence allowances at the usual rates may be paid to officers, provided that approval to attend has been obtained from the employing authority.

The conference dinner dance will be held at the Royal Hotel, Norwich on the evening of Thursday 29th April.

Ladies programme

A special ladies programme has been arranged. An introductory ladies coffee party will be held in the Royal Hotel on the first morning of the conference.

Hotel accommodation

Special arrangements have been made with the conference hotel, the Royal Hotel, Norwich, in regard to accommodation for delegates and wives.

Tickets for the Conference and the conference dinner dance, and registration for accommodation at the Royal Hotel, should be obtained by application to: The Secretary, The Institute of Hospital Engineering, 20 Landport Terrace, Southsea, Hampshire PO1 2RG.

The following subjects will be covered. Further details will be given in the next issue of *Hospital Engineering*.

'The use of reliability techniques in the design of medical engineering equipment'.

'Health and Safety at Work Act, 1974'.

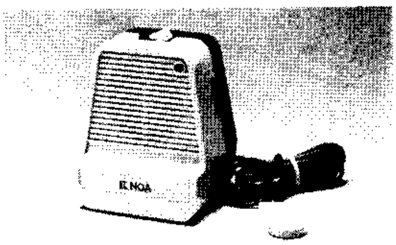
'Economics in design and operation of hospital engineering services'.

'The consulting engineer abroad'.

Product news

Telephone amplifier

The NOA amplifier operates from a standard long-life battery or from a separate plug-in mains power unit. It measures 7·5 × 7·5 × 5 cm and is housed in a grey and black moulded plastic case. A separate volume



control is fitted to enable everyone in the room to join in a telephone conversation, if required.

Hadley Sales Services, 112 Gilbert Road, Smethwick, Birmingham B66 4PZ, England

Alarm call point

The BG20 Slimpoint break-glass call point is manufactured to BS 381C/537 and will fit any BS 1363 plaster depth box. It is all-metal

finished in the standard signal red and incorporates a check test push.

Tann Synchronome Ltd., Stirling Corner, Borehamwood, Herts., England

Bed brochure

A 4-page colour brochure is available describing the Regent '75 RB multipurpose hospital bed. The full range of variable height and tilt positions is clearly shown and tabulated, together with other features such as the full-width bedstripper and epoxy-coated chassis etc. A range of accessories is also illustrated.

Elison Hospital Equipment Ltd., Wellhead Lane, Perry Barr, Birmingham B42 2TD, England

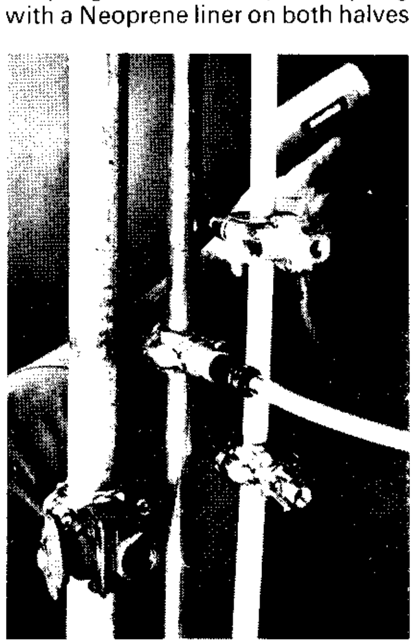
Building protection

Rentokil has introduced a new service for facade protection of buildings. Designated the MC 55 service, the process is based on the spray application of a titanium-based compound. The treatment does not trap moisture already contained within walls, impregnation of walling material to a depth of 4–7 mm providing adequate protection. The MC 55 solution is colourless and does not disfigure building facades.

Rentokil Ltd., Felcourt, East Grinstead, Sussex, RH19 2JY, England

Pipe couplings

Instant Tee pipe couplings can be fitted to new or existing pipework without cutting or dismantling. The coupling consists of a split alloy ring with a Neoprene liner on both halves

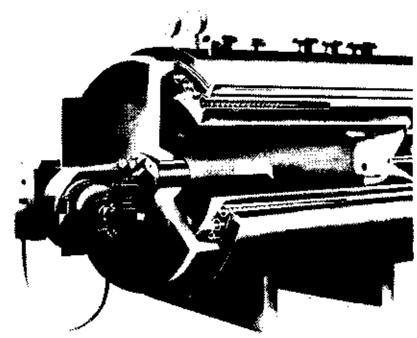


of the bore, two socket screws clamp the ring firmly onto the pipe at any desired position. Both BSP and metric sizes are available with single or double male or female outlets. Instant Tee can be fitted to most pipes, such as iron, copper, plastic etc.

