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THE INSTITUTE OF
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THE HOSPITAL ENGINEER

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AUGUST 1968

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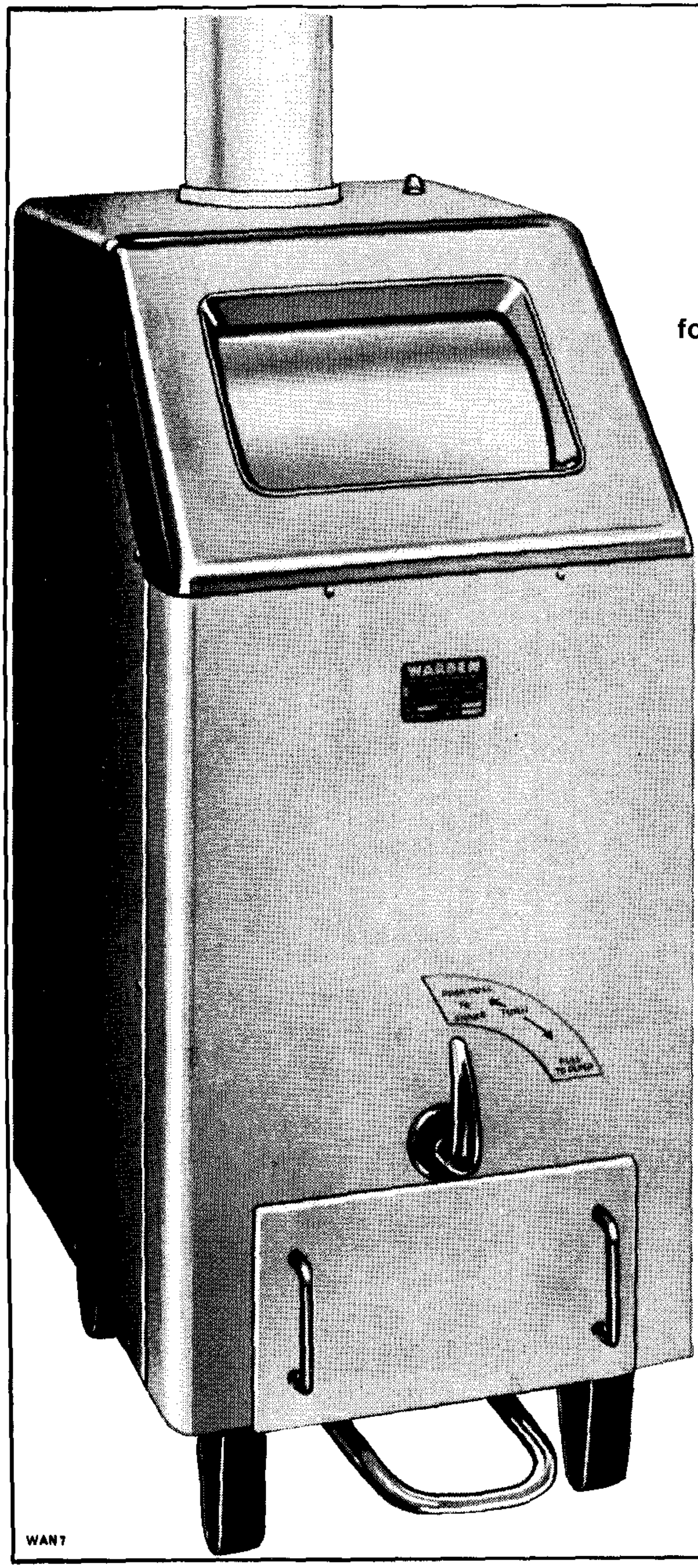

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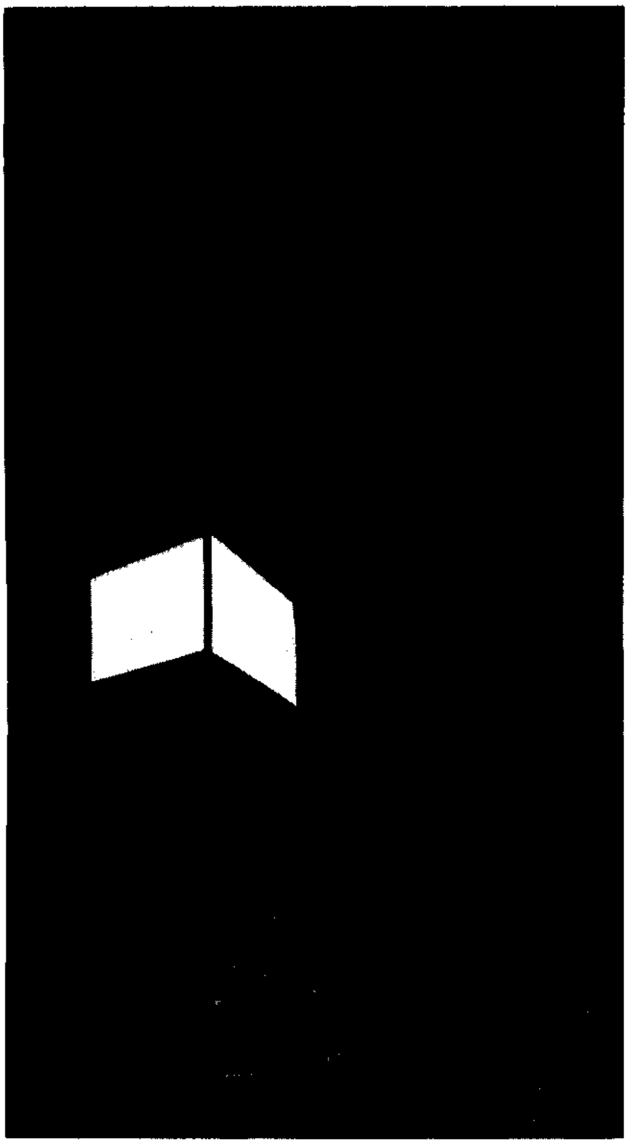

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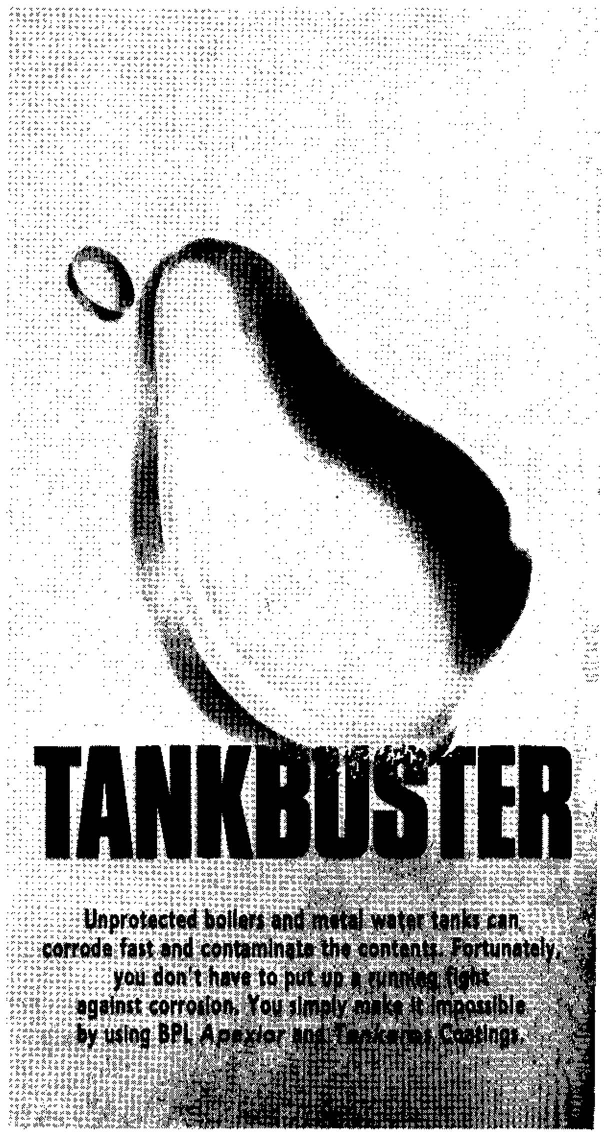

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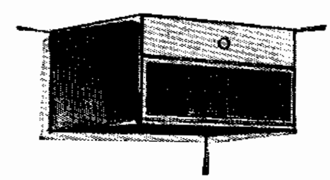

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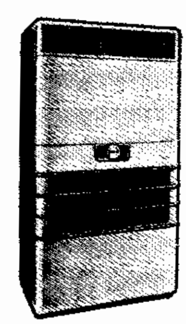

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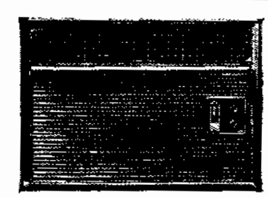

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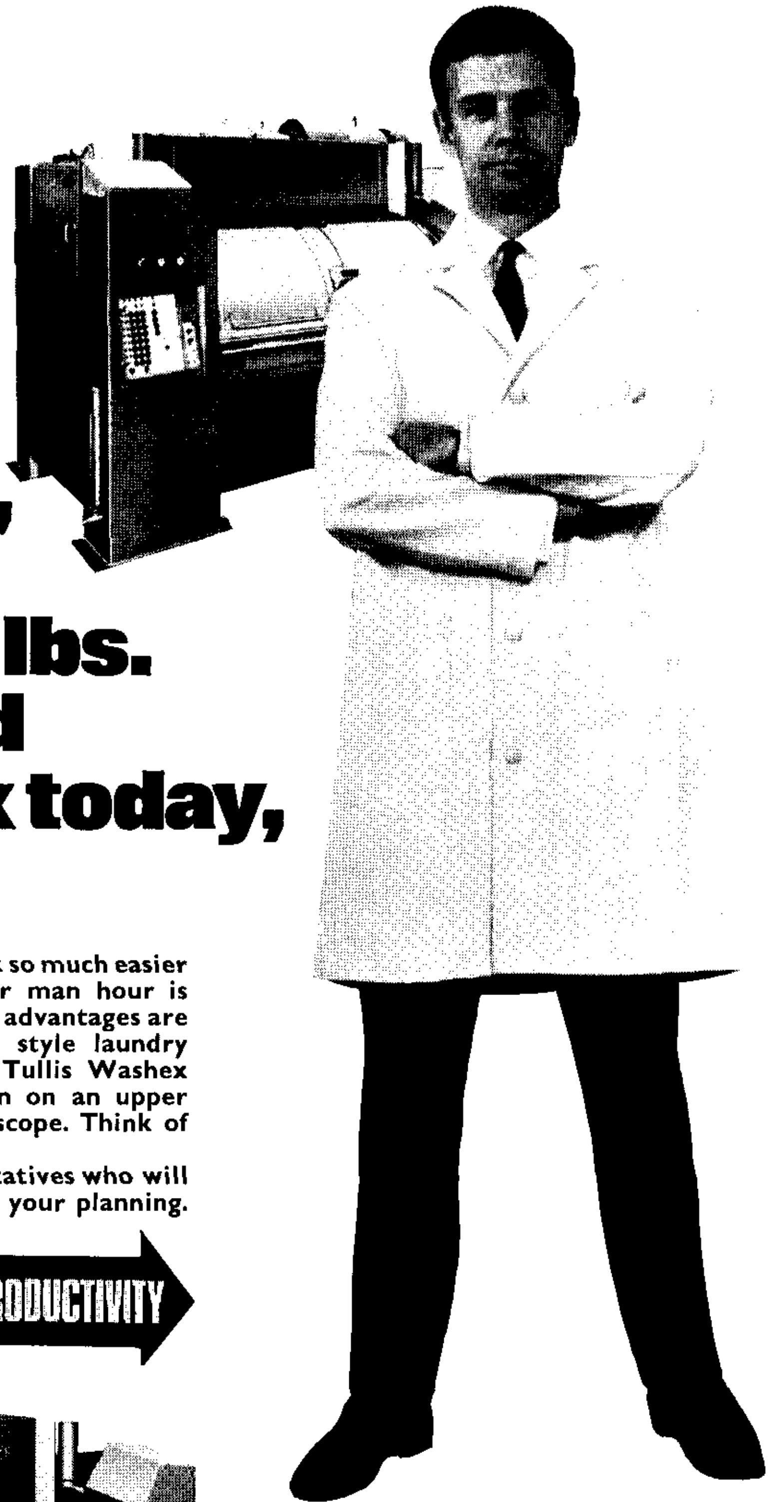

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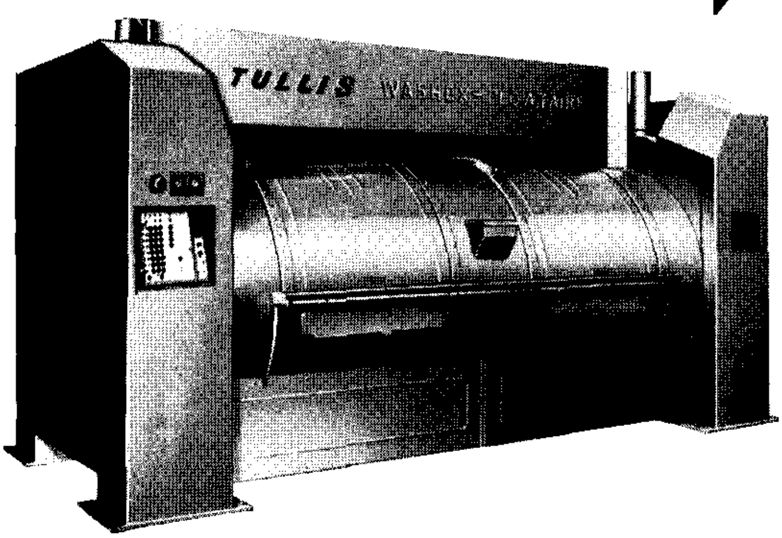

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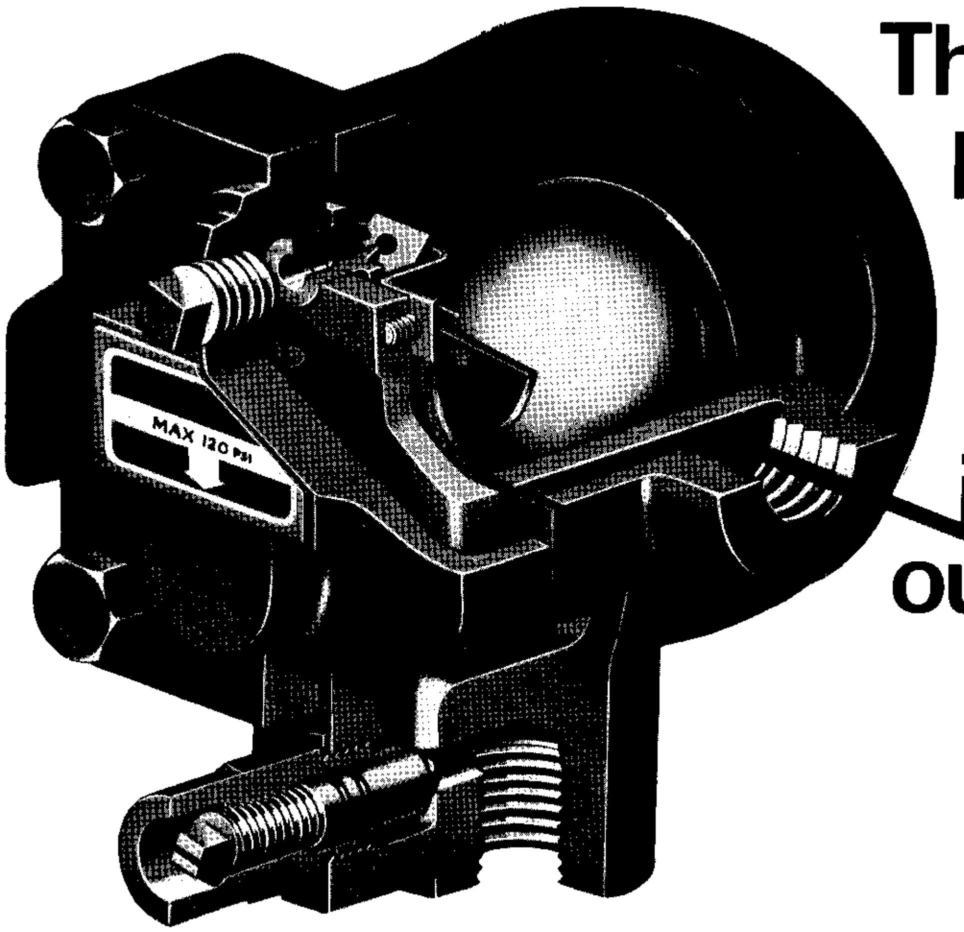

