NUCLEONIC INSTRUMENTS AT THE BRITISH ATOMIC ENERGY RESEARCH ESTABLISHMENT.*

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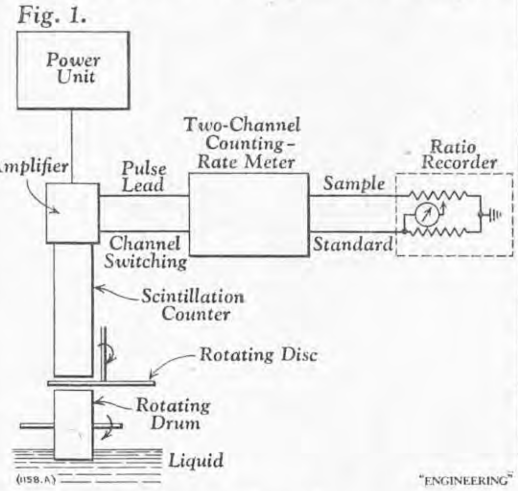
THE rapid progress made in Great Britain in the development of nuclear energy has involved equally rapid progress in the development and production of the requisite nucleonic instruments. A review of some of the earlier developments in nucleonic instrumentation was published in ENGINEERING on pages 631 and 644 of the 168th volume (1950). The present paper gives a review of more recent progress at the Atomic Energy Research Establishment, Harwell, and discusses the following developments: (i) measurement of the operating power level of nuclear reactors; (ii) measurement of α-activities in solution; (iii) gas counters operating in the proportional region; (iv) new types of counting apparatus; (v) a new type of dose-rate meter for β- and γ-rays; and (vi) nucleonic measuring equipment for geological survey and mining.

MEASUREMENT OF NEUTRON FLUX.

The operating power level of a nuclear reactor or atomic pile may be determined in terms of the neutron flux in the core, or near the core, of the reactor. This is the method commonly used both for controlling the power level of the reactor and for operating the various safety circuits associated with the reactor plant. The method of measuring the neutron flux using an ionisation chamber filled with boron trifluoride gas was mentioned in the earlier review. Much use is now made of chambers filled with an inert gas, such as argon, and with a deposit of boron on one, or both, electrodes. The mode of action in this case is the same as that of the earlier system, namely, neutron bombardment of the boron atoms producing α-particles (this is called an n-α reaction), and, in turn, producing ionisation of the chamber gas, but this alternative design allows the use of a more compact chamber capable of operation at a lower applied voltage. Moreover, the life of the chamber measured in megawatt-hours is at least as good as the original type of the chamber.

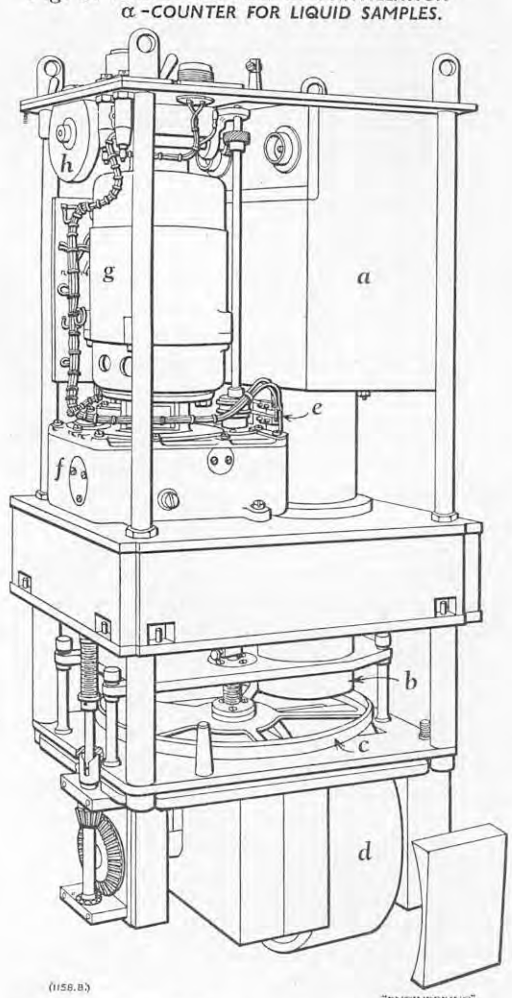
Fig. 1.



Both these types of ionisation chamber are slightly sensitive to γ-radiation. This is of little consequence when the reactor is operating at high power level, but at low power level (i.e., low neutron flux), the finite sensitivity of the measuring chamber to γ-radiation may result in the instrument reading being greatly in error. This is especially likely to be the case when the reactor is operating at low power level immediately after earlier operation at a high power level. To overcome this disadvantage special ionisation chambers compensated for γ-radiation are now used. They comprise effectively two chambers in one, connected in opposition. The first chamber uses boron-coated electrodes and is sensitive to both neutrons and γ-rays, whereas the second uses ordinary electrodes and is sensitive to γ-rays only. In both cases the filling is an inert gas and provision is made for varying the effective volume of one of the chambers so that accurate compensation of the system for γ-rays can be achieved experimentally.