Applied Pneumatics Ltd., Charlton Mead Lane, Hoddesdon, Herts. EN11 0EX, England

Hot-water boilers

B & E boilers have added to their existing range of hot-water boilers with 15 new sizes from 300 to 3600 kW (1 020 000 to 12 280 000 b.t.u./h) and pressure ranges of 0·20m, 0·344 and 0·488 N/mm^2 (30, 50 and 65 lb/in^{2}g). The whole

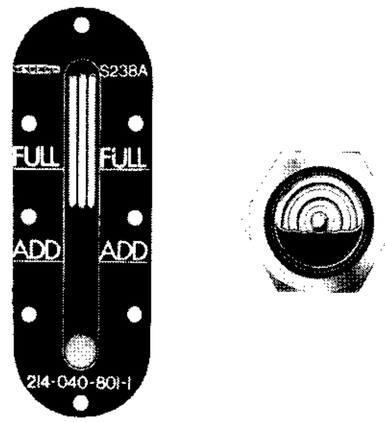


of the boiler shell is lagged with mineral wool, wired into position and encased in treated sheet-metal cladding. The boilers are designed to operate at gross thermal efficiencies of 80 to 82% on oil or gas applications.

B & E Boilers Ltd., Easthampstead Road, Bracknell, Berks. RG12 1NP, England

Gauges and oil eyes

A new line of oil eyes and contrast sight gauges has been developed



by Vactric Ltd. This range is designed for superior legibility of fluid level, regardless of colouration of the liquid used. These gauges reflect more than 90% of incident light.

Vactric Central Equipment Ltd., Garth Road, Morden, Surrey, England

A review of electricity as an aid to medical treatment

From torpedo to telemetry

by D. W. HILL, M.Sc., Ph.D., F.Inst.P., C.Eng., F.I.E.E.

Once the means of generating first static and then current electricity had been mastered, man was keen to harness the power of electricity as an aid to the treatment of a variety of complaints. It is fascinating to trace the application of simple electrostatic generators and then of simple electromagnetic generators and sparking coils to medicine and the growth of electrical departments in famous teaching hospitals.

Long before it was possible to generate electricity by artificial means, the effects of electrical shocks on man were known as a result of contacts with electric fish.

The Torpedo or Electric Ray was known by at least the 4th century BC. Plato mentions it and compares its stunning effect with the effect on the intellect of meeting Socrates. Aristotle discusses its properties in more scientific terms as does his pupil Theophrastus. He recorded that the shock can be conducted through rod and spear. Scribonius Largus served as Julius Caesar's chief medical officer during the 54 BC invasion of Britain. On returning to Rome, Scribonius set up a private practice and cured both headaches and gout with the Torpedo. Arthritic patients were taken to a nearby beach and placed their feet on the Torpedo fish, thus receiving a powerful shock.

Pliny the Elder (23–79 AD) found that the Torpedo does good if laid over the spleen and is very helpful in childbirth. The Greek, Paul of Aegina (650 AD), states that, in cases of headache, the Torpedo fish when applied to the head whilst still alive produces a relief of the pain, probably by its peculiar property of producing torpor from whence the fish got its name.

Scientific interest

Another electric fish, the Egyptian Electric Catfish, *Malapterus Electricus*, also aroused scientific interest after its discovery by Adanson in 1756 who compared its effects with those of the Leyden jar, and showed that the effect of its discharge could be conducted along a metal rod. The study of the freshwater Electric Catfish and the saltwater Torpedo aroused great interest. Their anatomy was studied by the famous anatomist John Hunter; Henry Cavendish built a model of the Torpedo, and Humphrey Davy, Michael Faraday and others confirmed that the electricity generated by fishes was identical with that produced from inanimate sources.

Efforts were made to determine the precise origin of the discharge as a model for the much smaller electric potentials produced by nerve and muscle fibres. These were difficult to study until sensitive recording instruments had been developed. Keynes[1] showed that an electric eel can, for a period of 2–3 ms, place in series a large number of electroplates or cells each having a potential across it for that period of about 100 mV, thus giving rise to a peak voltage for the whole fish in air of about 550 V.

The electric catfish grows to more than 1 m long, and its electroplates are arranged in 50–120 parallel columns with up to 6 000 cells in each column. In 1838, Faraday estimated a medium discharge from an electric fish 1·07 m long as being at least equal to the charge contained in a bank of 15 Leyden-jar capacitors containing a total of 3 500 in^2 of glass coated on both sides and charged to its maximum. The *Lancet* reported Faraday's lecture/demonstration on electric fish at the Royal Institution on the 18th January 1839.

Animal electricity

Luigi Galvani began his studies on the subject of animal electricity in 1780. When performing experiments on nervous excitability in frogs, he saw that violent muscle contractions could be observed if the lumbar nerves of the frog were touched with metal instruments in the presence of distant electrical discharges. Although Galvani was telling his anatomy students that the nervous fluid involved was animal electricity, he was not completely satisfied with this explanation and believed that he had discovered a new phenomenon.