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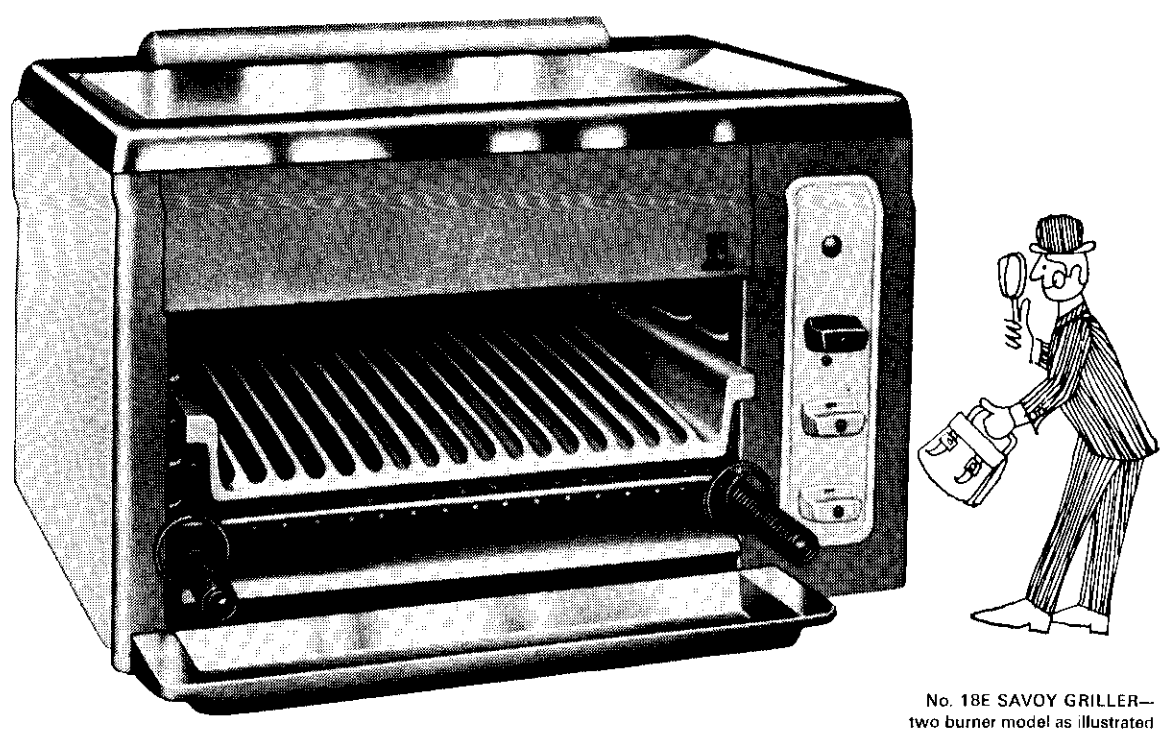

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Gamma Irradiation Plants and their Applications

By H. CHRISTEN

The importance of nuclear physics to industry is not confined to atomic power stations. New possibilities are being opened up by the use of radioactive substances, which are able to influence practically every field of industrial activity. As more nuclear reactors are brought into service, large quantities of radioactive isotopes are becoming available at reasonable prices. Originally radioactive substances were merely by-products, but an increasing number of useful applications have since been found for them. The technique has developed into a field of its own, in which Sulzer gamma irradiation equipment offers a key to effective utilization.

Gamma Radiation

Types of radiation

NUCLEAR radiation may come from natural or artificial sources. Natural sources comprise outer space (cosmic radiation), the upper atmosphere (soft X-rays) and the natural radioactive elements (uranium, radium, potassium etc.). Artificial radiation sources include solid, liquid, and gaseous residues from nuclear reactors and waste products from these, artificial radioactive isotopes, X-ray tubes and high-voltage apparatus. From the physical aspect these rays are divided into electro-magnetic radiation (gamma and X-rays) and corpuscular radiation (alpha and beta rays, protons, neutrons) (Fig. 1).

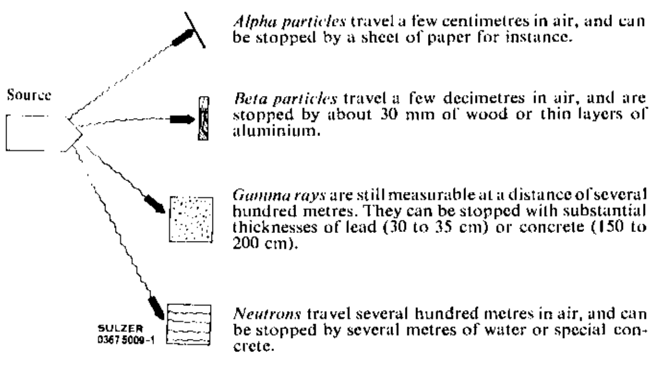

Fig. 1. Different types of radiation.

The gamma radiation emitted by radioactive isotopes consists of electromagnetic waves lying within a frequency range of 10^{19} to 10^{23} cycles. It is neither charged nor corpuscular, so that it is far more penetrative than alpha or beta radiation. Gamma radiation is of similar nature to visible light, differing from it only in its origin and wavelength.

Isotopes

Isotopes are atoms having the same atomic number and hence the same position in the periodic table, but different mass. Most isotopes are stable, which means that they emit no radiation. In addition to a few natural unstable isotopes, nuclear physics has succeeded in producing artificial unstable isotopes by exposing certain substances to the neutron flux in a nuclear reactor. Isotopes rendered active in this way are called 'radioactive isotopes', or simply 'radioisotopes'. They decay until a stable condition is reached, giving off radiation in the process.

The radioisotope employed mainly in our gamma irradiation plants is cobalt 60, which is obtained by activating cobalt 59. Every radioisotope decays to the stable

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state at its own particular rate. This constant is expressed by the half-life: the time in which the activity falls to half its original value. Cobalt 60 has a half-life of 5·27 years, which means that in the space of one year about 12·5 per cent of the initial activity disappears.

In isolated cases cobalt 60 (Co60) is replaced by caesium 137 (Cs137)—a fission product from burnt-up uranium fuel rods.

Data on Co60 and Cs137	*Co60*	*Cs137*
Nature of radiation source	metal	caesium chloride
Density of radiation source	8·9	3·2 grams/cm³
Half-life	5·27	30 years
Mean radiation energy	1·25	0·66 MeV

At first sight these figures might seem to indicate Cs137 as the better radiation source, with its much longer half-life. But it will be noticed also that Cs137 possesses much less radiation energy and therefore a lower radiation output, so that four times as much activity must be installed to achieve the same results as with Co60. Moreover cobalt has another advantage in that only about 10 to 15 per cent of the cobalt 59 is transformed into Co60 at each activation, depending on the specific activity. The stable 85 per cent or so left over in a Co60 source can be reactivated later again in a reactor, when the source has to be changed in any case because its activity has decayed too far. This possibility does not exist with Cs137.

Sulzer Gamma Irradiation Plants

A gamma irradiation plant consists essentially of a radioactive isotope emitting the desired gamma radiation, and the shielding arrangements to concentrate this radiation in a controlled zone. This controlled zone is called the 'irradiation cavern' or 'cell' according to the size of the plant, and may range from a few cubic decimetres to several cubic metres. The dimensions are governed mainly by the application and the material to be irradiated.

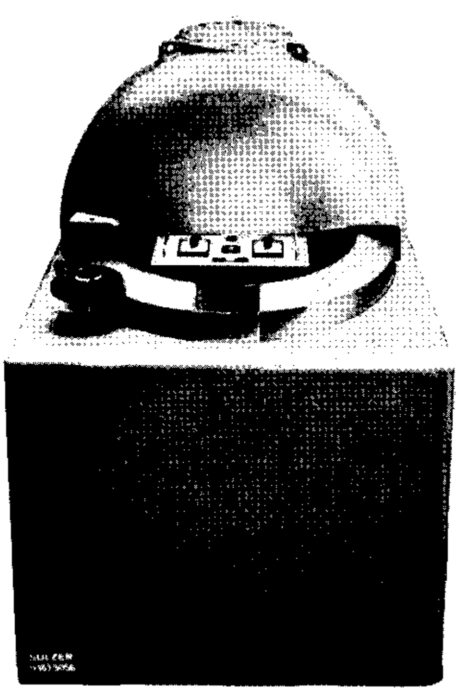


Fig. 2. Laboratory gamma irradiation unit for activities up to 10,000 c of Co60.

Units

Designation	Unit (abbreviation in brackets)	Definition
Activity	curie (c)	1 curie is the amount of a radioactive isotope sustaining $3 \cdot 7 \times 10^{10}$ disintegrations per second
Radiation energy	roentgen (r)	1 r is the amount of gamma or X-radiation producing so many pairs of ions in one cubic centimetre of air at 0°C that their total charge equals one electrostatic unit
Absorbed dose	radiation absorbed dose (rad)	1 rad = 100 erg/gram 1,000 rad = 1 kilorad = 1 krad 1 million rad = 1 megarad = 1 Mrad

Ancillary equipment for an irradiation plant includes the electrical control arrangements, lifting and conveying gear, ventilation or cooling, emergency generating sets for major industrial installations etc.

Our irradiation plants are divided into laboratory and industrial types. As the name implies, the first group is intended for scientific investigations, while the second group of plants, equipped with the necessary conveying systems, is built for economically viable, large-scale industrial duty.

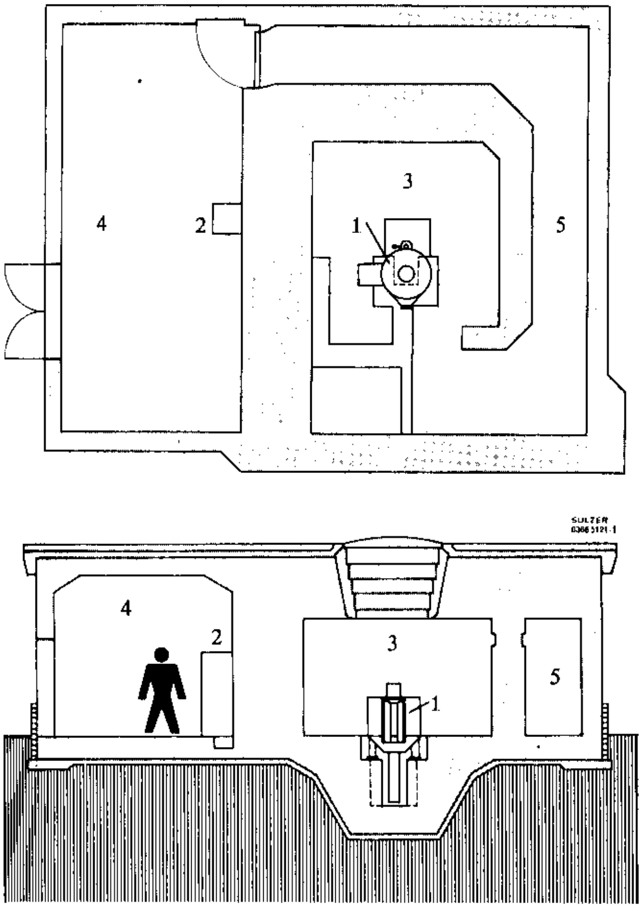
Further differentiation is between open and closed plants. This distinction is based on the position in which the source is stored and the radiation shielding. In the closed type the radioactive source remains stationary inside the lead shielding, while the material to be irradiated is brought inside this shielding. The 'Double Cell' type is one example.

If on the other hand the source is brought out of its safe position for irradiation, additional concrete shielding is necessary. Such an installation is called an open plant, as in the case of the room irradiation plant or pilot plant.

'Double Cell' laboratory irradiation unit (Fig. 2)

This is a simple, closed laboratory facility. The two irradiation chambers are fitted diametrically opposite to each other inside a ring structure which at the same time provides shielding; they are exposed to the radiation alternately. This unit is suitable for a wide variety of duties. Apart from solid bodies, liquid or gaseous media may also be irradiated in it.

The shielding of this plant is calculated for a maximum activity of 10,000 curies Co60.



1 Source container
2 Control console
3 Irradiation cell
4 Preparation room
5 Labyrinth

Fig. 3. Schematic layout of a room irradiation plant.

Among the principal advantages of the 'Double Cell' unit are:

The special efficacy of the twin-chamber system for series tests.

Good dose distribution in the irradiation chambers (capacity 3 litres each).

Pipe coils fitted fitted on the outer sides of the two source walls allow liquids to be irradiated under constant flow, unaffected by the other tests.

Good utilization of the radiation.

Compact shielding and hence low installed height.

Simple operation.

Room irradiation plant (Figs. 3 and 4)

This layout constitutes an open irradiation plant. Here additional radiation protection must be provided by the builders, because the source is raised from its lead shielding for irradiation duty.

Essentially this plant consists of the actual irradiation unit and the irradiation cell in which the source is exposed for irradiation. In contrast to the 'Double Cell', the material to be irradiated can be set up panoramically in large quantities at various distances from the source, or in the case of smaller tests it can be subjected to intensive irradiation in the centre of the circularly arranged source.

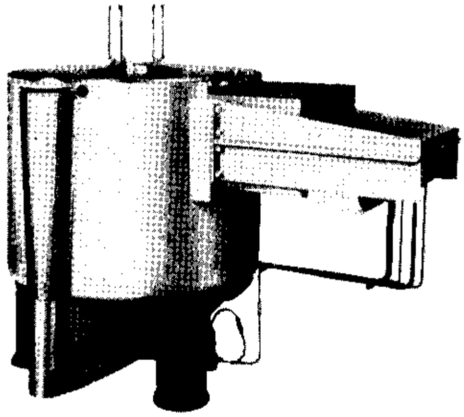


Fig. 4. Room irradiation plant.

All movements on this plant are actuated hydraulically. This applies to the radiation shielding drawer, the source raising mechanism by which the source is exposed in the irradiation cell, and the radiation shielding door to the cell. The shielding is dimensioned for a maximum of 100,000 curies Co60. The radioactive source must be loaded into the shielding container in a hot cell; this applies to the 'Double Cell' unit as well.

Pilot Plant

Flexibility is the special characteristic of these plants. Though they still belong to the laboratory plants, being particularly ideal for large-area test rigs under a wide range of irradiation conditions, they can also be employed for prestudies on the subsequent use of a commercial installation.

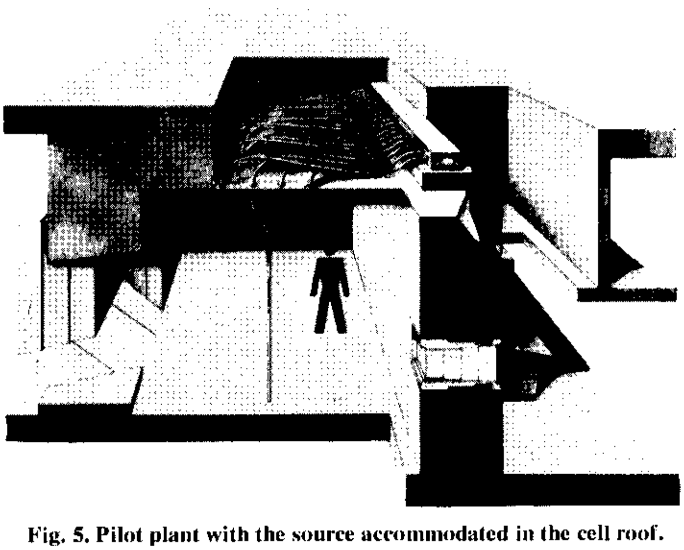


Fig. 5. Pilot plant with the source accommodated in the cell roof.