Another interesting development is the use of a special type of thermocouple for neutron-flux and pile-power measurements—the chromel-alumel thermocouple with one junction coated with a bead of boron. Such a couple is balanced under normal conditions for all temperatures, and a meter connected in series with the couple gives a null reading. However, if the thermocouple is placed in the core of a nuclear reactor a small electromotive force is generated due to the selective heating at the boron-coated junction, due, in turn, to the release of energy from the n-α reaction. The voltage generated is directly proportional to the neutron flux, and thus provides a particularly convenient method for pile-power measurement. A single thermocouple of chromel-alumel wires 0·012 in. in diameter in a flux of 10^{10} neutrons per square centimetre per second gives an output of 0·0005 volts, so that by using a multiple-element thermopile, the output can be sufficiently large to operate a robust indicating instrument without the use of a thermionic valve amplifier. One special advantage of the boron-coated thermocouple for pile-power measurement is its small size; its major disadvantage is its long time constant, of the order of several seconds, and

Fig. 2. PERSPECTIVE VIEW OF SCINTILLATION α-COUNTER FOR LIQUID SAMPLES.



(a) Photomultiplier unit.
(b) Tube containing Perspex rod with zinc-sulphide screen on lower face.
(c) Rotating disc holding standard α-active source.
(d) Sampling drum.
(e) Cam-operated contacts for operating counting channels.
(f) Gearbox for disc and drum drives.
(g) Driving motor.
(h) Thumb wheel for adjusting disc when disengaged from motor drive.

Fig. 3. "END WINDOW" COUNTER.

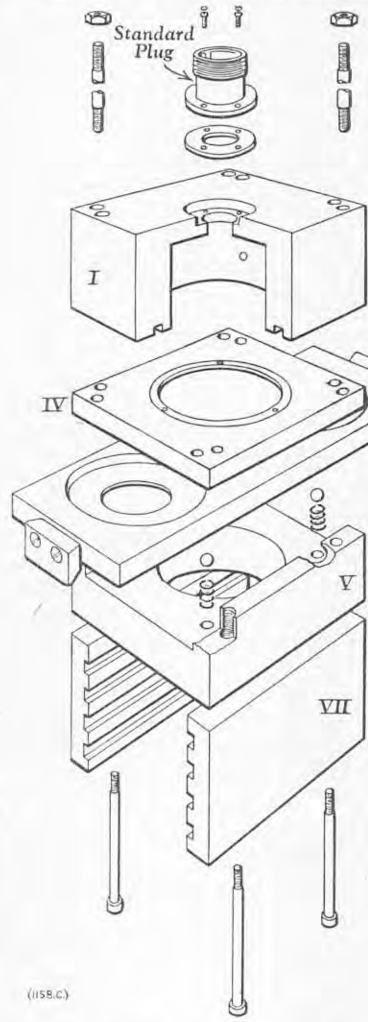


Fig. 4. ENLARGED SECTION OF STANDARD PLUG.

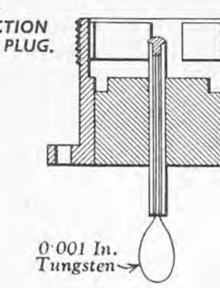
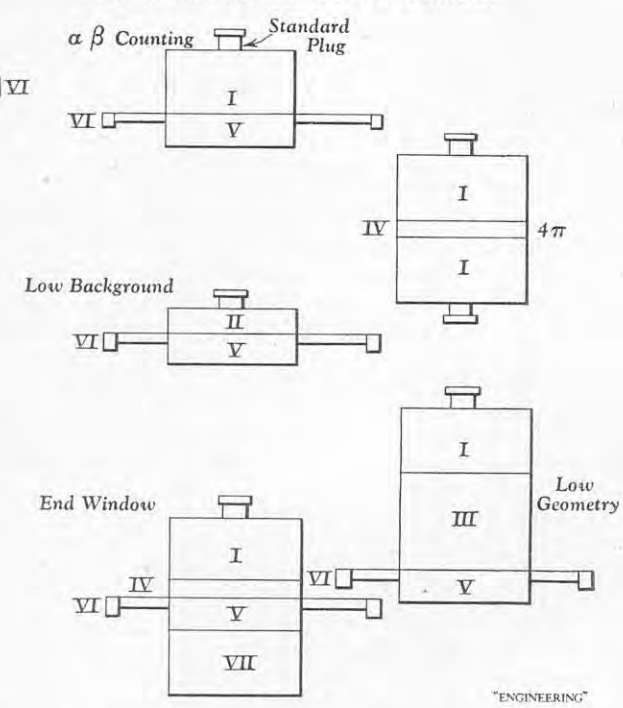


Fig. 5. ALTERNATIVE TYPES OF COUNTERS.



* Lecture presented at the Royal Institute of Technology, Stockholm, on May 19, 1952.

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Fig. 6.

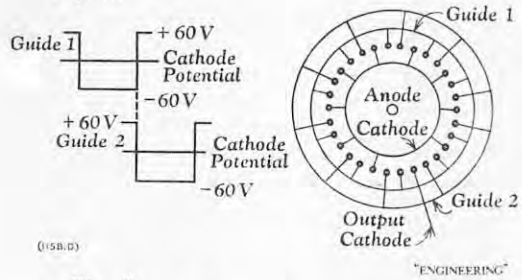


Fig. 7.