Originally, Galvani studied the effects of artificial electricity on the nerves and muscles of frogs. Subsequently, he experimented on warm-blooded animals with the natural electricity of atmospheric discharges. Galvani concluded that his frog preparation was an electric-current meter and the most delicate electrometer yet discovered. Later, Galvani made his famous discovery that, when a copper hook pierced the spinal cord of a frog and then touched an iron plate on which the frog was rested, there were strong muscular contractions in the frog. At first Galvani believed that the metals possessed the property of electrical discharge, but, soon afterwards, Galvani was strongly convinced of the existence of animal electricity which was discharged by metallic arcs. To collect new data to support his theory, Galvani studied the properties of the Torpedo fish.

Discovery of electric batteries

Galvani thought that, by connecting the nerve and the muscle of a frog by a metallic arc consisting of

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two dissimilar metals, he had discharged the animal electricity in the muscle. The nerve and muscle were analogues to the inner and outer conductors of a Leyden-jar capacitor. Volta (1793) realised that the essential requirement for making the muscle contract was the presence of two dissimilar metals joined at one end with their free ends connected to either the nerve or muscle and that the metal combination generated a potential. This led him to the construction of early forms of wet and dry batteries—voltaic cells. Volta was of the opinion that his pile of cells was basically similar to the natural electric organ of the Torpedo or electric eel rather than the Leyden jar.

The word 'electricity' was reserved for static electricity and the word 'Galvanism' was proposed by von Humboldt for direct (continuous) current. Humboldt's friend, a doctor named Grapengiesser, referred to a pile of voltaic cells as a battery and employed it to produce muscular contraction. During the 10 years following Galvani's publication of 1791, many suggestions were made that galvanism could be used as a criterion of death since it was not uncommon for unconscious persons to be buried alive. Subsequently, experiments were performed on the corpses of freshly hanged murderers. An account of such an experiment performed in 1819 says: 'In the third experiment, the supra-orbital nerve was touched when every muscle in the murderer's face was thrown into fearful action. The scene was hideous several of the spectators left the room, and one Gentleman actually fainted from terror or sickness'.

Galvanic (direct) currents were used in the treatment of pain and swelling following trauma, sprains, fractures and dislocations. Iontophoresis produced by direct current was used in various forms of therapy by driving into the affected tissues ions such as those of copper, silver, mercury, magnesium, lithium, quinine and iodine. Before the advent of antibiotics, this technique was employed for the treatment of ulcers and infections. Galvanic current interrupted periodically by a commutator was used to stimulate nerve and muscle.

Action potentials

Volta's conclusive demonstration that Galvani had not, as yet, discovered animal electricity was a severe blow for Galvani. Nevertheless, he persevered in his studies and showed that muscular contraction could in fact be produced without the requirement of metallic conductors. He held one foot of a frog nerve-muscle preparation and swung it so that the vertebral column and the sciatic nerve touched the muscles of the other leg. This caused the muscles to vigorously contract. It is now known that it was the injury potential of about 50 mV from the sciatic nerve which stimulated an excitable nerve and thus caused a muscular contraction. Subsequently, Carlo Matteucci showed that the development of a transient 'action potential' precedes the contraction of a skeletal muscle. Soon after this, the presence of an action potential was shown in both cardiac muscle and nerve. The determination of the time course of action potentials was made possible by the use of the rheotome. This was a sampling device which permitted measurements to be made with early galvanometers whose response times were too great for direct use.

Galvanometer techniques

In 1820, Oersted reported the discovery of electromagnetism, and this led him to develop the first galvanometers. It was John Schweigger who constructed the first moving-coil instrument and Nobili[3] (1828), an Italian physicist, developed a sensitive astatic galvanometer and compared its sensitivity with that of the most 'sensitive galvanometer' then available, Galvani's preparation of the decapitated trunk and hind quarters of a skinned frog. It is instructive to recall that, in the days before the advent of powerful magnets, in order to obtain sufficient sensitivity for his animal electricity experiments, Emil du-Bois Reymond had to wind 3·17 miles of wire for his galvanometer coil.

Heinrich Lenz (of Lenz's law) developed a segmented commutator or rheotome which could be arranged to sample a periodic waveform at known points of the cycle and thus feed a train of pulses, each corresponding to the amplitude of the waveform at that point, to a slowly responding galvanometer. By plotting the deflections against the time in the cycle at which they occurred, the complete waveform could be reconstructed. In 1868, Bernstein used a rheotome to chart the time course of the action potential in a nerve fibre.