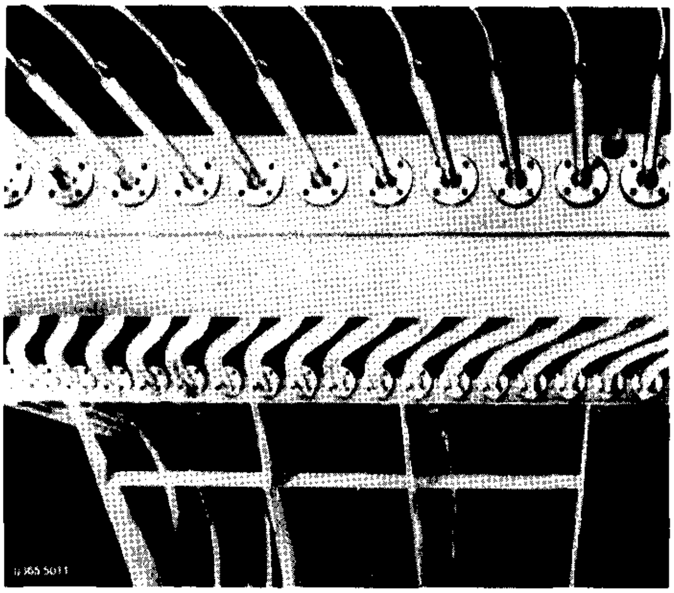


Fig. 6. Equipment of a pilot plant, recessed into the roof. Cooling box with piping for a pilot plant with 20 sources.

Irradiation is applied in a special irradiation cell provided with concrete shielding. When not in use the sources are stored in a cooled box inside part of this shielding; for irradiation duty they are run out into the irradiation cell in specially designed guide tubes (Fig. 5).

Features of the pilot plant are:

It can be built for any number of sources between 1 and 40, and these may be loaded with different isotopes of different activities.

The irradiation cell is absolutely free of obstructions for setting-up test rigs, because the sources are kept inside the concrete shielding.

Thanks to the flexible sources, the source geometry can be tailored to suit each test.

The plant can be extended on the module system, the only requirement being that all elements needed for the maximum number of sources must be installed in the shielding right from the start (Fig. 6).

The sources are loaded into the plant with a separate source transport container; this can be done straight inside the shielded irradiation cell.

Two plants of this kind have been supplied to the Farbwerke Hoechst in Germany, where they have yielded very good results. Moreover some interesting projects are in process of gestation.

Industrial-scale irradiation plant with vertical conveyor system (Figs. 7 and 8)

In 1965 we supplied one of these industrial-scale plants to the firm of B. Braun, in Melsungen, Germany. This installation is employed primarily for the sterilization of catgut, and it is designed to take a maximum loading of 60,000 curies Co60[1].

The material to be irradiated is placed in containers on a roller conveyor in the preparation room. These containers are accepted at intervals by the vertical conveying system in the irradiation cell, which takes them past the radiation source altogether eight times, at various distances and in different attitudes. Finally they are returned back into the preparation room on another roller conveyor.

The rod elements of the source are delivered in a separate transport container, from which they are loaded into the source holder through the concrete shielding 1·70 m thick. The source holder has more than 70 channels, in which the rods can be arranged at will (Fig. 9).

'Unicell' industrial-scale irradiation plant

At the present time we are working on the development of a new major industrial plant. In contrast to the installation just described, the movement of material will be horizontal chiefly in this new plant.

The 'Unicell' plant will feature:

Special suspended frames taking the individual irradiation containers past the source at various distances. The frames have more than one level, and every irradiation container has to be led once through the irradiation cell at each of these levels. The containers are switched from one level to the next outside the cell.

Close spacing between the individual frames, so that hardly any radiation is lost between the containers.

Entry of the frames into the cell as well as their exit from it will be effected through rotary cylinders or else labyrinth passages, with a horizontal conveyor system installed in them.

The rotary cylinders are filled with shielding material, and are recessed to take the frame device. Besides economizing with space they also provide shielding. Each frame is advanced into the irradiation cell by turning the cylinder 180°. This system is superior above all where certain temperature conditions have to be maintained in the irradiation cell, because very good sealing of the cell is ensured. In one version the source geometry can be determined with individually controlled separate source elements, as in the pilot plant. This facility is particularly appreciated when series tests are to be performed in the 'Unicell' as well as continuous irradiation. Odd source elements can then be retracted into the shielding, or transferred into another room if the appropriate arrangements are provided.

Another version embodies the compact source-wall, which is shielded either in a water tank located below the irradiation source or else in a dry pit. This layout is employed mainly with very high activities, or where only one particular material is to be irradiated and the activity does not have to be varied at all during production. The would-be owner of an industrial irradiation plant is interested primarily in the level of the operating

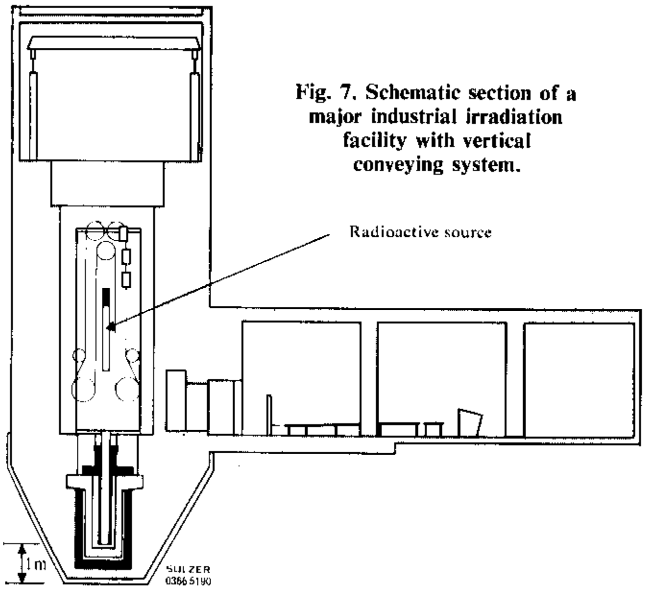


Fig. 7. Schematic section of a major industrial irradiation facility with vertical conveying system.

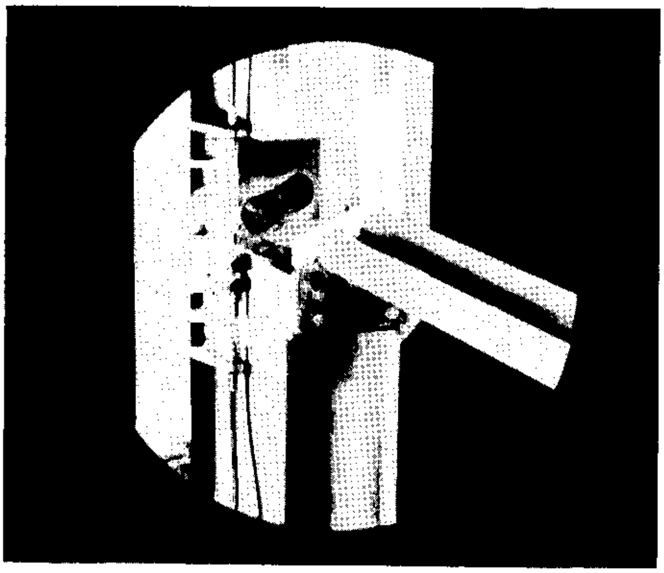


Fig. 9. View through the radiation shielding window 1·5 m thick from the loading room, showing part of the source holder in the irradiation cell.

costs. What are the factors chiefly influencing the irradiation costs?

With increasing isotope source activity there is a much less than proportionate rise in plant costs. For an installation using Co60, doubling the capacity means only a 30% rise in the investment costs—disregarding the cost of the radiation source. Thus the first requirement for low irradiation costs is a big plant.

The prominence assumed by the fixed operating costs may be illustrated with the following example: In a given irradiation plant the sterilization of a kilogram of material in three-shift operation works out at only 40% of the cost in single-shift operation.

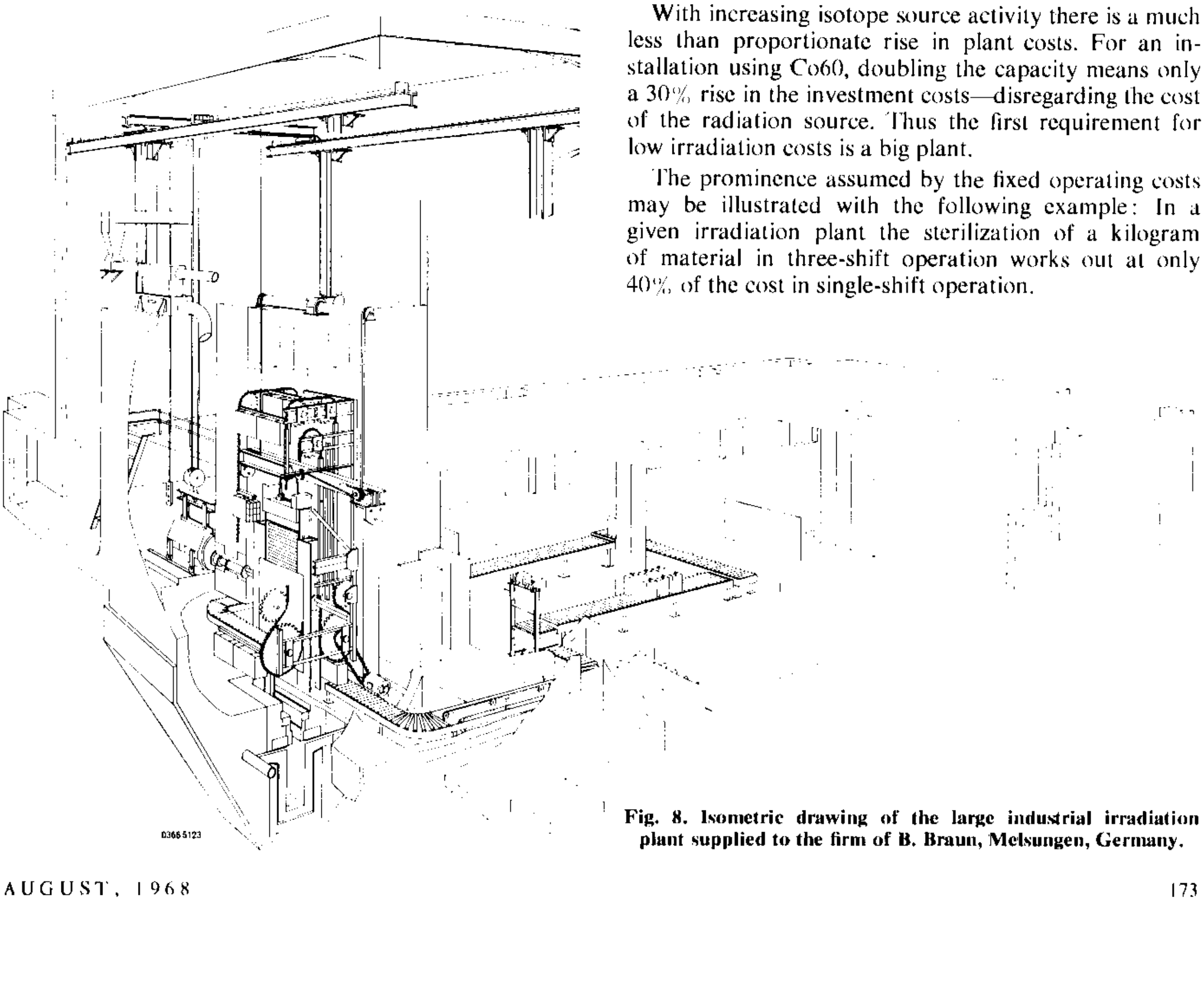


Fig. 8. Isometric drawing of the large industrial irradiation plant supplied to the firm of B. Braun, Melsungen, Germany.

Because an isotope source is decaying and giving off energy continuously, an irradiation plant should be utilized for as much of the time as possible. But if a large-capacity installation is to be fully exploited, it must be capable of fully automatic operation besides being versatile[2].

The efficiency of the plant—in other words the degree of exploitation of the radiation—is governed by the density of the material, the layer thickness and the arrangement of the material in the cell. Low-density materials absorb little radiation, and this means that they need irradiating with higher activities or for longer intervals compared with material of higher density having the same layer thickness. It follows from this that the biggest layer thickness possible should be chosen for low-density materials. But another problem is that high homogeneity is usually demanded of the irradiation, in other words the tolerance between the maximum and minimum absorbed doses should be as narrow as possible. Normally the ratio between the two ranges from 1·1 to 1·3. Now the thicker the layer is, the more difficult it becomes to achieve this tolerance dose. Thus allowance must be made for both efficiency and homogeneity in the design and optimation of a plant.

Duties performable with Sulzer Plants

Radiosterilization

At the present time the sterilization of catgut and surgical instruments is probably the most advanced application field for ionizing radiation. The process is applied chiefly to catgut and certain disposable articles, such as syringes, cannulas, infusors, scalpels—and recently hospital bed linen for use once only.

Conventional sterilization has certain inherent shortcomings. Catgut threads for instance acquire negative mechanical properties, sometimes becoming brittle as a result of inexpert sterilization by heating, while heat-resistant bacteria may survive. Moreover it has been shown that some patients are allergic to sutures sterilized in this way. And gas sterilization, by which the articles in question are welded into bags of very thin polyethylene, ensures sterility only for a limited period of time.

In general the conventional methods of sterilizing highly infectious organic materials call for meticulous care during the process. Thus these sutures must be produced in rooms as germ-free as possible, to ensure that their purity is not impaired in the course of production. This requirement places exacting demands on the air conditioning and ventilation of the work rooms, as well as on the actual manufacture and processing of the sutures.

All these drawbacks can be obviated to a large extent by making use of gamma rays. Furthermore sterilization by irradiation enables new and practical packages to be introduced, with a more rational flow of production. Thus both technical and commercial considerations favour the use of gamma radiation for sterilization:

Catgut and other disposable surgical articles can be sterilized already sealed in airtight packs. This greatly simplifies the whole production sequence and leads to substantial savings.

The margin between sterilization and damage to material is much wider; as much as 15 to 20% overdoses cause no damage. Resorption too is greatly improved. Reaction by the tissues is slight, and the wound heals in less time.

Another application for sterilization is the disinfection of animal hairs. This is already being practised in Australia on a large scale for example.

In general the hairs from goats, horses and other animals processed by horse-hair and other hair yarn spinning mills, as well as felt and carpet mills, are imported from countries like China, Pakistan, Persia, Turkey etc. Handling these materials is accompanied by the risk of anthrax infection, which often leads to fatal results. To prevent such infection, many countries have introduced laws and regulations making the disinfection of animal hairs obligatory. Experience has shown that irradiation plants with a capacity of 5,000 to 10,000 tons are able to compete on price with conventional procedures.

Irradiation of foodstuffs

The idea of irradiating foodstuffs probably originates from France, for a patent application in this sense was lodged there as long ago as 1930. Since then, intensive and promising work has been performed in many other countries on this problem. The fear often voiced that irradiated foodstuffs might be radioactive is of course groundless. It goes without saying that for any product of this kind an irradiation treatment is chosen which rules out this risk.

Without doubt the best known application is the irradiation of potatoes to inhibit sprouting. In the United States, Canada and the Soviet Union for instance, irradiated potatoes are released for retail sale. Doses between 10,000 and 20,000 rad will prevent germination, so that the crop can be kept under normal storage conditions from one season to the next without sprouting or deterioration.

In some countries irradiation is even being used for the storage of cereals, instead of conventional gas ventilation.

It is particularly effective in tropical countries, where up to 30% of the stored harvest may be lost to attack by insects and bacteria. By resorting to irradiation these losses can be almost eliminated. Against the background of the world nutrition problem, this opens up important prospects.