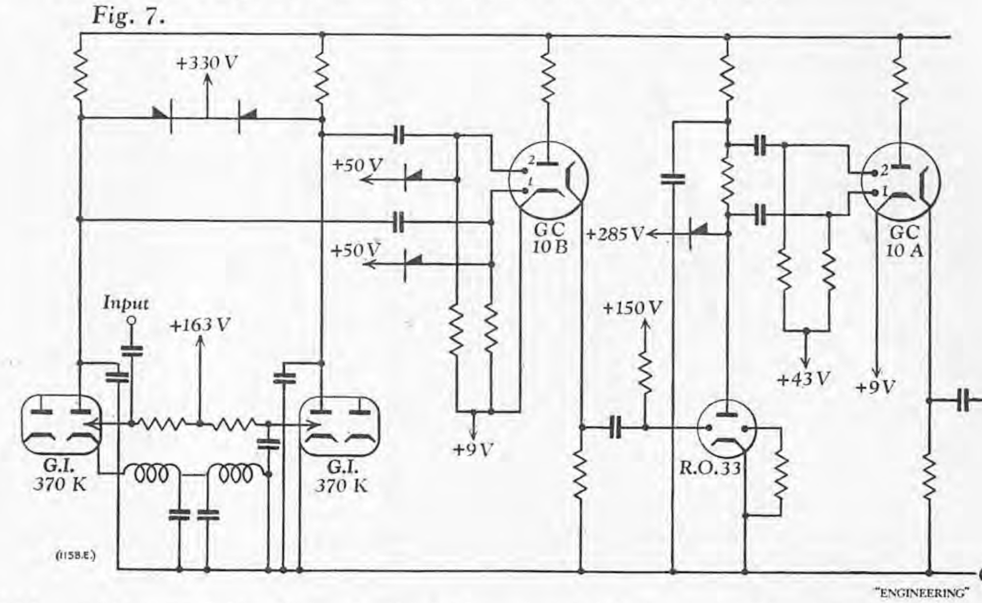
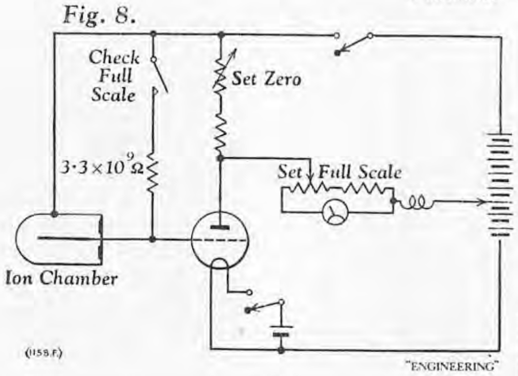


Fig. 8.



thus it cannot compete with the ionisation chamber for control purposes. A full account of the development and use of this thermopile and the γ-compensated ionisation chamber is to be communicated to the Institution of Electrical Engineers in a paper by Messrs. T. A. J. Jaques, H. A. Ballinger and F. Wade.

Monitoring of Active Liquors.

Active liquors containing β- or γ-active materials may be monitored continuously without difficulty, but since α-particles have a very short range, the continous monitoring of α-active liquors presents a considerable problem. A method* has now been evolved which appears to be highly satisfactory. It is illustrated in the diagram reproduced in Fig. 1; the apparatus incorporates a scintillation counter, a liquid-sampling device and a system of standardising against a standard radioactive source. The scintillation counter comprises a screen of nickel-quenched zinc sulphide as the phosphor, and a photomultiplier tube, both being mounted in light-tight compartments. The light-tight covering or window over the zinc sulphide screen must be sufficiently thin to allow the passage of α-particles to the screen; in the design shown, this window is made of plastic film (weighing 1 mg. per square centimetre) coated with a very thin opaque layer of gold or aluminium. The light from the phosphor scintillations is transmitted through a polished Perspex rod to the photosensitive layer inside the end face of the photomultiplier tube. This allows the latter unit to be mounted in an accessible position away from the active liquor.

A thin layer of the α-active solution is brought into close proximity to the zinc sulphide screen by the use of a rotating drum, the lower surface of which dips into the solution. This provides a convenient method of defining accurately the geometrical relationship between the active source and the sensitive area of the phosphor, and this is an important factor in the detection of α-particles with an air range of only a few centimetres. The speed of rotation of the drum is adjusted so that the thickness of the solution adjacent to the phosphor screen is somewhat greater than the range of the α-particles in the solution. The number of α-particles emitted per unit area of the liquid surface is then independent of small variations in the thickness which may be caused by changes in the surface tension and viscosity of the solution.

With such a source the energies of the α-particles reaching the zinc sulphide screen, and the resulting light-pulse intensities, vary from zero to a maximum value. A plot of the counting rate against the setting of the pulse-amplitude discriminator gives a continuous change of counting rate and no plateau region, where the counting rate remains unchanged with the setting of the discriminator. It is difficult to define and maintain an operating point on such a characteristic. This difficulty is overcome in the present instrument by comparing the counting rate observed with the solution sample with that obtained from a subsidiary standard source which has a similar characteristic curve. The standard is mounted on the rotating disc shown in Figs. 1 and 2. About one-half of the disc is covered with a standard source and the other half is cut away to expose the zinc sulphide screen to the solution. As the disc rotates, the alternate trains of pulses resulting from the solution and the standard source respectively, are counted in separate counting-rate channels. In order to obtain a characteristic curve from the standard source which is similar to that obtained from the solution, a standard source is prepared as a plastic film 2 mils thick using the same α-active material as that to be monitored in the solution. With this arrangement, first the solution and then the standard are presented to the counter, the whole cycle repeating itself every revolution of the disc, which is once per second. The trains of pulses are amplified and then pass on to a pulse-amplitude discriminator circuit which permits only those pulses greater than a definite threshold value to be passed to the counting appratus. The counting system is, as already described, a two-channel counting-rate meter, which is switched in synchronism with the disc rotation and gives two separate meter indications—one of the activity of the process solution and the other activity of the standard. Finally, the indications are recorded on a self-balancing potentiometric recorder* to give a continuous indication, not only of the two activities, but also of their ratio. The ratio record is used when reading off the activity at any time of the process solution; being a measurement of the activity of the solution in terms of the standard, any slow variations in the performance of the individual electronic units have only a small effect on the precision of the final measurement. Several instruments of this type have now been in use for long periods of continuous and intermittent use, and instrument calibrations have been maintained to within ± 1 per cent. The performance of the instrument under practical conditions depends, of course, on presenting a representative sample of the active liquor to the detector component and for some applications this has involved the use of a mechanical aid in the solution duct to prevent the formation of scum, etc., on the liquid surface.