By 1876, the capillary electrometer of Marey[4] and Lippman and the string galvanometer of Einthoven were available with a sufficient sensitivity and speed of response to record bioelectric events directly. However, preceding Einthoven's studies of the electrocardiogram, Marchand[5] in 1877 and Englemann in 1878 were able to chart the electrocardiogram using a rheotome.

The use of a ballistic pendulum to determine the velocity of a bullet led Pouillet (1844) to the concept of the ballistic galvanometer for the estimation of short-duration current impulses. In 1850, Helmholtz employed a ballistic galvanometer to measure the conduction velocity of a nerve impulse and found a mean figure of 30 m/s.

Electrostatic medical techniques

William Gilbert, physician to Queen Elizabeth I, had found that many substances, including amber, when rubbed, possessed the 'amber force' and could, attract light objects, i.e. they had become electrified. This phenomenon led to the development of simple frictional electrostatic generators, which were often used for entertainment purposes. In 1743, Johann Krueger, professor of medicine at Halle University, was asked by the students, 'What is the usefulness of electricity?' He replied that, since a use cannot be looked for in theology or jurisprudence, there is obviously nothing left but medicine. He predicted that the best use would be with paralysed limbs. Gottlieb Kratzenstein, subsequently professor of physics at Copenhagen University, heard Krueger's lecture and used electrostatics to enable a man to play the piano with two of his fingers that previously had been paralysed. The discovery in 1745 of the Leyden-jar capacitor gave a considerable impetus to electrical research. Benjamin Franklin treated a number of paralytics with shocks of static electricity in Philadelphia but did not discern any true improvement. John Wesley (of Methodist fame) published his book 'The desideratum' in 1759 and extolled the virtue of electricity in many diseases. He bought four electrostatic machines to treat the people of London. Over the next 100 years, there was much interest in the application of electrostatic electricity to a large number of ailments. In 1836, Guy's Hospital set aside rooms for an electrical department. In 1861, the French physician Guillaume Duchenne of Boulogne published his famous textbook on medical applications of electricity. By the end of the 1800s most US doctors had a static-electricity machine in their offices.

Electromagnetic generators

The name of Michael Faraday is famous for the discovery of electromagnetic induction, reported in *Lancet* in 1831, and Joseph Saxton (1834) is credited with the first construction of a rotating-coil instrument to generate electricity. Fig. 1 shows an early electromedical apparatus with a handle and gearing to rotate a coil between the polepieces of a horseshoe magnet, the output being taken via a simple commutator. A fascinating set of electrodes was provided: plate electrodes for the soles of the feet; a metal comb for stimulating the hair and a point electrode for checking that the nerve to a tooth was still alive (it was by no means unknown for a dentist to extract the wrong tooth!). The apparatus was recommended for the treatment of a wide range of disorders including nervous headache, colds, asthma, paralysis of the arms and palpitations of the heart (Fig. 2). In 1835, Faraday gave a course of 14 lectures on electricity to the medical students of St. George's Hospital. Joseph Henry (of inductance fame), in 1836 and at the request of a medical friend, administered an induced current to a patient with paralysis of the nerves of the face.

Electromagnetic induction also made possible the sparking coil, which was highly developed by Heinrich Ruhmkorff in 1851. According to Dujardin-Beaumetz, between 1840 and 1850, there was hardly a physician or hospital without an induction apparatus.

The interrupted current output from an induction coil was known as faradic current after Faraday and was employed to procure muscular contraction in the treatment of inflammation of fibrous tissue and muscles accompanied by adhesions and exudate.

In 1886, Heinrich Hertz produced a sustained oscillating current and this aroused the interest of Telsa, d'Arsonval and others. D'Arsonval was adept at physics, physiology and medicine and in 1892 had designed an apparatus capable of generating high-frequency currents at several hundred kilohertz. He built a solenoid large enough to surround a patient (Fig. 3) and connected this to his high-frequency generator. The method was used for the treatment of diabetes, gout and obesity. Subsequently, capacitive coupling to the patient was employed and this led to the concept of short-wave diathermy units and the radiofrequency heating of body tissues. In 1892, Oudin described a resonator that could raise the potential of d'Arsonval's high-frequency circuit suffi-