But the irradiation of fruit and vegetables is also meeting with growing interest, for the storage life achieved with these products using conventional methods leaves room for improvement. In particular, exceptionally

Some applications

Gamma irradiation of foodstuffs

Purpose	Effect	Dose needed
Extended storage life for root vegetables, such as potatoes and onions	Inhibited germination	0·01 Mrad
Disinfestation of silo cereals	Destruction of insects	0·02 Mrad
Extended storage life for fruits	Destruction of fungi	0·1–0·5 Mrad
Prevention of food poisoning due to salmonella (e.g. meat, eggs)	Destruction of salmonella	0·5–1·0 Mrad
Prolonging the cold storage (0–4°C) of meat and prepacked fish	Big reduction of decay-inducing bacteria, principally in vegetative form	0·3–0·5 Mrad
Sterilization of meat for storage at room temperature)	Destruction of micro-organisms and parasites	4–6 Mrad

high losses are sustained year in and year out due to the perishing of fruit. Statistics have been gathered in the USA on the losses by perishing.

Tomatoes	16%	Peaches	9%
Strawberries	15%	Oranges	2%
Grapes	11%		

According to estimates by the US Department of Agriculture, on the average 11% of the total American fruit crop is lost by decay in the course of distribution and retailing. In 1963 this represented a value of 1,100 million Swiss francs.

If fruit and vegetables could be kept only a few days longer—and with some varieties this has already been achieved by irradiation—then the losses would be largely eliminated. Namely in Switzerland this is of prime importance with strawberries for example, whose storage life can be lengthened by some 15 to 20 days. Tomatoes can be kept as much as 1½ to 2 months longer.

Very similar problems are encountered in the meat and fish trades. The extensive network of refrigeration facilities needed for distribution over long distances—especially with fish—is not always available. For that reason it is intended to install irradiation equipment on fishing vessels, in order to minimise losses by putrefaction.

With certain meat products complete sterilization can also be achieved by irradiation, though higher doses must be applied since every organism must be killed off. Products treated in this way can be stored at room temperature over extended periods without any signs of deterioration. At a symposium held in Karlsruhe last year, American contributors handed round ham for sampling which had been irradiated 21 months previously with 5·6 Mrad and subsequently stored at room temperature. Its quality was still judged to be excellent!

In Switzerland too, investigations are in progress on the irradiation of foodstuffs. For example a Federal commission on the irradiation of foodstuffs formed some time ago is participating in an international experimental program to evaluate the irradiation of fruit juices for preservation purposes. This work is being carried out by the Austrian reactor centre in Seibersdorf. The commission also initiated the first tests on the irradiation of tomatoes and strawberries. At present the construction of a major irradiation facility in the vicinity of Zurich with a maximum activity of 500,000 curies Co60 is under discussion.

Insect control

Experience has shown that individual varieties of insects cannot be combated with insecticides without undesirable side effects appearing. One should only recall that these chemical substances are deposited on soil, plants, fruits and vegetables, and have often produced deleterious secondary effects. Selective attack is impossible by this approach.

Recognition of this fact led to a search for new methods, and a highly effective procedure has been evolved making use of gamma rays. Paradoxically it involves breeding a large number of male insects of the variety which is to be combated. Shortly before the pupae emerge they are sterilized by means of gamma irradiation. After emerging from the chrysalis they are released from aircraft, to mate with the females living under natural conditions. Owing to their sterility, however, no offspring results from these unions. If the procedure is repeated for two or three generations, on the strength of mathematical probability the variety in question may be expected to become extinct in the area subjected to this treatment.

This method is already being applied with success against citrus, cotton, tobacco, olive, and tsetse flies, mosquitos and other insects.

Plant mutations

Tests have demonstrated that mutations can be induced in plant species by irradiating the seed. Among other things this makes it possible to breed cereal varieties better adapted to climatic conditions, for example a short, thick stalk for regions exposed to winds. Experiments on these lines have already been made with ground nuts, producing nuts two or three times the usual size.

Radiochemistry

The possibilities of employing radiochemical processes on an industrial scale have been the subject of lively discussions in recent years. Out of the great number of reactions involving gamma radiation investigated, for the time being only those with a high G value have any prospect of being exploited technically.

One field whose importance has been recognized only very recently is radiation-induced ionic polymerization.

Mechanisms of this nature have been discovered also in monomers reacting radically at normal temperature, such as styrol. Water, which acts as a cocatalyst in conventional ionic polymerization, is probably a powerful inhibitor often in radio-polymerization, so that products with low molecular weights and smaller conversions are obtained.

Irradiation of plastics: During recent years the irradiation of plastics has passed from the development phase into industrial production. Special use is made of the cross-linking of the macromolecules in the irradiation of organic high polymers.

In the cross-linking of polyethylene the following properties can be enhanced by irradiation with doses from 1 to 2 Mrad: plastic flow at elevated temperature, swelling capacity and solubility in numerous solvents, tensile strength, hardness and modulus of elasticity; while the susceptibility to tension cracks is reduced. Surface layers undergo changes moreover, so that plastics lend themselves better to printing or else graft polymerization becomes feasible. These improvements in quality may be exploitable in the form of material savings for example.

To mention only one application, shrunk polyethylene and shrunk tubes are now being turned out on a large scale for the production of cable connections. The temperature resistance of polyethylene-insulated cables is improved by this process. Large quantities of such cables can be employed in aircraft construction, for duties involving temperatures up to 250°C.

Irradiation of wood: To obtain improved properties in wood, a new radiochemical process has been evolved. The fluid present in the wood is extracted under vacuum. After this treatment it is then impregnated with a monomer, which is polymerized by subsequent irradiation. The result is a wood of higher strength, possessing other properties besides:

The wood neither distorts nor shrinks.

Material is economized by the enhanced quality.

It is proof against woodworm.

If a dyestuff is added to the monomer, no further paint finish is necessary.

Irradiated wood is employed as flooring, for furniture, in the construction of houses and flats—especially in the tropics, for shutters and outside weatherboarding for homes.

According to American reports, the hardening associated with polymerization treatment can be attained with much smaller doses of gamma radiation than those applied until recently. In many cases 0·5 Mrad is sufficient to obtain the desired effect, representing only 25% of the dose applied originally. This achievement is due in part to chemical additives in the plastic compounds, which act as catalysts. Thus the upgrading of wood into a material having predetermined properties is well on the way to becoming an economically viable process.

Detergents: To combat the contamination of water supplies, the detergent industry has introduced products manufactured by radiochemical means and amenable to biological decomposition. In these detergents, which are designated SAS (sodium alkane sulphonate), gamma radiation is used to trigger off a sulphonation process, through which a hydrocarbon fraction is formed that inhibits foaming in water.

Among other firms, Farbwerke Hoechst is carrying out investigations in this direction, using an irradiation plant supplied by Sulzer.

Rubber vulcanizing: For some time now attempts have been in progress to find a better way of vulcanizing rubber. At present sulphur provides the indispensable catalyst, but it has a negative influence on the quality of the end product. Large-scale investigations have now revealed that the requirements can be fulfilled without deleterious side effects by means of polymerization set in motion by gamma radiation and leading to vulcanization. Car tyres have already been produced experimentally in the Soviet Union by this process; a quality improvement of some 20 per cent was ascertained.

Among other possible applications, work is in progress at the present time on the production of lubricating oils using gamma radiation. Owing to stabilization of the viscosity, the viscostatic properties of the oils are improved by grafting-on vinyl compounds.

Very intensive efforts are being made also in the field of natural and synthetic latex emulsions, which are employed as paint finishes and form cross links upon drying at ordinary temperatures.

In the textile industry attempts are being made to bring about fibre modifications—particularly in polyesters—by adding unsaturated bifunctional acids, glycols and other substances which promote cross-linking under the action of gamma radiation. Such products have a higher softening and melting point, enabling blended fabrics with cotton having improved washing characteristics to be turned out for example. The modifications are induced in the fibre production stage, irradiation being applied to the cones. Relatively small doses are needed, for a chain reaction is set in motion.

Future Prospects

The use of gamma radiation on various areas is opening up new vistas for many industrial processes. Radiosterilization—already pretty familiar—should find increasing application in industry. In foodstuffs irradiation, preliminary investigations are already concluded in some cases. Intensive work is going on in other fields too, such as the irradiation of wood-and-plastic combinations. Further development may be viewed with confidence.

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The Metric System

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YOU WILL recently have been aware of an increasing amount of space given in the National Press to the adoption of the Metric System. This will affect in time all walks of life in the U.K. but it is probably the Engineering Industry that will undergo the most radical changes.

How did we arrive at this decision to adopt such a system?

The Confederation of British Industry in 1965 consulted its member firms and found the majority view was that a change to the metric system was inevitable and that it should be introduced as soon as is practicable in the U.K. In May, 1965, the President of the Board of Trade announced in the House of Commons that the Government had been impressed with the case put to it by the C.B.I. and they would encourage industry to effect the major part of the change by 1975. If a cross section of technologists were asked what they understood by 'the metric system' it would probably be true to say that different definitions would be given depending upon whether the training undergone had been mechanical or electrical; engineering or scientific. The purpose of this article is to explain the basis and implications of the international Metric System or to give it its correct title, S.I. Units, which we as practising Engineers will have to put into effect. To do this successfully it is as well to trace the history of measurement systems on this universe.

History of measurement systems

To get an idea of size, man has always compared himself with things around him. More particularly he has compared the size of objects with his own hand, finger, foot and arms (e.g. the yard was supposedly the distance between the nose and the tip of the fingers of one arm extended). From about 1500 up to the present date, two main systems have been the preferred systems of weights and measures viz. the imperial system and the metric system. Each system has appeared in many guises depending upon whether the engineers gravitational units or the scientists absolute units or the particular requirements of the mechanical engineer or the electrical engineer were met.

The first standard yard dates from 1496 and evolved into the 'Imperial Yard' of 1855 which became the basis of all length measurements in this country. However multiples and sub-multiples of the yard and of other quantities (e.g. weight) used in the 'Imperial' system are arbitrary, e.g. there are multiples of 3, 12, 14, 28, 112 and 1760 and sub-multiples of $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$ etc.

From the first, the metric system has been a consistent system even though the selection of the unit length and weight might at first be thought just as arbitrary as the comparable inch in the Imperial system. Nevertheless some attempt at a scientific basis was made in the selection and the system did adopt a uniform multiple or sub-multiple factor of 10. This system originated in 1791 from a report of the French Academy of Science who recommended that the measurement of lengths should be based on the length of a quadrant of the earth's circumference measured along a meridian (i.e. the longitudinal line from the pole to the equator), the intention being that a metric was to be one ten millionth of this distance.

From the metric measurement of length, the cgs (centimetre, grams, second) system was developed in the nineteenth century and then later the MKS (metre, kilogram, second) system in 1908 with a further offshoot in 1919 known as the Metric Technical System. (This employs the engineers' 'Kilogramme force' which involves standard gravitational acceleration, i.e. 1kgf = 9·81 newtons).

About this time, Professor Giorgi put forward the MKSA system which is based on the MKS system with the addition of a further basic unit (i.e. Amp) for electricity and magnetism. This system was adopted for use by members of the International Electro-Technical Commission and is well known to practising electrical engineers in this country today.

The Imperial or FPS (foot, pound, second) system has remained the 'preferred' system in the U.K. but, before the Government announcement in 1965, a considerable body of opinion had swung round to the view that in the long term it was essential that an internationally agreed system of weights and measures should become the system here. Why should the metric system gain favour over the imperial system for international use? Over the last century, many countries have been adopting some form of the metric system and it is estimated that about 85% of the world's trade is carried out in this system in one form or another. Clearly however in these days of closer communication between countries and the block mergers such as the European Common Market and the European Free Trade Association it is essential that a common language of units should be adopted in order to try and abolish the independent and unrelated systems already created for the needs of the engineer and the scientist.

The metric (S.I. units) system

After much international discussion it was decided to adopt a logically derived system based on the MKSA

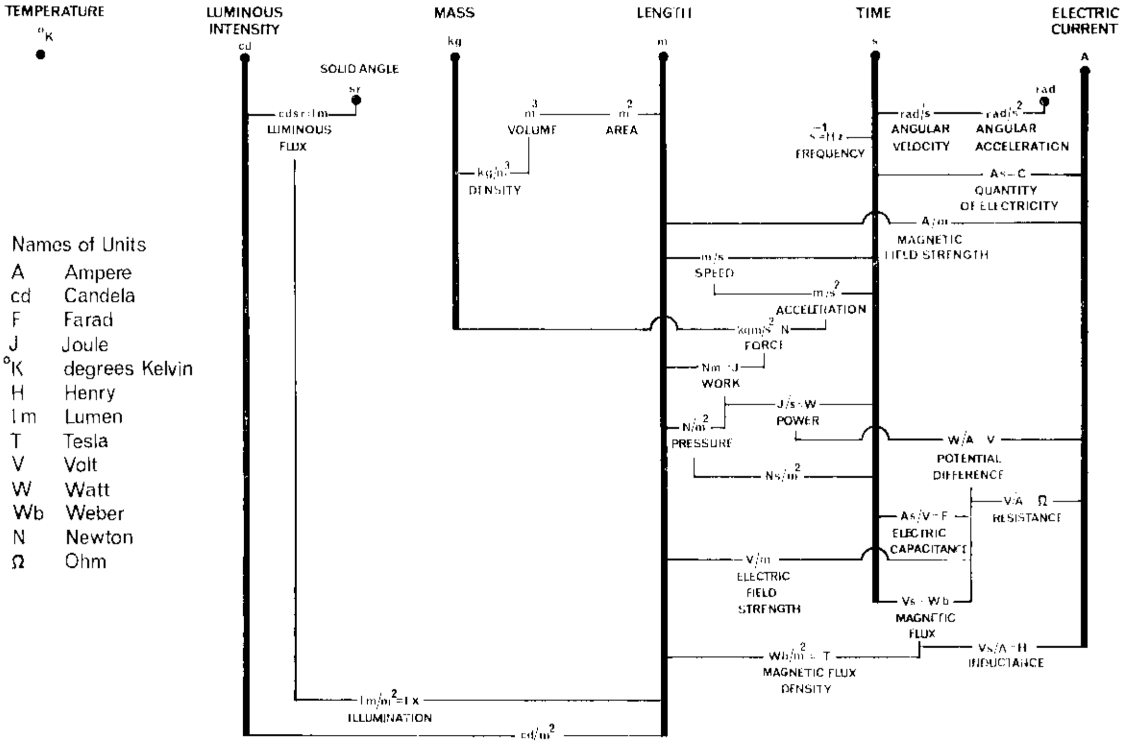

Fig. 1. The S.I. Units Family Tree.

system. This system, the 'Système International d'Unités' was accepted at the Eleventh Conférence Générale des poids et Mesures (C.G.P.M.) in 1960. This system is now referred to in this country as S.I. Units.

The S.I. system is built up from the following six basic units:

Description	*Name*	*Symbol*
Length	Metre	m
Mass	kilogramme	kg
Time	second	s
Electric Current	Ampere	A
Temperature	degree Kelvin	°K
Luminous Intensity	candela	cd

The first four units above correspond to the four basic units of the MKSA system to which have been added two further units for defining relations in thermodynamics (°K) and visible radiation (cd).

Other units are derived from these basic units (see Figure 1). To complete the system, two further or supplementary or 'non-derived' units have been added, namely the 'radian' and the 'steradian' to cover angles.

The magnitude of the unit can be varied by multiplying the unit value by some power of 10 (see Figure 2). The magnitude should be selected as far as possible from a preferred range in which the factor is $10^{\pm n}$ (where n is a whole number and a multiple of 3 (i.e. 3, 6, 9, 12 etc.). An example is 3,000 metres per second which should be expressed as 3×10^3 metres per second or 3 kilometres per second. Figure 2 also shows some common everyday examples for some of the multiples.

Other important guide rules that have been established in the use of units are that when you have a numerator and a denominator, it is only the numerator that has the multiple or sub-multiple prefix (e.g. $MN/^2m$ not N/mm^2 .... see also the point made about this unit further on in this article) and that compound multiplying prefixes must not be used: thus we write nm (nanometre) not mμm and Gg not Mkg. This then is the S.I. Units system. Its advantages are that it offers greater simplicity, compared with present systems, because it is a rationalised selection of known metric units which preserve the principle of coherence by deriving from 6 basic units + 2 supplementary units, for all the quantities required for scientific or engineering use on an international basis. To help to illustrate this point, Figure 3 shows a comparison of commonly used units, both the old (F.P.S. and Metric) and the new (S.I. Units). You will notice from this table that S.I. states a common unit for energy and one for power ... an advantage that the other systems shown in the table cannot boast. In addition such derived units are derived from the basic unit by a direct relationship and not through arbitrary conversion factors. Reference once again to Figure 1 proves this point.