Assaying Solid Radioactive Materials.

For the assay of solid radioactive materials, ionisation chambers, Geiger counters and scintillation counters can be used, but in cases where high precision of measurement is necessary, flow-proportional counters are now more widely used. They comprise a central electrode consisting of a small loop of wire carefully insulated from the metal case, which acts as the second electrode. The active material may be placed inside the counter for assay purposes, and when counting the sample, a gas, usually methane or argon, is passed through the counter. Only a few minutes are necessary for flushing purposes. The apparatus in this form is suitable for use with both α- and β-active materials. The counter is used in association with a counting-rate meter, or a scaling circuit and register. As many variants of this type of counter are required for different purposes, Mr. J. Sharpe, of the Atomic Energy Research Establishment, has evolved a universal design which allows the different types to be assembled from a few standard parts. The standard parts and a few typical assemblies are shown in Figs. 3, 4, and 5. Part I is the counter body used for normal work. Part II is a replacement part for I used for low-activity measurements. It is of smaller internal dimensions than part I, and the background counting-rate obtained when using this body in the absence of a radioactive source is very low. Part III is a collimating section used when low geometry is required. ("Geometry" refers here to the orientation and location of the radioactive source with respect to the detector. "Low geometry" implies a geometry which allows only a small fraction of the total particles emitted by the source to be detected.) This is valuable when assaying strong sources, since with the collimating section in use only a small, but known, fraction, of the particles emitted from the source enter the sensitive volume of the counter and are detected. Part IV is a window section, which may be used when the sample to be assayed is to be placed outside the counter. Parts V and VI form a slide section to carry the sample for insertion into the counter volume. Part VII provides a rack for sample trays, absorbers, etc., when the window section (Part IV) is employed. Fig. 5 shows a number

* "Radiation Measuring Instruments for X-Rays to Cosmic Rays." D. Taylor and W. Abson. *Proceedings of the Institution of Electrical Engineers*, vol. 98, Part II, December, 1951, page 760.

* "Self-Balancing Instruments and their Application to Nucleonic Measurement," R. S. Medlock and W. A. Kealy. *Journal of the British Institution of Radio Engineers*, vol. 2, part 9, September, 1951, page 393.

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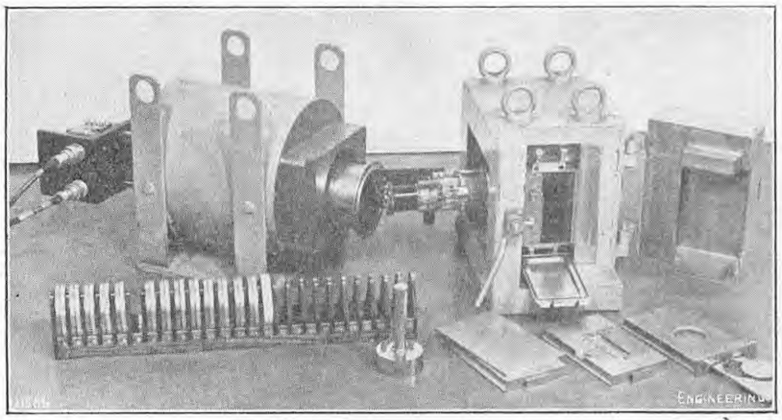

FIG. 9. INSTRUMENT FOR ASSAYING RADIOACTIVE ORES.

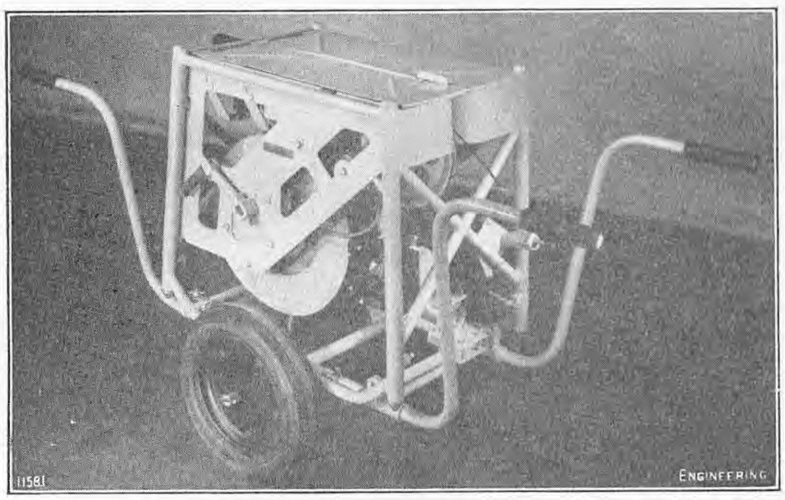

FIG. 10.

FIG. 11.

FIGS. 10 AND 11. BOREHOLE LOGGING EQUIPMENT FOR LOCATING RADIOACTIVE DEPOSITS.

of possible combinations of these counters. Thus, parts I, V and VI form a simple flow-type counter suitable for α-counting with argon as the flow gas. In this case, the operating voltage with an anode loop of $\frac{1}{1000}$ in. tungsten is 800 volts, and the background counting rate is 10 counts per hour. The same system may be used for β-counting, but methane gas and an operating voltage of 2,500 must be employed. With part II substituted for part I, a low-background α-counter suitable for the measurement of very low activities is obtained. The background counting-rate in this case is about 1 count per hour. The other systems shown diagrammatically are (i) an end-window β-counter with provision for absorber changing; (ii) a 4π counter for counting either α- or β-particles and (iii) a low geometry counter for counting either α- or β-particles. Measurements with absorbers are often necessary to obtain data about the hardness of the radiation; such information is often of value in identifying the material being assayed. The 4π geometry counter is of value when very low activities have to be measured. In this case two counter bodies have to be employed, one on each side of a very thin sample of the material being assayed.