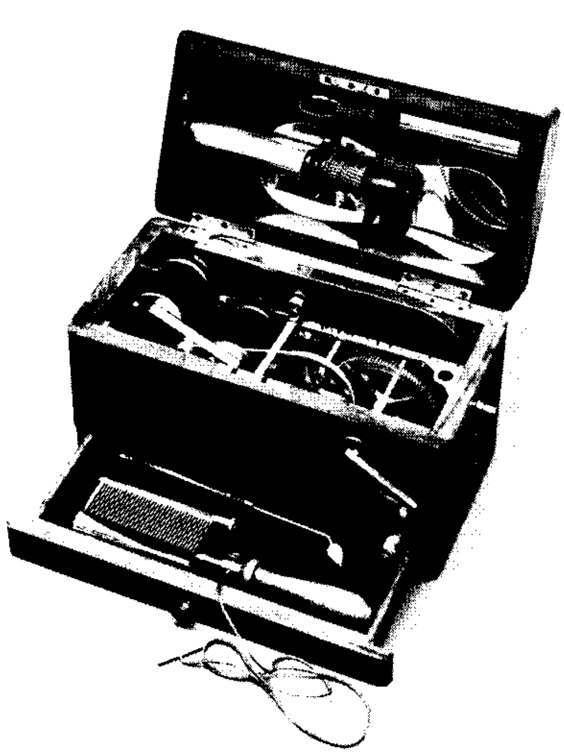
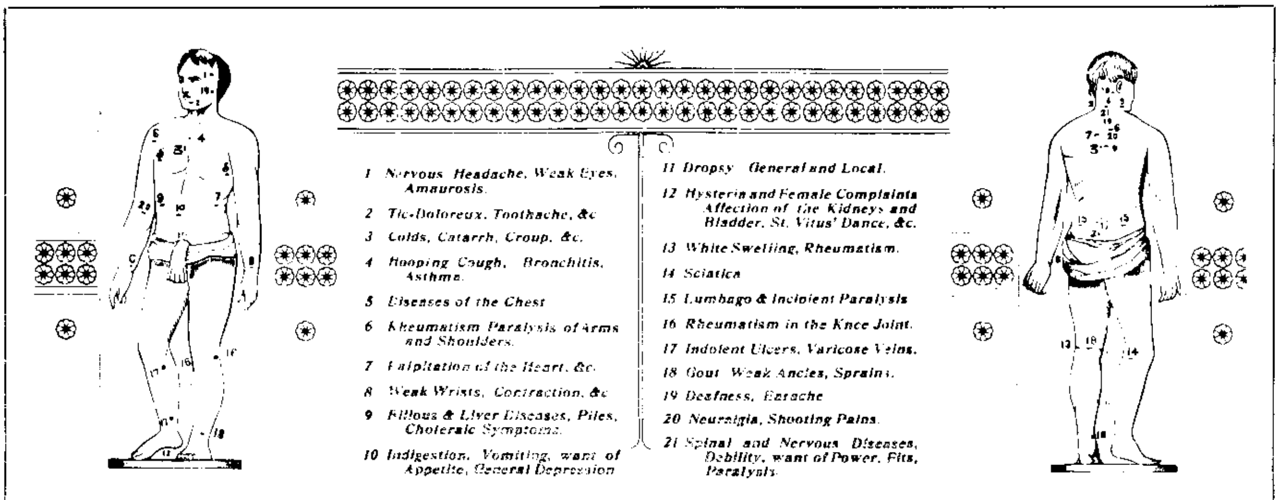


Fig. 1 Early therapeutic electromagnetic generator

Fig. 2 Leaflet supplied with the generator of Fig. 1



ciently so that a long brush discharge or effluve could be produced at its free end. Applied directly to the skin, this brush discharge could destroy superficial tissue.

The availability in the 20th century of thermionic valve generators led to the widespread use of short-

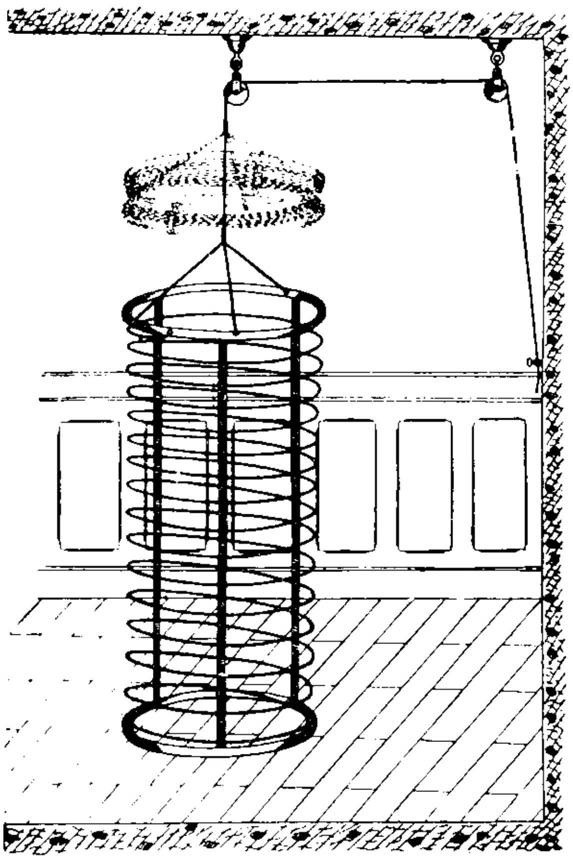


Fig. 3 Coupling for the treatment of a patient with high-frequency currents (from Cumberbatch, 1929)

Fig. 4 Use of a 3-stage amplifier and Braun cathode-ray oscilloscope for the measurement of action currents in nerve (from Gasser and Erlanger, 1920)

wave diathermy units in departments of physical medicine, where faradic stimulation and the measurement of nerve conduction velocities are regularly performed. The development of valves, cathode-ray tubes and efficient biological amplifiers has led to routine electrophysiological examinations of patients.