The Table (Figure 3) indicates that some systems are classified 'absolute' and others 'gravitational', the S.I. Units system being an 'absolute' system. A word of explanation should be given here on this point. Gravitational systems introduce gravity into their basic unit of force i.e. the force which will accelerate a Unit mass at standard gravitational acceleration ($32{\cdot}2ft/s^2$ or $9{\cdot}81$ m/s^2). The S.I. system employs a basic unit of force (the

Fig. 2. The Internationally agreed Multiples and Sub-Multiples.

Factor by which the unit is multiplied		Prefix	Symbol	Common everyday examples
One million million (billion)	10^{12}	tera	T	
One thousand million	10^{9}	giga	G	gigahertz (GHz)
One million	10^{6}	mega	M	megawatt (MW)
One thousand	10^{3}	kilo	k	kilometre (km)
One hundred	10^{2}	hecto*	h	
Ten	10^{1}	deca*	da	decagramme (dag)
UNITY	1			
One tenth	10^{-1}	deci*	d	decimetre (dm)
One hundredth	10^{-2}	centi*	c	centimetre (cm)
One thousandth	10^{-3}	milli	m	milligramme (mg)
One millionth	10^{-6}	micro	μ	microsecond (μs)
One thousand millionth	10^{-9}	nano	n	nanosecond (ns)
One million millionth (one billionth)	10^{-12}	pico	p	picofarad (pF)
One thousand million millionth	10^{-15}	femto	f	
One million million millionth	10^{-18}	atto	a	

*to be avoided wherever possible.

newton) which is independent of gravity and which will accelerate the basic unit of mass (the kilogramme) at the rate of the basic unit of length (the metre) per unit of time (1m/s²). If we express this in equation form, then:

$$F \propto Ma$$

In Metric Technical Units (Gravitational)

1 kgf = (1 kg x 9·81) m/s² (where 9·81 represents standard gravitational acceleration)

In S.I. Units (Absolute)

1N = 1 kg x 1 m/s²

It should be remembered in the foregoing that weight is a force which in S.I. Units is expressed in newtons and not a quantity of substance (mass) which in S.I. Units is expressed in kilogrammes. Unfortunately a lot of confusion arises over this point and regrettably the current Weights and Measures Act adds to the confusion by stating that both terms are synonomous. Whilst mentioning mass (the kilogramme), the author considers here lies one of the weaknesses of the system . . . the adding of a multiple 'kilo' to a basic unit. This is a current topic which has been well ventilated recently in the technical press correspondence columns without unfortunately any national success. 'Einstein' or 'burg' have been suggested as an alternative name to replace the kg. (mass) and 'styne' for kg (weight)—the latter as a new term to prevent confusion as to whether one is talking about mass or weight.

Having now discussed the framework of the S.I. Units system, we should now consider how we should apply it in our professional activities.

Practical considerations on S.I. units

The previous paragraphs indicate certain guide rules to follow and indeed the purist will argue that if we keep to these rigidly then we have the system working in its simplest form. Unfortunately it is not as straightforward

Fig. 3. Commonly used units of measurement.

	SI (Absolute)	FPS (Gravitational)	FPS (Absolute)	cgs (Absolute)	Metric Technical Units (Gravitational)
length	metre	ft	ft	cm	metre
force	newton	lbf	poundal (pdl)	dyne	kgf
mass	kg	lb or slug	lb	gram	kg
time	sec	sec	sec	sec	sec
temperature	°C, °K	°F	°F, °R	°C, °K	°C, °K
energy {mech. / heat	joule†	ft lbf Btu	ft pdl Btu	dyne cm = erg calorie	kgf m k cal.
power {mech. / elec.	watt	hp watt	hp watt	}erg/s	metric hp watt
electric current	amp	amp	amp	amp	amp
pressure	N/m²	lbf/ft²	pdl/ft²	dyne/cm²	kgf/cm²

†1 joule = 1 newton metre or 1 watt second

as this and certain adaptations and compromises are necessary.

The realist has pointed out that many units are so totally ingrained in our life because of their social or commercial importance that they cannot lightly be discarded. The prime example obviously is the year, month, week, day, hour, minute. Similarly the circle of 360 degrees is another one that will be retained. So the first departure from a 'pure' system is the continued use of certain 'non S.I. Units'.

Discussions are still in progress on the preferred magnitude of units to be adopted for Pressure and Stress. For Pressure, present national thinking seems to favour the use of N/m^2 for calculations etc. whilst for practical purposes a unit expressing greater magnitude equating to about 1 atmosphere ($14{\cdot}7 lbf/in^2$) is required and as a result the 'bar' ($= 10^5 N/m^2$) with possiby its own derivatives (millibar, hectobar) may shortly be introduced. In addition to this it should be understood that the existing metric using countries will have to make sacrifices in bringing their units into line and the old unit of pressure under the Metric Technical Units system was the kgf/cm^2 which, within 2%, equates to the 'bar'.

In the field of stress, the basic unit once again should be the N/m^2 but in measuring a tensile strength for instance it is argued that a square metre is too large an area to which to equate a value so present national opinion favours the use of the N/mm^2 . . . this incidentally bears a relationship of 9·81 with the kgf/mm^2 (Metric Technical Units) which has already for some years found favour in ISO Recommendations for Iron and Steel products. So you see in the area of pressure and stress the contingencies of existing practices have forced opinions which contravene the carefully knit system which has been set up. The author who practices as a mechanical engineer finds that this area of pressure and stress with the abandoning of a lifetime habit of using gravitational units of force perhaps the most difficult part of the system (as proposed nationally) to get over to people.

The last unit which requires special mention is the measurement of temperature. The basic unit is an absolute unit (°K) which when compared with the customary temperature (celsius —°C) equates to °C + 273·15. Whilst °K will be used for thermodynamic calculations, the customary temperature of °C will continue for many years. We should now consider the whole system as applied to professional problems. Obviously a system as new as this cannot be learnt overnight so for a trial period it may be preferable to add the existing imperial units against the S.I. Unit. In this respect it is interesting to see the National Physical Laboratory communication on Pg. 18 of the January/February edition of 'The Quality Engineer' which adopts this technique.

This practice should only be adopted for a very limited period otherwise we will suffer the failure similar to that of the BBC in their continued prolification of °F/°C in weather forecasts.

This particular N.P.L. article also illustrates another point on the conversion. This is a conversion to a metric module or concept and not just a straightforward 'arithmetical' conversion. For instance the measurement of 1 inch which equates to 25·4 millimetres exactly would in a metric concept be translated to 25 or 26 millimetres To get the full benefits of rationalization, B.S.I. have in preparation a standard giving a list of 'preferred numbers' to be used as the basic sizes for selection for engineering purposes.

When converting, it is essential that where this has to be carried out, a common set of conversion tables should be used. The author recommends here that reference be made to B.S.350 Pts. 1, 2 and 3 (Conversion tables).

In calculations, the simplicity of the system comes into its own. It is advisable to work in basic units multiplied by the relevant power of 10 rather than to work in multiples and sub-multiples. To end this article, a simple structural example is given using an imperial problem and converting to S.I. Units. This problem adopts the continental system of using a comma as the decimal sign which is now currently seen as a logical consequence of Great Britain's decision to move generally to the system of weights and measures in metric (S.I.) units.

Example: Calculate the deflection at the end of a cantilevered beam 10 ft. long supporting a weight of 1 ton force at its extremity, ignoring the weight of the beam and given $E = 30 \times 10^6 lbf/in^2$; $I = 69{\cdot}2\ in^4$
Converting the data to a consistent set of S.I. Units:

$$W = 1\ tonf = 9964{,}02N = 9{,}964\,02 \times 10^3 N$$

$$L = 10ft = 3{,}046m$$

$$E = 30 \times 10^6 lbf/in^2 = 30 \times 10^6 \times 6{,}895 \times 10^3 N/m^2$$

$$I = 69{\cdot}2\ in^4 = 69{,}2 \times 41{,}623\,2cm^4$$

$$= 69{,}2 \times 41{,}623\,1 \times 10^{-8} m^4$$

(note here that $1cm^4 = 10^{-8} m^4$ not $10^{-2} m^4$).

Having got all our units into basic S.I. you will note from the formula below how the powers of 10 cancel themselves out then Formula for deflection $= \frac{WL^3}{3EI}$

$$= \frac{9{,}964\,02 \times 10^3 \times (3{,}048)^3}{3 \times 30 \times 10^6 \times 6{,}895 \times 10^3 \times 69{,}2 \times 41{,}623\,1 \times 10^{-8}}$$

$$= 0{,}0158m$$

$$= \underline{15{,}8mm}$$

In practice values such as Young's Modulus, the Second Moment of Area etc. will in due course be obtainable in S.I. Units thus eliminating a lot of the steps taken above. If this problem was worked out in existing inch units then W = 1 tonf would have to be converted to pounds by the arbitrary constant 2240 and

L = 10ft has to be converted to inches by the arbitrary constant of 12 thus illustrating the non-coherence point made earlier.

This article has given a brief introduction on the new International Metric System which is now here to stay, and has discussed at length some of the problems that may arise. Nevertheless these problems concern only a few units out of a multitude of derived coherent units. We are the unfortunate generation who having been taught one system are now faced with the difficulty of learning and thinking in the new system. Let us accept this as a challenge for when we have mastered it we shall be thinking in terms of an international 'language' for weights and measures in both our domestic and professional lives.

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The Protection of Domestic and Industrial Electrical Installations

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APPENDICES—PART 4

APPENDIX "A"

Measurement of Earth-Electrode Resistance

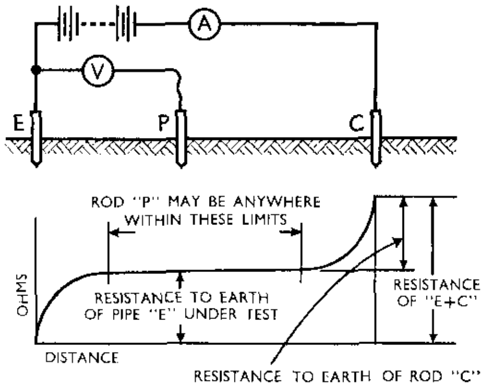
(See I.E.E. Regulation E.5 and Appendix 6)

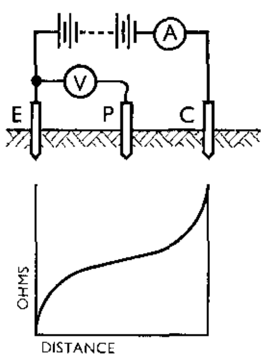
As can be seen from Figs. 1 and 2 in pages 98 and 99, the effective resistance area of an earth electrode extends for some distance around the actual electrode; but the surface voltage dies away very rapidly as the distance from the electrode increases.

If it is desired to measure the actual earth electrode resistance, the method basically adopted is to pass current into the soil by way of the electrode concerned and then to measure the voltage needed to produce this current. This basic circuit is shown at Fig. 27. Provided the distant rod "C" shown in this diagram is sufficiently remote from the electrode under test, it will be possible so to position the potential electrode "P" that the measured voltage (V) remains substantially constant when "P" is moved slightly nearer to, or further from, "E."

To meet this requirement, the current electrode, "C," must be far enough away from the electrode under test, "E," to ensure that the two resistance areas effectively do not overlap. This means that the resistance curve must have a portion which is nearly horizontal, as shown at Fig. 27.

The potential electrode "P" must be placed outside the resistance areas of both "C" and "E." In other





(Above): Effect of the position of distant rod (C) on resistance measurement. (At left): Resistance curve has no horizontal portion if the rod (C) is too near (E) and the two resistance areas overlap.

Fig. 27.

words, it must be sited somewhere within the horizontal portion of the resistance curve. For practical purposes a spacing of 100 to 150-ft. between "E" and "C" is normally sufficient to ensure that both these requirements can be met. Providing these requirements are met, the earth electrode resistance is then by the ratio $\frac{V}{A}$.

One difficulty about using the simple method of earth electrode resistance measurement shown at Fig. 27 is the fact that the effect of back E.M.F.'s—due to electrolytic action—have to be taken into account when testing. In addition, there is the possibility of stray currents being present in the soil due to leakages from distribution systems, etc. As a result it is becoming common practice to use specially designed instruments for earth electrode resistance testing, the Megger earth tester being a typical example of this type of unit.

The circuit diagram for a Megger earth tester is shown at Fig. 28. From this it will be seen that the hand-driven generator applies an alternating current to the various electrodes. This automatically compensates for the effect of any electrolytic back E.M.F. As far as stray currents are concerned, their immediate effect will be to cause the pointer to waver at certain handle speeds. It is only necessary either to increase or to decrease the speed of the generator handle in order to obtain a steady reading.

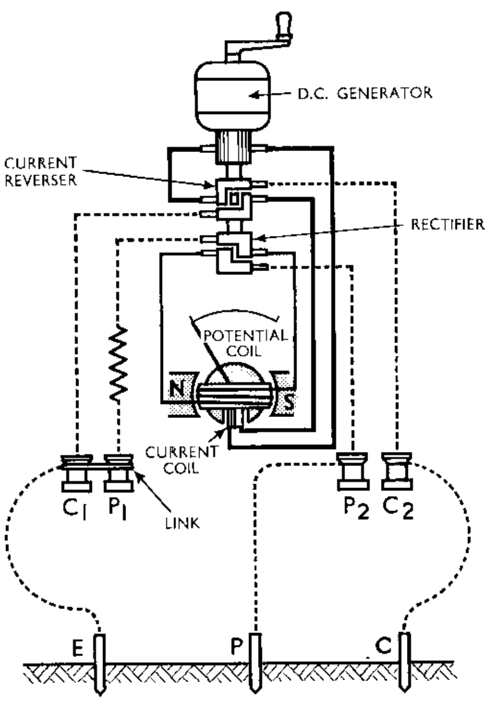


Fig. 28.

APPENDIX "B"

Measurement of Earth-Loop Impedances

I.E.E. Regulations F.4 and Appendix 6 recognises three basic methods of checking earth-loop impedances. These are as follows:

(*a*) Test of line-earth loop made by connecting line direct to earth through a known resistance.

(*b*) Test of neutral-earth loop made by injecting AC from a step-down transformer into the system.

(*c*) Test of neutral-earth loop made by injecting current into the neutral-earth loop from a DC source, the polarity of which is rapidly and continuously reversed.

Method (a)

In this method the earth-loop impedance testing instrument is arranged to apply a fault direct from line to earthed metalwork for a short duration of time (see Fig. 29). The fault current is limited by resistance R and the value of fault current can be ascertained by measuring the voltage V. From this data it is possible to calculate whether a direct earth fault would actually blow a fuse.

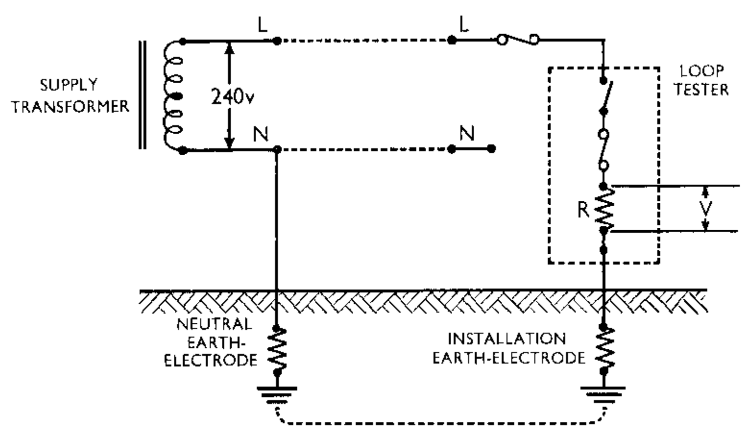
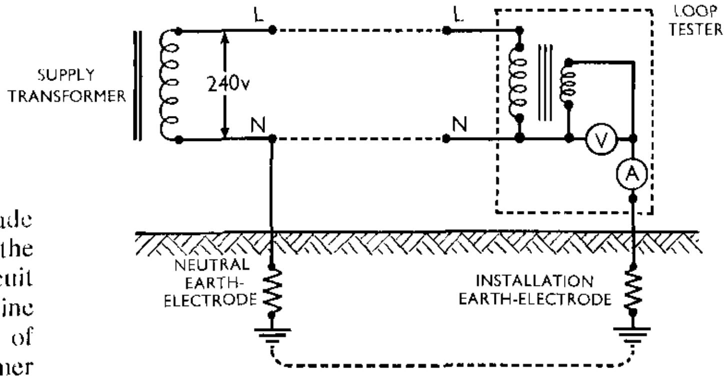


Fig. 29.