AUXILIARY APPARATUS.

In the past much use has been made of the hard-valve scaling circuits of the decade type,* but now these are gradually being replaced by scalers using a gas-filled type of scaling tube. The principle of this tube will be clear from Fig. 6. The tube† consists of a central anode surrounded by three interlaced systems of ten wires each, called the cathode, first guide and second guide systems respectively. The gas filling is mainly neon. The first and second guides are normally higher in potential than the cathode, so that the discharge takes place between the anode and one of the cathodes. If the first-guide potential is reduced below that of the cathode for a suitable period of time, the beam will transfer to the first guide adjacent to the cathode which was previously struck. If, as the first guide is returned to its normal potential, the second guide is reduced in potential for a suitable period of time, the beam will transfer to the second guide and finally, when the guide potential returns to normal, it will pass on to the next cathode. Thus, two successive negative pulses, each of the required duration, are needed to cause the beam to transfer from one cathode to the next. The electrode system is arranged so that the glow discharge takes place at the end of the tube; hence, the tube is self-indicating.

Much use is being made at the A.E.R.E. of the cold-cathode decade scaling tube manufactured by Ericsson Telephones Limited, Beeston, Nottingham, and designated the Dekatron tube. Fig. 7 shows the circuit diagram of one type of scaler using these tubes, designed by Mr. C. D. Florida. Two trigger tubes are used in the input circuit, the first tube being triggered by an input pulse and the second by the delayed pulse from the first. When using the Ericsson scaling tube type GG10B, this circuit has an input resolving time of 500 microseconds which makes it suitable for moderate counting rates. The scaler has the advantages of very low power consumption, high reliability and comparative cheapness, and, if required, it can be made exceedingly compact.

Cold-cathode scaling tubes capable of much faster operation are becoming available, and it is then preferable to use rather different circuits. Mr. K. Kandiah,* working at the A.E.R.E., has suggested new coupling circuits in which the first driving pulse is provided by simple cold-cathode tube coupling between the decade scaling tubes, while the second driving pulse is provided by a common source and is applied to all scaling tubes in parallel. It seems likely that Kandiah's circuit will be used in many future scalers. The fastest cold-cathode scaling tubes have a resolving time of about 100 microseconds. For very fast operation, therefore, it is necessary to use a pre-scaler, which can use hard valves, in front of the cold-cathode scaler. A suitable design for a fast pre-scaler has been evolved at the A.E.R.E.† Fortunately, many of the requirements at Harwell can be satisfied by using the simple cold-cathode scaler without a hard-valve pre-scaler.

Corona stabilising tubes are now being used in the high-voltage power supplies for counters. Nucleonic and Radiological Developments, Limited, Leadenhall-street, London, E.C.3, have produced and are marketing stabilisers of this type operating at stabilising voltages every 100 volts over a range 400 to 1,300 volts. Fixed-voltage power units using these tubes are now employed at Harwell in place of the variable-voltage power units formerly used. This is quite satisfactory for proportional counters, and it is also satisfactory using the new halogen-quenched Geiger counters, since the latter have an almost infinite life and can be manufactured to operate at defined voltages. Halogen-quenched counters are used in the British Atomic Energy Project, and the use of corona-stabiliser power units

* "Scale-of-Hundred Counting Unit," J. Rotblat, E. A. Sayle, and D. G. A. Thomas. *Journal of Scientific Instruments*, vol. 25, No. 2, February, 1948, page 33.

† "The Dekatron: a New Cold Cathode Counting Tube," R. C. Bacon and J. R. Pollard, *Electronic Engineering*, vol. 22, No. 267, May, 1950, page 173.

* British patent application No. 8914/52.

† "A Fast Amplitude Discriminator and Scale-of-Ten Counting Unit for Nuclear Work," F. H. Wells, *Journal of Scientific Instruments*, vol. 29, No. 4, April, 1952, page 111.

and cold-cathode scalers simplifies the counting equipment; this is particularly valuable where the equipment is needed for routine measurements. The new apparatus is both easier to use and maintain, and the capital cost is less, than the equipment which has been used in the past.

Recently Messrs. P. Holton and J. Sharpe have designed a corona-stabiliser power unit for use with the universal proportional counter already described. A paper describing this instrument has been communicated to *Electronic Engineering*. It consists of a small transformer, a Cockcroft and Walton rectifier-multiplying circuit, and three corona-stabiliser tubes connected together to give a choice of three output voltages, viz., (i) 800 volts using argon as the flow gas in the counter for α-counting; (ii) 1,600 volts using hydrogen as the flow gas in the counter for low-geometry α-counting; and (iii) 2,500 volts using methane as the flow gas in the counter for β-counting.

Dose-Rate Meters.

The earlier review mentioned the use of radiation monitors for the control of health hazards in laboratories containing nuclear reactors, or particle accelerators, or in laboratories where radioactive materials are handled. An interesting development in health instrumentation is a new type of dose-rate meter. This instrument operates on the ionisation-chamber electrometer-valve principle, but differs from the linear-scale instruments in that, instead of passing the ionisation current through a fixed resistor and measuring the voltage across it, the ionisation current is passed directly to the grid of the electrometer valve. The valve then passes (electron) grid current to equal the ionisation current. The anode current is an approximately logarithmic function of the ionisation current and is remarkably stable and reproducible. Fig. 8 shows the basic circuit of an instrument of this type.