By 1929, a Dr. Elkin Cumberbatch, author of a book on 'The essentials of medical electricity', described himself as medical officer in charge of the electrical department of St. Bartholomew's Hospital and examiner in medical electrology of the University of Cambridge. On the title page of his book on electromedicine, Dr. M. La Beaume was proud to describe himself as a medical galvanist and gratuitous electrician to the Bloomsbury and Northern Dispensaries. Back in 1885, a Dr. Campbell had stated that 'The employment of electricity in medicine and surgery has now reached that point of recognition when no medical man can be considered a master of his art who remains in ignorance of its principles'.

Thermionic valves and cathode ray tubes

Einthoven's string galvanometer had been used for the recording of electrophysiological signals but it was limited in its sensitivity. Forbes and Thatcher in 1920 used a triode valve to drive by *RC* coupling a string galvanometer, the amplifier having a gain of 25. Gasser and Newcomer (1921) employed a single-sided triode valve amplifier coupled to a string galvanometer to record physiological action currents in the phrenic nerve, whilst Gasser and Erlanger in 1920 used an early Braun cathode-ray oscillograph with a 3-stage triode *Y*-amplifier and a motor-driven potentiometer timebase to study the action currents of nerve (Fig. 4). They showed that the propagation velocity in nerve is related to the fibre diameter and were awarded the Nobel Prize. The use of differential amplifiers led to the regular recording of electroencephalograms, electromyograms and electrocardiograms.

Following the Second World War, cathode-ray-tube monitors developed for radar purposes became commonplace in electrophysiology and patient monitoring.

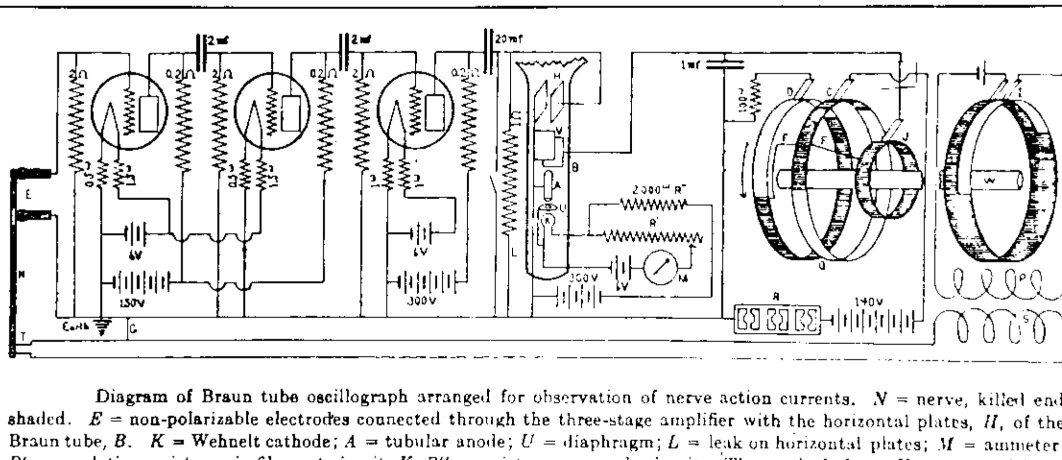


Diagram of Braun tube oscillograph arranged for observation of nerve action currents. *N* = nerve, killed end shaded. *E* = non-polarizable electrodes connected through the three-stage amplifier with the horizontal plates, *H*, of the Braun tube, *B*. *K* = Wehnelt cathode; *A* = tubular anode; *U* = diaphragm; *L* = leak on horizontal plates; *M* = ammeter; *R'* = regulating resistance in filament circuit, *K*; *R''* = resistance in anode circuit. The vertical plates, *V*, connect with the spreading device, *O*. *D* = discharging wheel, *C* = charging wheel and *J* = continuous contact wheel (metallic parts shaded) all connected conductively by *P*; *R* = charging resistance to 1 mf. condenser. *I* = rotating interrupter in primary circuit, *P*; *S* = secondary coil; *T* = stimulating electrodes grounded through *G*. 1 Ω = 1 megohm. For the intertube leaks labeled 2 Ω, 0.5 Ω was used.

Sensitive pressure transducers permitted venous and arterial pressures to be recorded on direct-writing recorders using heated stylus, ultraviolet or ink-jet techniques.