In practice, a number of resistances are usually available; the resistance corresponding to the rating of the protective device concerned is chosen for this test. Normally, no attempt is made to measure the voltage directly as it is only applied to the circuit for a fraction of a second. Instead of a volt-meter, an electronic indicating device may be used. This automatically indicates whether the momentary voltage across the resistance is large enough to correspond to a sufficiently low value of earth-loop impedance.

When testing in this way, precautions must be taken to ensure that, in the event of the earth circuit being defective, the voltage momentarily appearing on earthed metalwork cannot cause danger.

Fig. 30.



Method (b)

For this method of test, the basic assumption is made that the impedance of a loop path consisting of the neutral conductor and the normal earth return circuit is equivalent to that of a path consisting of the line conductor and the earth return circuit. This type of tester applies low voltage from a step-down transformer to this neutral-earth-loop—the earth-loop impedance being calculated from the current produced by a given voltage (see Fig. 30). In practice the tester normally incorporates a single measuring instrument scaled directly in ohms.

When using this form of tester, test currents of up to 25 amp. may be used to prove the effectiveness of the earth continuity conductors, although this heavy current normally flows only during tests on low impedance paths. With this type of instrument, the tester must be so arranged as to take account of the effect of neutral currents and voltage drop in neutral due to such currents. Furthermore, it is necessary to ensure that no danger can arise if the circuit is defective or if mains polarity is incorrect, etc.

Method (c)

In the third method, the testing instrument incorporates a hand-operated generator which produces a rapidly and continuously reversed direct current. This method also measures the neutral-loop impedance; not the true fault-loop impedance.

When using this instrument it is necessary to ensure, by inspection, that there is no form of inductor or choke in the earth continuity conductor. In addition, a correction should be made to take care of the impedance of any steel conduit or pipe which may be included in the total loop path. Details of the appropriate correction are given in the I.E.E. Wiring Regulations.

The rapidly reversed type of unit gives a reading which may be rendered indepedent of any variation, due to voltage-drop in neutral, by increasing or decreasing the speed of rotation of the generator handle.

In this method of testing care must again be taken to ensure that no ill effects can arise if the circuit tested is defective; the primary factor to be guarded against being the question of reversed polarity on the installation.

General

All three methods of test should give a reasonably reliable indication of whether fuses may or may not be relied upon to give an acceptable level of earth-leakage protection; but none of the methods of test necessarily demonstrate exactly where any high impedance is located if the loop-path impedance is too high. With the continuously reversed DC instrument, however, the tester may normally be used to check sections of the installation. If necessary, it may also be used as an earth electrode tester in order to check the impedance of the earth electrode. In consequence, this unit may normally be used to locate any high impedance in the earth-loop circuit.

It is also interesting to note that methods (*a*) and (*b*) can only be used when the installation actually is, or is about to be, connected to the mains supply. In other words, with these methods there is no possibility of the contractor carrying out a check on the effectiveness of the installation earth electrode prior to requesting a supply from the local supply authority. With the rapidly reversed DC method of testing, however, the contractor would normally be in a position to check whether all is in order at the installation end before a supply is requested.

With method (*c*) however, it must be realised that only very small test currents are used. In consequence, this method of test may well accept earth continuity paths of a very limited current-carrying capacity.

Methods (*a*) and (*b*) however, use much larger test currents, and so should detect any weak links in the earth-continuity loop path.

APPENDIX "C"

Comparison of Methods of Earth-Fault Protection for Electric Cookers

Statistics tend to show that the most prolific source of electric shocks, on the normal domestic installation, is the electric cooker. The following tables have therefore been prepared to illustrate and compare the degree of earth-fault protection afforded to a 30 amp. feed to an electric cooker by direct earthing and rewirable fuses (Table No. 1); by 30 amp. current-operated earth-leakage circuit breakers having a rated earth leakage tripping current of 500 mA (Table No. 2); and by 30 or 60 amp. voltage-operated earth-leakage circuit breakers so installed as to function at the 24 volt, 200 ohm level of sensitivity (Table No. 3).

TABLE No. 1. Protection by 30 amp. SEMI-ENCLOSED FUSE AND DIRECT EARTHING

Earth-loop Impedance (Ohms)	Earthing conditions (for 30 amp. cooker circuit)	Worst earth-fault condition liable to persist indefinitely		General observations
		Fault current (Amp.)	Shock voltage (Volts)	
0	Optimum. Cannot be achieved in practice.	50	0	Fault current is only limited by fault resistance.
1	Normal for 30 amp. circuit.	50	50	Shock voltages in excess of 50 volts may persist on installation metalwork until circuit fuse blows: 100 volts may well persist for about 10 sec.
2	Poor for 30 amp. circuit. (Unacceptable for 60 amp. circuit.)	50	100	200 volts may persist for about 10 sec.; full mains voltage for about 6 sec.
2·7	Limiting impedance permitted by I.E.E. Regs. (14th Edition) for 30 amp.	50	135	Full mains voltage may persist for about 10 sec.
4	Earth electrode or earth continuity conductor has deteriorated marginally.	50	200	Full mains voltage may persist nearly indefinitely. On anything but direct earth fault, fuse is unlikely to blow.
5	Earthing slightly worse. *Fuse will not blow even on direct earth fault.*	48	240	Fault current now limited by loop-impedance to a value insufficient to blow fuse. Highly dangerous fault conditions may persist indefinitely.

TABLE No. 2. Protection by 30 amp. CURRENT-OPERATED EARTH-LEAKAGE CIRCUIT BREAKERS

Earth-loop Impedance (Ohms)	Earthing conditions (for 30 amp. cooker circuit)	Worst earth-fault condition liable to persist indefinitely		General observations
		Fault current (Amp.)	Shock voltage (Volts)	
0	Optimum. Cannot be achieved in practice.	½	0	Compared with direct earthing, heating effect of max. sustained earth fault current is reduced in ratio of $(50)^2 : (\frac{1}{2})^2$, or 10,000 : 1.
5	Reasonably good earthing.	½	2½	At this moderate value of earth-loop impedance, protection by direct earthing is no longer possible.
10	Max. value normally encountered on industrial or commercial installations.	½	5	Excellent fire and shock risk protection.
20	Suggested working limit for 60 amp. current-operated e.l.c.b. protection for farm installations.	½	10	With 60 amp. unit, tripping at 1 amp. earth-fault current maximum sustained shock voltage still does not exceed 20 volts.
40	I.E.E. Wiring Regulations limit for 1 amp. tripping.	½	20	Even with 60 amp. unit, the maximum sustained voltage is still restricted to safe limit of 40 volts.
80	I.E.E. Wiring Regulations limit for ½ amp. tripping.	½	40	Cooker is still effectively protected against both fire and shock risk.
120	Earthing extremely poorly maintained.	½	60	Installation is still reasonably safe, with shock voltage still below European safety limit of 65 volts.

TABLE No. 3. Protection by 30 or 60 amp. VOLTAGE-OPERATED EARTH-LEAKAGE CIRCUIT BREAKERS

Earth-loop Impedance (Ohms)	Earthing conditions (for 30 amp. cooker circuit)	Worst earth-fault condition liable to persist indefinitely		General observations
		Fault current (Amp.)	Shock voltage (Volts)	
0	Optimum. Cannot be achieved in practice.	50 (50)*	0 (0)	As there is no voltage rise, fault current limitation is by sub-circuit fuse, as for direct earthing.
1	Excellent earthing conditions.	48 (50)	24 (40)	Loop impedance is assumed to be divided equally between installation earth and neutral earth.
5	Reasonably good earthing.	6 (10)	24 (40)	This assumes a neutral earth-electrode resistance of 1 ohm.
10	Max. value normally encountered on industrial and commercial installations.	3 (5)	24 (40)	This assumes a neutral earth-electrode resistance of 2 ohms.
20	Proposed practical limit for current-operated e.l.c.b. protection for farm installations.	1·5 (2·5)	24 (40)	This assumes a neutral earth-electrode resistance of 4 ohms. The level of protection is effectively equivalent to the 1 amp. 20 volt performance of a 60 amp. current-operated e.l.c.b. (Table No. 2.)
40	Reasonable parallel earth on instal-on installation.	0·7 (1)	24 (40)	Excellent fire and shock risk protection.
100	Degree of parallel earthing exists on installation.	0·3 (0·45)	24 (40)	Current through e.l.c.b. trip coil (about 50 mA) now becomes significant in relation to parallel earth current. Total undetected current is well below the ½ amp. and 1 amp. current operated e.l.c.b. level.
200	Negligible parallel earth on installation.	0·17 (0·25)	24 (40)	Normal operating conditions for the majority of voltage-operated e.l.c.b. installations.
500	Fortuitous parallel earthing exists.	0·10 (0·13)	24 (40)	Earth-leakage fire and shock risk completely negligible.
Infinity	Installation only earthed through e.l.c.b. trip coil.	0·050	24 (40)	Even if e.l.c.b. earth electrode deteriorates from 500 ohm to 800 ohm resistance, shock voltage will still be limited to about 60 volts.

*Values in brackets correspond to 40 volt, 500 ohm level of sensitivity.

From these tables, it is very clear that direct earthing is vulnerable to a relatively minor deterioration in the earth-loop path. It is also extremely vulnerable to interfering fingers. Any arbitrary uprating of the fuse—either by using a larger gauge of fuse wire or an extra strand of wire—and the fuse may very effectively have been prevented from blowing.

By comparison, both current-operated and voltage-operated units will continue to afford a very reasonable degree of protection, despite relatively gross deterioration of earthing conditions.

For the normal domestic 60 amp. service feed, the level of fire and shock risk protection afforded to the installation by the two types of earth-leakage circuit breaker, becomes roughly equivalent when the value of the earth-fault-loop impedance reaches about 20 ohms. Below this value, a 60 amp. current-operated unit, having a rated tripping current of 1 amp., will give the closer shock and fire risk protection. Above this value, the voltage-operated unit will give closer protection than the comparable current-operated unit.

APPENDIX "D"

Earth-Leakage Protection: A Summary

1. Voltage-operated earth-leakage circuit breakers operate by detecting any dangerous voltage which may appear on accessible installation metalwork. Current-operated units directly detect earth-leakage currents.

2. When correctly installed, both types of unit protect the installation against earth-leakage fire and shock risks.

3. Both types are instantaneous in operation (½ to ¾ cycle).

4. The degree of protection afforded is independent of the rating of any back-up fuses. It cannot be nullified by any arbitrary uprating or by tampering with these fuses.

5. Earth-leakage circuit breakers are virtually universal in application even in extremely poor earthing conditions.

6. They do not encourage the flow of high fault currents and so they reduce the risk of fire or damage.

7. Unlike fuse protection, they will detect high resistance fault conditions, thus ensuring excellent fire risk protection.

8. Earth-leakage circuit breaker protection, unlike P.M.E., may readily be applied both to new distribution networks and to extensions to existing supply networks.

9. It is easy to check correct operation (other forms of earth-leakage protection are rarely, if ever, checked).

10. Both types should continue to ensure a reasonable degree of safety despite a major deterioration in earthing conditions: such a deterioration does not automatically render them inoperative.

11. Both types may incorporate overload and short-circuit tripping, so providing all the added circuit breaker advantages of closer protection, convenience in operation, etc., with a worth-while saving in space and installed cost.

(Concluded)

BLOOD DONOR ORGANISATION BY COMPUTER

INTERNATIONAL Computers, in conjunction with the Manchester Regional Hospital Board, is developing a system for the organisation of blood donors by computer for the Manchester Regional Blood Transfusion Service.

The system, called DONALD (Donor Appointment and Linkage of Data), is intended to replace the existing manual system and will be run on the System 4-30 computer now installed in the Board's new office, Gateway House, Manchester. A special software applications package is being developed for the project, comprising three major programmes, which will eventually be available to other Regional Hospital Boards.

The Manchester Regional Hospital Board supplies over 300 hospitals with blood and deals with about 120,000 donors subdivided into 350 "panels." The system is being planned initially for the largest of these panels, Roby Street, where a special centre deals with some 22,000 donors in the central Manchester area.

The idea of the system is basically to forecast the availability of blood donors. Records of each donor's personal details and medical history will be stored on magnetic tape and the 4-30 computer will select donors for each session then print out special call-up cards for those selected. At the Roby Street Centre, sessions are held twice daily, each being attended by approximately 150 donors. The flexibility of the selection method will allow the composition of sessions to be specified according to the reliability of various groups of donors. For each session, data required by the medical and clerical staff will be produced for each donor scheduled to attend. These details will be printed on specially designed forms which will enable the donor's records to be updated or amended quickly and easily.

After each session laboratory tests will be carried out on the blood taken and the results, together with any new data arising from the session, will be fed back into the computer to check against previous records.

The System 4-30 will also be used to predict the future availability of blood donors and, because of the increasing need for blood, this information will be of value in the planning of recruitment drives.

The system will become operational shortly and it is expected that it will eventually be used as a basis for developing blood bank stock control.

BLOODSTREAM GENERATES ELECTRICITY

AMERICAN researchers have developed a technique for turning the bloodstream of a living being into a permanent electrical power supply. In a sense, the discovery uses the blood flow as a source of energy on a very small scale in the way engineers have for many decades harvested hydro-electric power from waterfalls.

Until now, the experiments have been conducted solely on laboratory animals. But the same technique may lend itself to human patients so as to draw electricity from their own bloodstream to power internal medical devices. For example, it might be used to power a pacemaker, a small electronic device which controls the heart beat rhythm of patients whose natural heart control mechanism has become defective through disease.

At present, such pacemakers are implanted surgically into the patient's body, and each replacement of batteries requires a new surgical procedure. In contrast, a self-generating power source such as the one now developed would presumably drive the pacemaker indefinitely throughout the patient's lifetime.

The new system was developed by a research group headed by a physician and a research engineer at the University of Maryland which found that when electrodes are properly implanted in the heart, a steady flow of electrical energy is induced through attached wires.

Abstract of Reports

WINCHESTER GROUP H.M.C.

Quadrennial Review, 1st April, 1963 to 31st March, 1967

The four years which ended on 31st March, 1967 brought many changes within the Group, the most prominent being the joining together of the Winchester and Alton Hospital Management Committees in April, 1964. Throughout the period there has been a steady increase in work, a corresponding rise in costs and a number of necessary capital improvements. The most exciting and far-reaching event, however, has been the commencement of building work on the first stage of new district general hospital in Basingstoke. There is now every likelihood, unless there is a major change in government policy, that the whole of the Basingstoke Hospital will be completed by 1973. Furthermore, the new maternity unit at the Royal Hampshire County Hospital, again the first part of a new hospital, will almost certainly start at the end of 1968. Both of these new hospitals are becoming more and more urgently needed. Basingstoke and Andover have development schemes jointly with the Greater London Council and in addition the rate of population increase in the area served by the Winchester Group is greater than anywhere else in the Wessex Region.

The revised Hospital Building Programme, as stated in the 1966 Command Paper, contains proposals as follows:-

Basingstoke ...	District general hospital—new wards, operating theatres, accident department and ancillary departments.
Winchester ...	Royal Hampshire County Hospital—maternity unit.