Mr. R. J. Cox, at the A.E.R.E., has designed a number of logarithmic scale instruments with some unusual features. Firstly, he uses a small β-source inside the chamber to ensure that zero external-radiation field corresponds to a definite anode current. This causes the initial part of the meter scale to be approximately linear instead of logarithmic. Secondly, he uses only one small battery in addition to the filament battery, comprising eight small mercuric oxide cells, each of 1·3 volts in series. The complete battery is about 2 in. long and $\frac{1}{2}$ in. in diameter, and the cross-section is different at the two ends so that it can only be inserted into the battery compartment in the right way. Thirdly, a check full-scale switch is included; when this switch is pressed, the meter should normally read full-scale (500 röntgens per hour in the case of one of the instruments designed for civil purposes).* There is a red line on either side of this point corresponding to the acceptable error of the instrument. When the meter deflection reaches one of these lines, the filament cell is changed. At this time, two controls "set zero" and "set full-scale" are adjusted so that the meter reads zero in the absence of an external radiation field and full-scale when the check full-scale switch is pressed. The stability of the instrument is such that these controls do not normally need to be touched until the filament cell has run down. When this test indicates the maximum acceptable error at full-scale, the error at zero is usually much smaller than this. This method of operation allows a test to be made that the instrument is operating satisfactorily even in radiation fields up to 100 röntgens per hour. In Cox's design the operation of the "set zero" and "set full-scale" controls are independent of one another and are quite simple to operate, but, to discourage their adjustment, the instrument is designed so that special tools are necessary to alter the controls. Logarithmic dose-rate meters are now being used in health and radiac (civil defence) instruments and they are likely to replace many of the linear-scale instruments.

* "Radiac Instrumentation," D. Taylor, *Journal of Scientific Instruments*, vol. 29, No. 10, October, 1952, page 315.

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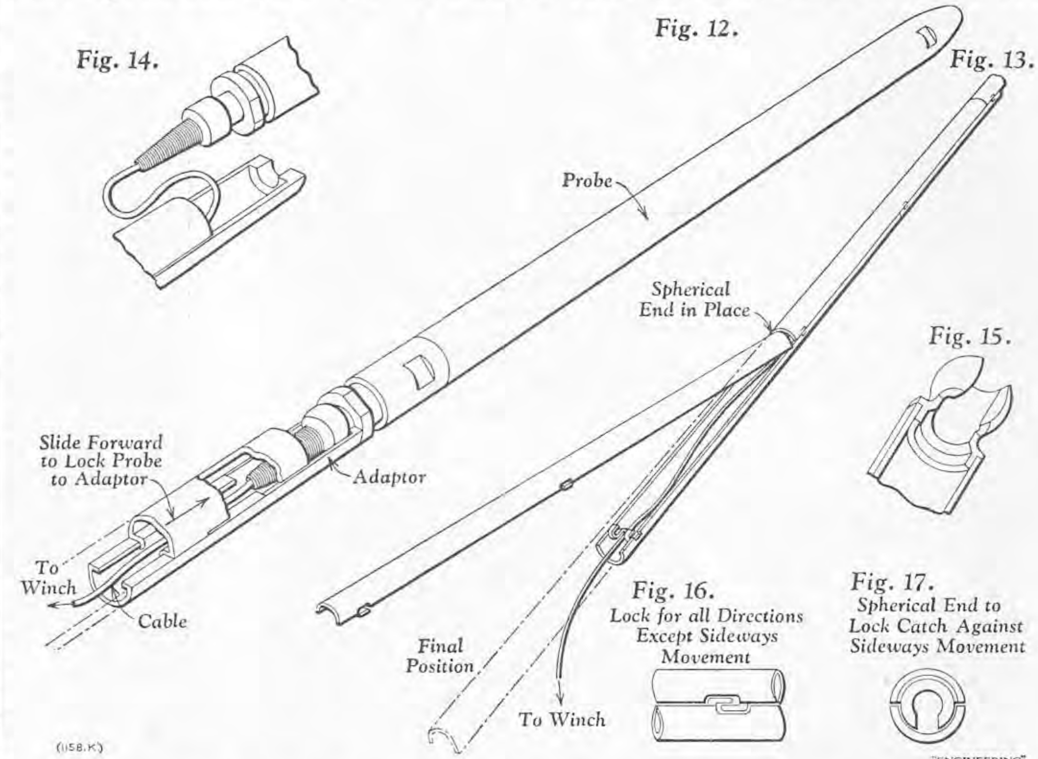


Nucleonic Measuring Instruments for Geological Survey.