Low-grid-current electrometer valves allowed the pH of blood and other biological fluids to be monitored with glass electrodes, the measurement of intracellular potentials with microelectrodes and the accurate measurement with relatively simple apparatus of the dose of radiation delivered by X-ray sets.

Transistors and integrated circuits

The advent of transistors and integrated circuits has led to more compact equipment and the use of 'radio pills', radiotelemetry and implanted circuits, e.g. cardiac pacemakers and various forms of stimulator. When an electrical connection has to be made directly into a ventricle of the heart, the need to limit mains leakage currents to less than 50 μA has been recognised, and photoisolators and other methods to do this are in common use. Digital techniques have led to the widespread application of memory type oscilloscopes and the increasing use of both offline and online digital computers.

Field-effect transistors have greatly improved the input impedance and in-phase rejection-ratio characteristics of bioelectric amplifiers. Nuclear and conventional battery performance has been improved to give a longer effective life for implanted circuits. All of this is a very far cry from the Torpedo fish of the Mediterranean and their early use to cure arthritis!

When Galvani published his accounts of animal electricity, several doctors thought that this new electric force might have life-saving applications. In 1899, Prevost and Batelli suggested the use of electrical stimulation to restart a person's heart when it stopped beating, and this was made of practical use by Beck and Rand in 1949. An electrocardiogram can show whether the heart has simply stopped or is in the condition known as ventricular fibrillation where it is contracting in an uncoordinated manner. Beck and Rand suggested the use of a brief pulse of 1·5 A at 110 V, 60 Hz applied via electrodes on each side of the heart, but Kouwenhoven *et al.*, resuscitated closed-chest patients by using a 480 V, 60 Hz current for a quarter of a second. Lown *et al.* developed the concept of a d.c. defibrillator[6] in which a high-voltage capacitor was discharged via an inductor across the patient's chest. This technique has proved valuable in terminating both ventricular and atrial fibrillation. In the case of atrial fibrillation, the capacitor discharge is synchronised with the patient's electrocardiograph so that it occurs during the down slope of the R wave. A discharge during the T wave is likely to throw the heart into ventricular fibrillation.

Another much used application of alternating current to the body has been in the passage of mains frequency between the temples in the form of electroconvulsive therapy for schizophrenia and depression.

X rays

On the 8th November 1895, Wilhelm Röntgen, professor of physics at the University of Würzburg in Germany first discovered X rays. Working in a darkened room he saw that a paper coated with barium platinocyanide emitted a greenish light when placed a few metres distant from a Crookes' vacuum discharge tube which was completely covered with black cardboard. On moving his hand between the tube and the paper, Röntgen saw a black shadow cross the fluorescent surface. The Crookes' tube was energised from a Ruhmkorff induction coil. Soon afterwards, Röntgen substituted a photographic plate for the primitive fluorescent screen and took an X ray picture of his wife's hand.

The basic mechanism for the production of X rays has changed little since Röntgen's time, but the refinement of the rotating anode X ray tube has resulted in the provision of high outputs at high kilovoltages for radiotherapy applications. A great deal of engineering skill has gone into facilitating complex cycloidal movements of the X ray tube and plate holder which are required for tomographic techniques. Similar considerations apply to the versatility in positioning the patient which is needed in neuroradiography and in ring table systems for stomach and bowel examinations. The advent of the image intensifier coupled the power of television technology to the X ray image and has markedly advanced the art of cardiac catheterisation and 'screening' procedures generally. Videotape allows the recall of dynamic procedures such as micturition to be replayed for subsequent diagnosis or for teaching purposes. Online digital computers are now being employed in cardiac catheterisation laboratories for the calculation of venticular volumes, begin and end-diastolic pressures and the pressure gradients across heart valves.

Electrical safety

Consequent upon the development of commercial electricity supplies, the risk of death from electrocution became significant and it is interesting to look back on the arguments for the use of the supposedly more dangerous alternating current for the first legal electrocutions in America (1890). Although Thomas Edison advocated the passage of the current from hand to hand, this was found to be less effective than from head to calf.[7] In 1899 Prevost and Battell at the University of Geneva showed that the usual cause of death from low voltage shocks was ventricular fibrillation.[8]

In recent years much effort has been expended on improving the standard of construction of electrical equipment with which patients may come into contact in order to prevent gross electrical shocks from occurring, particularly when the patient is earthed, for example by means of an earthed e.c.g. reference electrode. In sensitive patients it has been shown that currents of the order of 100 μA at 50 Hz can cause venticular fibrillation if passed into the right or left ventricle, whereas more than 3 mA is needed into an atrium. Such a microshock can be delivered via a pacing electrode or pressure catheter located in a ventricle. For this reason, leakage currents should be reduced to less than 50 μA at 50 Hz by the use of 'isolated' preamplifiers and pressure transducers. No connection made to a patient should be capable of passing a dangerous current into or out from the patient. In the United Kingdom, Hospital Technical Memorandum specifies the standard of construction required of electrical equipment which can be connected to patients.