Alton

The changes in the Lord Mayor Treloar Hospital particularly which this amalgamation brought about considerably altered the way of life in the hospital. It was, therefore, extremely difficult for the staff, overnight as it were, to take over the role of a General Hospital and at the same time maintain the orthopaedic tradition which had been established.

Soon after the joining together of the two Groups, the Accident and Emergency Department and the surgical wards moved from the Alton General Hospital to Lord Mayor Treloar Hospital. It was decided that the beds at the General Hospital should be used for post-operative cases, geriatric cases and General Practitioner patients. Unfortunately, pupil and student nurse recruitment dropped to such a low level that in 1965 it became necessary to close all the post-operative beds and they have not yet been re-opened. The future of Alton General Hospital is a matter of concern to the Hospital Management Committee as it becomes more certain that the increased load which was expected from Basingstoke will not now materialise.

A considerable amount of upgrading and modernisation of the buildings at Treloar Hospital has been done. A second theatre was provided by the Regional Hospital Board and an extremely fine Casualty Department was built where previously the hydrotherapy pool had been. A new pool has been built alongside the physiotherapy department and is extensively used. One of the most disappointing decisions which the Management Committee had to take during this period was partially to close the Accident and Emergency Department. It is quite impossible to attract a sufficient number of medical staff to ensure that the Accident Department is manned for twenty-four hours a day.

Basingstoke

The most important happening since the date of the last report has been the commencement of the first stage of the new District General Hospital in the grounds of Park Prewett Hospital. The unit under construction is a 96-bed maternity unit and this is due to be completed in the first half of 1969. The Regional Hospital Board has announced that the remainder of the District General Hospital of 600 beds will be built as one contract and this will commence as soon as the maternity unit is completed.

It is more than probable that at the outset the 96-bed unit will be used for general cases as well as maternity cases, partly to cope with the demand for general beds in the Basingstoke area and partly because the full number of 96 maternity beds will not be required immediately.

In addition, accommodation for the staff who will have to be resident will be built and will be ready by the time the 96-bed unit is open. A new boiler house to serve both the new hospital and Park Prewett Hospital is also under construction.

The standard of accommodation at Basing Road Hospital has been a particular concern of the Management Committee and tremendous improvements have been made in all the buildings. In the hutted wards oil-fired central heating has been installed. One of the wards close to the railway lines has been converted into kitchens to serve the whole of the hospital and dining rooms for the staff. The patients from that ward were transferred to the main block which was considerably improved and modernised at a cost of approximately £40,000.

Winchester

The most important decision in the period under review was taken by the Regional Board and the M.o.H. when it was finally agreed that the new County Hospital would be built on its present site and would start in 1968 with the 90-bed Maternity Unit as the first phase. It is estimated that, by 1981, the County Hospital will be serving a population of nearly 200,000 in the area extending from Andover in the north to Eastleigh in the south. The detailed planning of the Maternity Unit has been in progress for some time and it is hoped that it will be ready for use in 1970.

The existing Maternity Department is very inadequate despite a splendid 20-bed post-natal ward which was built and opened in 1965. The new unit, when it is available, will be used initially for both obstetrics and gynaecology and the existing accommodation will be available to provide a much needed outlet for the other expanding specialties. It is probable that the 20-bed post-natal unit will become a General Practitioner obstetric unit.

Because of the continually increasing work at the County Hospital it has been necessary to implement a large programme of upgrading and modernisation in the wards and departments.

On the Market *A review of new equipment and materials and their development*

NEW DEFROSTING THERMOSTAT BY DANFOSS

Danfoss (London) Ltd., 6, Wadsworth Road, Perivale, Middlesex, announce the introduction of their 090B4 evaporator and defrosting thermostat.

The new model, which is a single pole thermostat with special alloy silver contact points, is designed for semi-automatic defrosting and since it makes circuit on a rise in temperature, is ideal for controlling compressors where defrosting of the evaporator is required.

In order to start the defrosting cycle a push rod mounted on the top of the thermostat casing must be depressed—this causes the contact points to remain open until the bulb temperature reaches between 41° and 45°F (5°–7°C). At this point the push rod returns to its normal position and the thermostat 'makes' and 'breaks' circuit again in the normal way.

The Danfoss type 090B4 thermostat is available with a cut-out range of between 9° and 27°F (5° to −15°C) within an overall temperature range of approximately −31° to +23°F (−35° to −5°C), with differentials of between approximately 7·2°F (4°C) and 21·6°F (12°C) depending on the temperature range.

Normal capillary tube lengths are 31 in. and 48 in. although any length within limits can be supplied.

SIMPLE LOW-COST MERCURY FLOAT SWITCH MAINTAINS LIQUID LEVELS

A new low-cost mercury operated switch designed for maintaining a pre-set level of liquid has been developed by **Warwick Pump & Engineering Co. Ltd.,** of Ferry Lane, Hythe End, Staines, Middlesex.

The switch is fitted to the arm of a conventional ball valve with the valve removed, and will control pumps, valves, indicators or warning devices, etc. It can be placed in such a position to operate in the reverse manner to maintain a low level in the container if necessary.

Called the Levelmaster, the switch can be used as a direct on-line starter for 250 volt ¾ h.p. A.C. motors or for up to 10 amps non-inductive loads. For larger currents, three phase or D.C., a contactor unit must be fitted.

No servicing or maintenance is required. The mercury tube is totally embedded in shock-absorbing silicone rubber inside a polypropylene case. The Levelmaster measures 3-3/16 in. x 1¾ in. x ⅝ in. and is supplied with 5 ft. of P.V.C. coated cable and a clamping bracket. It costs £2 12s 6d.

WOODS NEW SERIES 'C' ROOF VENTILATORS

A new lower cost range of roof ventilators has been introduced by **Woods Fans Ltd.,** Colchester, Essex. These Series C ventilators are available in seven sizes, 12 in. to 48 in. fan diameter. The extract capacities range from 600 c.f.m. to 28,000 c.f.m. and are guaranteed. Sizes up to 30 in. diameter have propeller fans, the 36 in. and 48 in. units have ring axial fans.

The capacities without shutters match the performance of other Woods propeller fan powered roof units and approximately the same outputs are maintained when shutters are fitted.

Purlin and curb mounting units are available. The bases are square and incorporate a weathering skirt. Low contour is a feature of the design. The weather cap is circular and shallow. On sizes 12 in. to 30 in. the cap is hinged, providing easy access for maintenance and cleaning; the two larger sizes have an access door in the fan housing. Robustly constructed of welded steel, the units are hot dip galvanised as standard.

Heat conservation shutters can be fitted as an optional extra, as also can fire release shutters with a fusible link.

Lubrication of the fan motors is required only once in five years. The motors are moisture resistant, and suitable for atmospheres of up to 95 per cent relative humidity.

For applications where extra low sound level is essential, Woods new sound baffles can be fitted to sizes up to 24 in.

NEW JETFREEZER PIPE FREEZING KIT

A kit is available from **The Distillers Company Ltd.,** Cedar House, 39 London Road, Reigate, Surrey, for stopping the flow of liquids in pipes by localised freezing. Known as the Jetfreezer, this equipment is simple and versatile, certain in operation and cheap to run.

The kit includes a syphon cylinder containing 20 lbs. of CO_2, a length of high pressure hose and a specially designed low temperature jacket to fit round a pipe at the point where the plug of frozen liquid is to be formed.

At the turn of a valve, liquid carbon dioxide is discharged through a calibrated jet into the space between the pipe and the jacket. The sudden drop in pressure of the CO_2 from cylinder pressure to atmospheric pressure causes dry ice (−109°F., −78°C.) to form round the pipe and this freezes stationary water in ½ in. bore piping in three minutes, or ¾ in. bore piping in four minutes. It is effective for bores up to 1½ in.

It is possible to work on a pipe within 1 ft. of the ice plug and the jacket may be applied to pipes in all but the most inaccessible positions whether horizontal or vertical, or straight or bent. If it is necessary to restore the service very quickly the ice plug may be melted by warming the pipe with a blow lamp.

JABSCO PUMP FOR VARIABLE FLOW

The Jabsco variable flow pump is capable of an infinitely variable rate of flow from 0 to 3·5 g.p.m. The pump is made of bronze and has a nitrile impeller and is of the positive displacement type. It has many applications because it is capable of pumping thin or viscous fluids and can handle particles in suspension.

The control unit consists of a transformer and a silicon rectifier network with a variable resistance which can give an output of 0 to 24 volts D/C. The unit is fed from 250v 50 cycle A/C supply. The maximum power consumption is 100 watts. The pump is capable of a suction lift of 10-15 feet when primed, and can work at a pressure of 13 p.s.i.

The Jabsco Variable Flow Unit is marketed and distributed by **Jobson and Beckwith Ltd.,** of 62 Southwark Bridge Road, London, S.E.1.

BIGWOOD DEVELOP UNDERFEED STOKERS

Solid fuel is still claimed to be the cheapest form of heating and an improved range of underfeed stokers developed by **Bigwood Unicalor Ltd.** of Wolverhampton, Staffs, is now available with prices from as low as £250. The new stokers, known as the Unidrive Mark III, were developed by Bigwood Unicalor after an approach by the National Coal Board enquiring what could be done to produce fully automatic underfeed stokers complete with controls at a price which would allow the Coal Board to offer the machine in competition with installations using other fuels. To accomplish this, the Company uses a friction drive motor in the stoker instead of one involving gears.

Available in five sizes in both hopper and bunker types, the machines feed a wide range of bituminous coals at a rate of between 38 lbs an hour and 165 lbs an hour.

Needing only one person to carry out the routine maintenance work of raking off ashes etc., the Unidrives ensure that, although fueled by coal, burning complies with the Clean Air Act. They can be supplied in lengths to suit a customer's requirements or boiler house conditions and the bunker feed worm comes in lengths up to six feet.

HONEYWELL MARKET DIGITEST MULTIMETER

Honeywell Controls Ltd., Brentford, Middlesex, announce that the Digitest 333 is £190. This self-contained digital multimeter, either mains or battery powered, will measure a.c. and d.c. volts, a.c. and d.c. amps, and ohms in 23 ranges. The window on the left of the instrument's facia has three gas-filled digital indicating tubes and three neon indicators showing the + and − polarities and overload respectively. A red indicator shows when the instrument has voltages applied which are dangerous for the range in question, or when a voltage has been applied to the instrument when it is in the ohmmeter position.

The Digitest's four main sections comprise: an input amplifying, rectifying or attenuating stage; an analogue-digital converter; a counting and display circuit; a power supply unit.

The power supply unit employs a high efficiency d.c.—d.c. static converter, which allows the Digitest to be run from a battery of 10 standard torch dry cells or accumulators.

In the mains-battery version, the instrument is run from the accumulators which are float-charged by the incorporated rectifier.

The instrument is fully protected against overloads or incorrect use by a system of biased diodes and fuses.

AUTOMATIC AIR DRYING UNIT

The Birmingham firm of **Bellis and Morcom Ltd.,** now merged with W. H. Allen & Co. Ltd., to form a new company, Amalgamated Power Engineering Ltd., Bedford, offer to compressed air users an industrial air/gas dryer which incorporates several notable features.

Known as the "Dryaire," the unit employs the refrigeration method of drying, effecting a saving of some 85% in operating cost in comparison with dryers which evaporate absorbed moisture by the use of electrical heaters.

In operation, air entering the unit at 80°F 100 p.s.i.g., saturated with water vapour, is cooled to 50°F in the precooler. It then passes to the final cooler where it is cooled by a refrigerated liquid to 36°F, the water vapour being condensed and the moisture laden air passed through the separator. The condensate is discharged to waste and the air passed back through the pre-cooler where it is re-heated to 74°F.

Water/Glycol is held at 32°F by on/off thermostatic control of the refrigeration compressor. By controlling the temperature at 32°F the possibility of icing up on the air side of the final air cooler under low air flow conditions is avoided.

Cooling water to the refrigeration unit is automatically controlled to give correct condensing temperature.

ECONOMICAL D.I.Y. DUST EXTRACTION KIT

Matthews and Yates Ltd., incorporating Turner and Brown Ltd., have recently introduced an economical and easily adaptable dust extract unit suitable for installations with 1 to 4 suction connections.

The basic unit, 4.D.E., comprises the latest No. 4 paddle blade fan from the proven "Cyclone" range, complete with two h.p. drip-proof motors and separate starter.

Optional ancillary equipment includes discharge connectors, inlet connectors, extract hoods and galvanised sheet steel or flexible plastic ducts in standard lengths of ten feet. Damper control sections are also available.

Further information may be obtained from: Department P.D., Matthews and Yates Ltd., Turbro-Cyclone Works, Gibraltar Street, Bolton, Lancs.

THE MACROTOME

Brittle materials such as bones, teeth, ceramics and glasses are conventionally cut by feeding the work against a diamond saw rotating at several thousand r.p.m. The Macrotome is a saw which violates this convention.

This precision cutting device was first developed at the Royal Radar Establishment, Malvern, to cut slices of indium antimonide. It uses a slowly rotating blade (50-500 r.p.m.) and is designed so that the feed rate depends on the cutting rate. By employing slow cutting and avoiding a positive feed the Macrotome does less damage than high speed slicers, cuts thinner slices and leaves a better surface finish.

It is now being marketed by **Metals Research Ltd.,** of Melbourn, Royston, Herts.

Notes for Members

OBITUARIES

C. A. Scutts

We regret to announce the death in July of Mr. Cyril Alfred Scutts.

After serving an apprenticeship with J. & E. Hall Ltd., at Dartford, Mr. Scutts spent fourteen years with various engineering firms, including six years at sea with the P & O Company. In 1937 he was appointed an Assistant Engineer at St. Bartholomew's Hospital and was promoted to Engineer-in-Charge in 1949. He retired from the Service in 1962.

Mr. Scutts was elected an Associate Member of the Institute in 1944 and was subsequently a regular supporter of the London Branch.

W. P. Lavers

We regret to announce the death in May of Mr. Richard P. Lavers.

An apprenticeship was completed with S. Hodge and Sons Ltd., after which Mr. Lavers served as a Marine Engineer for nine years, and obtained his B.o.T. Certificate. He joined the engineering staff at St. Thomas's Hospital in 1932 and was appointed an Assistant Engineer at Netherne Mental Hospital in 1934. In 1939 he was appointed Chief Engineer at Brookwood Hospital, Woking and held this post until his retirement from the Service in 1966.

Mr. Lavers was elected a Member in 1944 and gave constant support to the activities of the London Branch.

ELECTIONS TO MEMBERSHIP

Applications for membership have resulted in the following elections:

Members

L. S. Brown, Surbiton; South West Metropolitan R.H.B.
B. Franklin, Hemel Hempstead; Steensen, Varming, Mulcahy & Partners.
A. V. Jones, Salisbury, Rhodesia; Government of Rhodesia.
D. J. King, Chepstow; Newport and East Monmouthshire H.M.C.
N. M. Macdonald, Lochgilphead; Lochgilphead Hospitals B.O.M.
D. Murray, Salisbury, Rhodesia; Government of Rhodesia.
L. M. Prior, Stockton-on-Tees; South Teesside H.M.C.
A. L. Sykes, Leeds; United Leeds Hospitals.
J. W. Taylor, Warrington; Warrington & District H.M.C.
A. T. A. Thom, Falkirk; Stirling & Clackmannan Hospitals B.O.M.

Upgraded to Member

F. R. Waite, Cardiff; Welsh Hospital Board.

Associate Members

G. Clough, Stainton; South Teesside H.M.C.
V. K. Condliffe, Stoke-on-Trent; North Staffordshire H.M.C.
D. J. Coultas, Kidderminster; Mid-Worcester H.M.C.
C. B. Denne, Stoke-on-Trent; North Staffordshire H.M.C.
C. C. E. Farrant, Chatham; South West Metropolitan R.H.B.
R. F. A. Gerry, Plymouth; Plymouth & District H.M.C.
S. Lingwood, Bovey Tracey; Exeter & Mid Devon H.M.C.
J. W. North, Sheffield; Sheffield R.H.B.
R. J. Parry, Plymouth; Plymouth & District H.M.C.
R. Pollock, Kilmarnock; Northern Ayrshire B.O.M.
D. J. Roughsedge, Kirkburton; Storthes Hall Group H.M.C.
G. S. Sanderson, Morpeth; Northgate & District H.M.C.
D. J. Sutherland, Plymouth; Plymouth & District H.M.C.
L. R. Tilley, Folkestone; South East Kent H.M.C.