Messrs. E. Franklin, D. H. Peirson, R. K. Barnes and D. Williams have contributed a great deal to the development of nucleonic measuring instruments for geological and mining applications and several papers have been published on the work of this team.* In this review two examples will be given of hitherto unpublished developments. The first is largely the outcome of early work by Franklin and Barnes on developing a method for the assay of natural radio-active ores. Such a method has to be capable of use with ores containing uranium which may, or may not, be in equilibrium with its decay products (including radium), and in which there might also be thorium present. The equipment used is shown in Fig. 9, and comprises a scintillation counter in a lead "castle" with an arrangement of filters which can be placed between the source to be assayed and the detector. It is designed so that the samples and filters can be changed without allowing any light to meet the phosphor, or the photomultiplier. The method consists essentially of measuring the γ-ray intensity and effective hardness, and then to estimate the uranium by measuring the β-activity and calculating the excess β-activity above that due to the radium and thorium alone. The variation of self-absorption between different samples is allowed for solely on the basis of the weight of the sample filling the holder. The sample depth is $\frac{3}{16}$ in., so that the γ-ray self-absorption is slight, and for β-rays the sample is equivalent to a close approximation to one of infinite depth unless the sample has an unusually low density. A thallium-activated sodium iodide crystal $\frac{3}{8}$ in. thick is used both for the β-ray and the γ-ray measurements. This thickness is a compromise to give, on the one hand, a reasonably good counting efficiency, and on the other hand reasonably good discrimination between the γ-rays from the thorium series and the radium series. The crystal is enclosed in a capsule containing paraffin to prevent deterioration of the crystal surface, and having a thin metallic window facing in the direction of the sample and a transparent window in the direction of the photomultiplier.

* "A Survey Equipment using Low-Voltage Halogen-Quenched Geiger-Müller Counters," E. Franklin and W. R. Loosemore, *Proceedings of the Institution of Electrical Engineers*, vol. 98, Part II, No. 62, April, 1951, page 237.

"The Design of Portable Gamma- and Beta-Radiation Measuring Instruments," E. Franklin and J. Hardwick, *Journal of the British Institution of Radio Engineers*, vol. 11, No. 10, October, 1951, page 417.

"Aerial Prospecting for Radio-Active Minerals," D. H. Peirson and E. Franklin, *British Journal of Applied Physics*, vol. 2, No. 10, October, 1951, page 281.

"Alpha-Particle Assay and the Measurement of the Thorium-Uranium Ratio in Radio-Active Ores," D. H. Peirson, *Proceedings of the Physical Society*, vol. 64 (B), No. 10, October 1, 1951, page 876.

With this apparatus uranium contents down to 1 per cent. can be measured with 10 per cent. accuracy with up to about 20 times as much ThO_2 as U_3O_8 present, or with up to 10 times the equilibrium content of radium. The apparatus is first calibrated by using synthetic mixtures. The method can be best explained by quoting some actual measurements and calculating the results. Let us suppose that the following counting rates are obtained after subtracting the background counting rate:—

Counting rate without filter = 1,694 counts per minute.
Counting rate with $\frac{1}{16}$-in. lead filter = 752 counts per minute.
Counting rate with $\frac{5}{8}$-in. lead filter = 224 counts per minute.
$\therefore$ Effective hardness factor = 752/224 = 3·36.
Referring to a calibration chart, radium-to-thorium ratio = 0·834.

This ratio is expressed in derived units, the radium being expressed in terms of the uranium with which it would be in equilibrium.

Further reference to the calibration curves shows that with the $\frac{1}{16}$-in. lead filter, thorium gives 475 counts per minute per percentage of ThO_2 and radium gives 935 counts per minute per percentage of U_3O_8 with which it would be in equilibrium for the sample weight used.

Hence percentages of ThO_2 present = $\dfrac{752}{0\cdot834 \times 935 + 475} = 0\cdot60$. Also percentage of U_3O_8 with which the radium would be in equilibrium $= 0\cdot834 \times 0\cdot60 = 0\cdot50$. We next assume that the absorption of the γ-rays is logarithmic and calculate what the γ-ray counting rate would be without a filter, knowing that the γ-ray counting rates with the $\frac{1}{16}$-in. and $\frac{3}{8}$-in. lead filters are 752 and 224 counts per minute, respectively. This gives a counting rate of 860 counts per minute. Hence of the total counting rate obtained, namely, 1,694 counts per minute, 860 counts per minute must be due to γ-rays and 834 counts per minute due to β-rays. Referring to further calibration curves and deducting the β-ray counts shown as due to 0·60 per cent. ThO_2 and the radium already determined, this leaves 379 counts per minute due to uranium. Knowing that chemically pure U_3O_8 gives 752 counts per minute per percentage of U_3O_8, the percentage U_3O_8 in the sample is 0·5, and hence the uranium is in equilibrium in this case.

A final example of the instrumentation developments at Harwell is the borehole logging equipment used for locating radioactive deposits in the earth's crust. Where wide boreholes, say 2 in. or more in diameter, are used, there is a great deal to be said for using scintillation counter detectors, particularly for deep boreholes. However, for small diameter boreholes, it is necessary to use Geiger counter detectors which are usually quite acceptable for shallow holes. The equipment to be described has been designed for the detection and measurement of changes in the intensity of γ-radiation. The sensitivity has been chosen so that it is best suited for the detection of deposits of radioactive materials such as in mine control, rather than for the more general stratographic logging. The use of the equipment in mine control results in the following design considerations: (i) provision must be made for logging of downward sloping holes, upward holes and holes near the horizontal; (ii) the equipment must be robust, reliable and unaffected by moisture and it must be capable of being used and maintained by a geologist without electronic training; (iii) it must be of such a size, shape and weight that it may be readily transported by road (in a station wagon), along tracks inaccessible to vehicles, across rough country and within mine workings.

Fig. 11 shows the apparatus with the winch set up ready for use. The probe is seen in the foreground. It is of stainless steel tube with a bullet-shaped nose. It contains the Geiger counter and its associated circuit. It is glanded to the cable and sealed to withstand 700 lb. per square inch hydraulic pressure. The winch also carries the remaining equipment i.e., the power unit and counting-rate meter. The total power consumption of the apparatus is only 50 milliwatts, and the battery life is about 2,000 hours. Fig. 10 shows the winch assembled ready for movement to another location.