Defibrillators

When Galvani published his first accounts of animal electricity, several doctors thought that this new electric force might have life-saving applications. Prevost and Battelli also published papers which clearly explain the possible use of electric defibrillators by suggesting the use of electrical stimulation to restart a person's heart when it stopped beating. They carefully documented the action of a.c., d.c. and pulse-type shocks on animals. Their work started Kouwenhoven in 1930 working on the development of a defibrillator for use with man. Electrical defibrillation was used *in man* by Beck and Rand in 1949. An electrocardiogram can show whether the heart has simply stopped or is in the condition known as ventricular fibrillation where it is contracting in an uncoordinated fashion. Beck and Rand suggested the use of a brief pulse of 1·5 A at 110 V 60 Hz applied via electrodes on each side of the chest, but Kouwenhoven *et al.* resuscitated closed-chest patients by the use of a 480 V 60 Hz current for 0·25 s. Later, Lown *et al.*[9] developed the concept of the d.c. defibrillator in which a high-voltage capacitor was discharged via an inductor across the patient's chest. This technique has also proved valuable for the reversion of atrial fibrillation when the discharge is synchronised with the e.c.g. to occur during the downslope of the R-wave of the e.c.g. A discharge occurring during the T-wave is liable to throw the heart into ventricular fibrillation. This condition is fatal within a few minutes as the failure to pump blood by the heart quickly renders the brain anoxic and produces irreversible brain damage. Hence hospitals have one or more d.c. defibrillators instantly available for action. Another much used application of mains frequency alternating current to the body has been with the passage of current between the temples in the form of electroconvulsive therapy for the treatment of schizophrenia and depression.

Transistors and integrated circuits

The advent of transistors and integrated circuits has led to the increasing use of online computers connected to patient monitors and clinical laboratory instrumentation and the use of 'radio pills', radiotelemetry and implanted circuits, e.g. cardiac pacemakers and various forms of stimulator e.g. for the treatment of incontinence and the relief of chronic pain. The availability of digital technology has introduced the popular memory type of oscilloscope.

Field-effect transistors have revolutionised the characteristics of differential amplifiers for use with physiological signals. Nuclear and conventional battery performance has been greatly improved to extend the working life of implanted circuits. The multiplicity of electronic equipment now available for use in hospitals highlights the need for an effective maintenance organisation. All of this is a very far cry from the torpedo fish of the Mediterranean and their use to cure arthritis, headache and anal prolapse!

I should like to express my thanks to the committee of the IEE Professional Group on the history of technology for their encouragement to put this material together. Elizabeth Allen, Curator of the Hunterian Museum of the Royal College of Surgeons of England, and B. Cook of the British Museum have kindly provided helpful references to the electric fish. Sidney Light's 'History of electrotherapy' has provided many valuable references. Finally, I would like to acknowledge much historical information provided by Profs. Hebel Hoff and Leslie Geddes.

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De la torpille a la telemetrie

Une fois qu'il avait bien compris l'électricité statique et ensuite l'électricité sous forme de courant, l'homme a tenu à mettre en oeuvre la puissance de l'électricité comme moyen de traiter de nombreuses maladies. Il est intéressant de suivre l'application médicale des simples générateurs électrostatiques, des générateurs électromagnétiques et des bobines d'allumage, ainsi que la croissance des services électriques dans des hôpitaux d'enseignement célèbres.

Vom Torpedo zur Telemetrie

Sobald es dem Menschen gelungen war, zuerst statische und dann galvanische Elektrizität zu erzeugen, war er darauf bedacht, sich die Kraft der Elektrizität bei der Behandlung der verschiedensten Beschwerden zunutze zu machen. Wenn man die Anwendung einfacher elektrostatischer Generatoren und die einfacher elektromagnetischer Generatoren und Zündspulen auf die Medizin und das Anwachsen der elektrischen Abteilungen in berühmten Universitätskliniken zurückverfolgt, wird man faszinierende Feststellungen machen.

Dalla torpedine alla telemetria

Trovata la maniera di generare dapprima l'elettricità statica indi la corrente elettrica, l'uomo ha desiderato imbrigliare l'energia elettrica ed adibirla al trattamento di diverse malattie. E'affascinante esaminare la storia dell'applicazione di semplici generatori elettrostatici indi di semplici generatori elettromagnetici e bobine nel campo della medicina e lo sviluppo dei reparti elettrici in famosi ospedali scuole mediche.

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For further details phone Mr. Tony Round, District Engineer, Basingstoke 25906.

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