Graduates

A. Akinsiku, London; The Royal National Orthopaedic Hospital.
A. J. Brown, London; Thames Group H.M.C.
J. R. Hayes, Cambridge; East Anglian R.H.B.
D. T. Jackson, Sandbach; North Staffordshire H.M.C.
E. P. Miles, Stoke-on-Trent; North Staffordshire H.M.C.
J. K. Millington, Burslem; North Staffordshire H.M.C.
R. Povey, London; Westminster Hospital.
R. A. Richards, Swansea; Glantawe H.M.C.
D. Swiffen, Pontefract; West Riding County Council.
D. L. Taylor, Warley; United Birmingham Hospitals.
F. Tomkinson, Stoke-on-Trent; North Staffordshire H.M.C.
D. A. Whitehurst, Stoke-on-Trent; North Staffordshire H.M.C.

Affiliate Member

Peak Electronics Ltd., Newcastle upon Tyne; Manufacturing Mechanical Electrical and Electronic Engineers.

H. A. ADAMS

After thirty years in post, Mr. H. A. Adams retired from the Hospital Service at the end of July as Group Engineer of the Glenside and Barrow H.M.C.

Mr. Adams served a six-year apprenticeship with Phillip and Son of Dartmouth, followed by nine years at sea with the British India Steam Navigation Co. and then two years at the Bristol Aeroplane Co. He was appointed Chief Engineer at Glenside Hospital in 1938.

A Founder Member of the Institute, Mr. Adams was elected to Council in 1943 and served as Chairman from 1959 until the end of 1966 when the Institute became Incorporated, having made significant progress under his guidance. He was a member of Council at the time of his retirement and will continue with this responsibility. He was also Chairman of the South Western Branch and its first Hon. Secretary for a term of twelve years.

Mr. Adams is a Member of the Institution of Plant Engineers and one time Chairman of its South Western Branch, and a Member of the Institute of Marine Engineers. He was awarded the M.B.E. in 1961.

Few, if any, can have devoted more effort to the interests of the Institute; evidence to the Tyler Committee, Conference activities at the bi-annual Hospital Exhibition, the success of the Keele University courses and the achievement of Incorporation being the more prominent gains while he held the reins.

1969 CONFERENCE

The Institute will hold the 1969 Annual Conference on the first three days (2nd to 4th June) of the International Hospital Equipment, Medical Engineering and Services Exhibition, which will be held in the Grand Hall, Olympia, London.

1970 CONFERENCE

Consideration is being given, already, to the staging of a Conference during 1970. Certain possible venues are in mind and it may well be that a place within the area of the Midlands Branch will be chosen. Further information will be promulgated when progress has been made.

NATIONAL QUALIFICATION AND TITLE

The Standing Conference for a National Qualification and Title met at the Council of Engineering Institutions on Wednesday, 31st July, 1968 and elected a Sub-Committee to draft the constitution of a National Body which will award the National Title.

AMERICAN NUCLEAR INSTRUMENT EXHIBITION

The United States Trade Centre is holding an exhibition of American Nuclear Instrument Systems and Components at 57 St. James's Street, London, S.W.1, from 18th to 26th September.

Any members who would be interested to go may obtain tickets by applying to the Trade Centre at the above address.

NORTH EASTERN BRANCH

A meeting of the North Eastern Branch on Saturday, 25th May, 1968 took the form of a visit to the Atomic Power Station at Calder Hall, Cumberland, and a visit to the West Cumberland Hospital, Whitehaven. The party numbered 36, including 19 guests, and a coach was hired for the trip from Sunderland and Newcastle.

On arrival at West Cumberland, an excellent lunch was enjoyed through the good offices of the West Cumberland Hospital Management Committee. The party then toured the Calder Hall Power Station plant complex, the tour being preceded by an introductory talk in the Operations School. Here they learnt that this Station was opened in 1956 and was the world's first nuclear power station to generate electricity on an industrial scale. The reactors are housed in concrete buildings 90 ft. high and 60 ft. in diameter, with walls 7-8 ft. thick. The fuel charge of Uranium weighs over 100 tons and has a life of about three years. As a result of the considerable research conducted and experience gained at Calder Hall the Atomic Energy Authority have produced more advanced designs and, to date, a total of ten stations producing 4,000 megawatts of electricity have been commissioned. Britain still has the largest nuclear generating capacity in the world.

The visit lasted over two hours and was extremely interesting to all present. After this the party returned to the West Cumberland Hospital where it spent the available time remaining inspecting the principal engineering features of this, the first completely new hospital built under the National Health Service.

LONDON BRANCH

The London Branch held a meeting at Royal Surrey County Hospital on 22nd June, 1968.

The Branch Chairman welcomed the members, the Chairman of the Group Works Committee, and representatives of the companies co-operating in the scheme described.

The Regional Engineer, Mr. K. J. Eatwell, was present, accompanied by Mr. Otto Geeser, Chief Engineer to the Ministry of Health, Hungary.

The meeting opened with "Automated Boiler Houses", a lecture and demonstration by Mr. J. W. Parsons and his engineering colleagues. Mr. Parsons opened the proceedings by describing the situation existing in the Boiler House at this hospital, the design intent, and the economies and improvements in efficiency resulting.

The three existing Cochran size 20 boilers were fired with 3,500 sec. oil, difficulty being experienced in maintaining steady steam supply, partly through the inability to recruit and keep good stokers and partly from hand control lagging behind demand. It was, therefore, decided to convert to automatic firing, selecting equipment lending itself to automatic control and monitored in such a way that the Boiler House could be left unattended for 128 hours per week, emergency conditions being attended by other staff available on call without delay.

The sum available for this work was restricted to £7,600, so that other improvements such as installation of an economiser and stand-by generation could not be undertaken at the time. The layout has been designed to accept these units as soon as money can be provided. The manufacturers' representatives described the items installed, and the members then visited the Boiler House where each was demonstrated. After lunch a lively and informative session of question and answer lasted for a full hour. From these it was learned that the Insurance Company's technical officers were fully satisfied with the installation; that the CO_2 had been improved from 8% to 11%; that efficiency had risen, as much from better combustion as from stable steam conditions brought about by automatic control.

Close attention to refractory design had done away with smutting, which had been a considerable past nuisance.

LANCASHIRE BRANCH

The Lancashire Branch were invited to visit, on 4th July, 1968, the factory of W. T. Glover & Company Ltd., cable makers, at Trafford Park, Manchester.

On arrival at the factory the members were met by Mr. F. B. Oldfield, the production manager, who introduced the members of his staff to be our guides for the tour round the factory.

The party split up into three groups to facilitate movement round the various departments and zones. After the tour the members were joined by Mr. Oldfield with some of his technical staff for light refreshments, after which there was a very interesting discussion period, during which he gave the history of the Company during the past 100 years.

The chairman, Mr. D. H. Mellows, thanked the staff of Glovers for the interesting way that they had conducted them round the factory, and also to Mr. Oldfield for his talk. All agreed that much had been learned on the technique of cable making, and the visit was well worthwhile.

Index to Advertisers

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Classified Advertisements

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EAST ANTRIM HOSPITAL MANAGEMENT COMMITTEE
GROUP ENGINEER

Salary: £1,454-£1,693 per annum.

Salary from 1st September, 1968: £1,550-£1,805 per annum.

The Officer will have responsibility for the engineering services at the Moyle, Smiley, Carrickfergus and Dixon Hospitals.

Minimum qualifications: Higher National Certificate or Higher National Diploma in Electricity or Mechanical Engineering; or City and Guilds Mechanical Engineering Technicians Full Technological Certificate (Part III) with appropriate endorsements; or an equivalent qualification approved by the Northern Ireland Hospitals Authority.

Application forms and further particulars from Secretary, East Antrim Hospital Management Committee, Moyle Hospital, Larne, for return by 9th September, 1968.

CHARGEHAND FITTER required for Guy's Hospital to assist the Foreman in the supervision of the maintenance of the comprehensive mechanical services installed at Guy's. The conditions of service will be as laid down by the Ancillary Staffs Council, the salary will be 8s. 10¼d. per hour. Basic 40-hour working week with overtime available. Applicants over 35 years of age with comprehensive experience of mechanical services in a large organisation should apply in writing to the Group Engineer, Guy's Hospital, London, S.E.1.

THE HOSPITAL FOR SICK CHILDREN
GREAT ORMOND STREET, LONDON, W.C.1

Applications are invited due to the impending retirement of the present holder, for the post of

GROUP ENGINEER

responsible for the Works Department of the group which covers five hospitals. The successful applicant will have had experience demonstrating ability to control a staff of 85; to maintain engineering services and supervise maintenance of plant and fabric of buildings; to plan or participate in schemes of minor capital expenditure; and to be involved, so far as they affect services in general, in major new building projects handled by outside consultants.

Salary on scale *£2,115-£2,265-£2,340-£2,415-£2,495* including all allowances and London Weighting. Applicants should be corporate members of The Institution of Electrical Engineers or of the Institution of Mechanical Engineers. A flat may be made available at reasonable rental, if required.

Application forms, to be returned by 23rd September, 1968, obtainable from the House Governor.

MISCELLANEOUS

ENGRAVED PLASTIC NAME PLATES AND STAFF IDENTITY BADGES manufactured. Singles or quantities. Workshops for the Disabled, Northern Road, Cosham, Portsmouth. Tel.: Cosham 76533.

CIRCULATING PUMPS and Steam Turbines. Complete units, electric and steam, spares and service. TURNEY TURBINES Ltd., *67 Station Road, Harrow. Tel.: 1355 and 3449.*

GUILLOTINES. Revolutionary "GABRO" machines provide 0 to 10G (12G Stainless) Capacity, straight and notching, to UNLIMITED, UNDISTORTED length for £60. Full details, GALE BROS. (ENGINEERS) LTD., Smallfield, Horley, Surrey. Tel.: Smallfield 2157.

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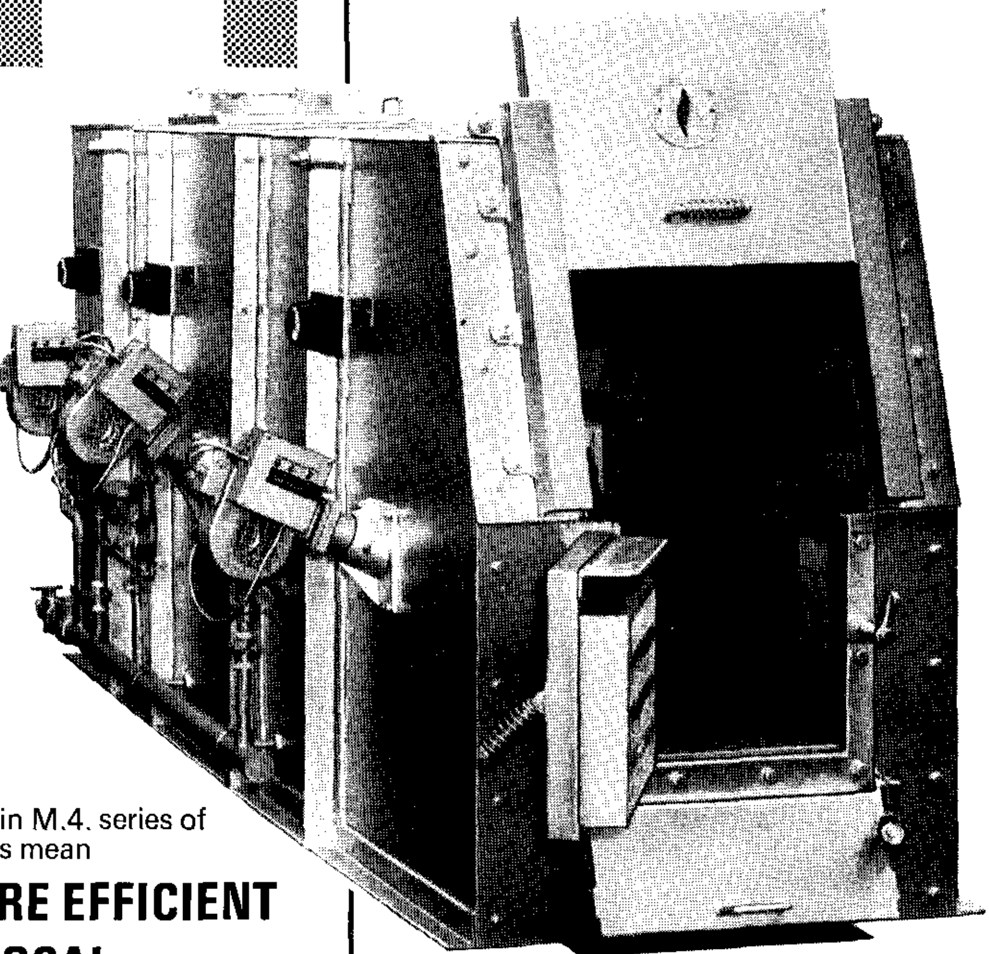

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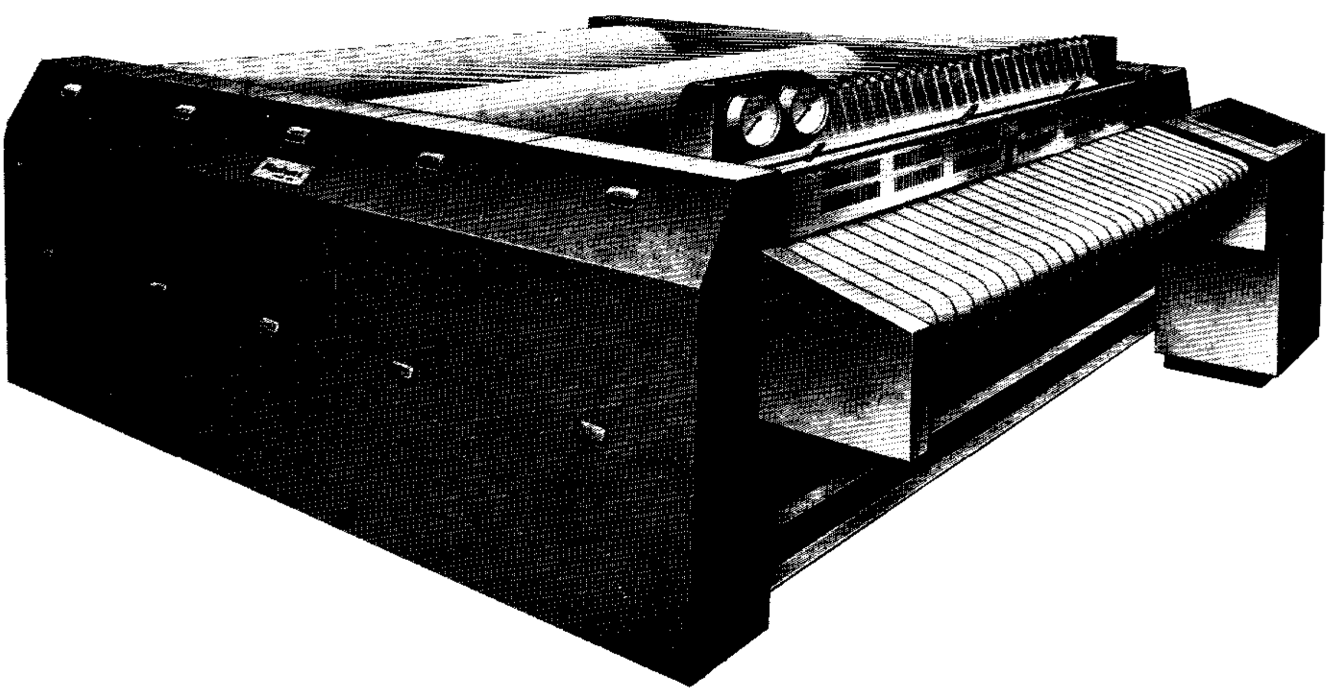

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