When the probe is to be used in a downward hole it may be lowered under its own weight, but for horizontal and upward holes push-rods must be used. Figs. 12 and 13 shows some push-rods of a novel type designed by Mr. J. B. Marsh of the A.E.R.E., while Figs. 14-17 show some component parts. They consist of 1-m. tubular half-sections which interlock and form a complete tube, of diameter equal to the probe, which completely encloses the cable. These push-rods are used in lengths up to 100 m.

I am indebted to several of my colleagues at the Atomic Energy Research Establishment who have provided me with information for the preparation of this paper. In particular, I am indebted to Mr. R. J. Cox for information about his new dose-rate meter, Mr. R. K. Barnes for the numerical data given about uranium/thorium assays and Messrs. W. Williams and J. B. Marsh for information about their borehole logging equipment. The paper is published by permission of the Director of the Atomic Energy Research Establishment, Sir John Cockcroft. Crown Copyright of Figs. 2, 9, 10 and 11 is reserved. Figs. 2 and 6 have already appeared in the *Proceedings* of the Institution of Electrical Engineers, to whom acknowledgment is made.

THE ENGINEERING OUTLOOK.

XI.—AGRICULTURAL MACHINERY.

THE need for a vast expansion in the world production of primary products has been so frequently emphasised in recent years as to become a commonplace. The world's population is increasing at a rate of 1 to 1½ per cent. per annum, and it is estimated that, by the end of this century, it will amount to 4,000 million people, compared with 2,300 million at present—provided that the increase is not checked by lack of food. This increase in population will require not only a corresponding increase in food supplies, but also of industrial raw materials. In an agricultural expansion of this order, the agricultural machinery industry has an important part to play, both in extending the area of land under cultivation and in improving methods of cultivating it. Assuming that this world development will be undertaken—which depends on large-scale investment by the developed countries in the undeveloped areas, with little prospect of immediate reward—the long-term prospects of the agricultural machinery industry (like those of many other branches of the engineering industry) are good. In the short term, however, the prospects are less favourable, and the experience of the industry in 1952 gives cause for uncertainty about the immediate future.

The year's results, in terms of production and exports, were not substantially inferior to those of 1951, which was, in most respects, a record year. The total production of tractors and implements was slightly higher in value in 1952, though this was almost certainly due to higher prices; the volume of production probably declined. The production of tractors fell by nearly 10 per cent., and the production of both horse-drawn and tractor-drawn ploughs was also substantially lower. The 25 per cent. reduction in the output of milking machines was due to severe cuts in steel supplies; in other branches of the industry, it was deficiency of demand rather than shortage of materials that was the difficulty during the year. Some details of production, in the United Kingdom, of agricultural machinery of various types is shown in Figs. 1 to 7, on pages 454 and 455.

The demand for agricultural machinery is closely related to the level of farm incomes, and the decline in commodity prices from the peak levels of mid-1951 must have had a depressing effect on farmers' plans for mechanisation. Apart from the direct effect of lower commodity prices on producers' incomes, the fall must also have had a detrimental effect on their outlook; falling prices and the reappearance of world surpluses of some agricultural commodities are not the most encouraging circumstances for investment in agricultural machinery. In the short term, these influences may prove more important than the long-term upward trend of agricultural prices which will result from the growing pressure of demand for the world's food supplies.

Even in Britain, where the farmer is alleged to be "feather-bedded," the agricultural outlook seems rather less assured than in previous post-war years. In recent months, there have been indications that the Government's determination to remove controls and subsidies and to develop a more competitive outlook extends even to the farming sphere. The decontrol of eggs and feeding-stuffs has not been immediately accompanied by the establishment of marketing boards, though farmers have been assured that the guaranteed price structure will not be weakened. The need for higher food production in the United Kingdom is so generally accepted, however, that the farming community should be able to look to the future with reasonable confidence; the point of dispute will be the price to be paid for this higher output.

A drive for higher food production in the United Kingdom would not necessarily cause a significant increase in the demand for agricultural machinery. Increased production cannot be achieved by appreciably increasing the area of agricultural land; the little that can be done in bringing new areas under cultivation will do no more than offset the loss of agricultural land to housing and industrial expansion. What is required is higher yields per acre and better selection of products, and increased mechanisation is not the principal means of achieving either of these aims.

The latest *Annual Review of Farm Prices* emphasises the importance of the expansion of meat production, which, in turn, will require a higher production of home-grown feeding-stuffs. The White Paper suggests that the necessary increase could be achieved by increasing the area under coarse grains by about a million acres, and by achieving a 5 per cent. increase in the yield per acre of tillage crops and a 15 per cent. increase in grassland production. Of these aims, only the first will directly involve any additional purchases of agricultural machinery. In addition, there is a good case for an increased production of wheat, one of the most expensive dollar food imports; here again, the aim must be to raise the yield per acre from its present national average of 21 cwt. to something nearer the 30 to 35 cwt. consistently obtained by good farmers from quite moderate land, rather than to increase the acreage under wheat.

British agriculture is already the most highly mechanised of any in the world, whether measured in terms of the numbers of tractors per unit of arable land, or in terms of the division between tractor and animal draught for particular implements. The tractor "population" of the United Kingdom has risen from 55,000 in 1938 to over 300,000 in 1952. The initial expansion was caused by the war-time need to increase the volume of agricultural production with a reduced labour force, with little regard to the cost. Inevitably, the mechanisation was too rapid in many cases to allow time for a careful choice of equipment and the development of correct techniques. Though a high level of agricultural production is still required, increasing attention has to be paid to costs and efficiency. Investigations of the costs and profits of mechanised farms have shown a wide range of profitability, from about 2*l*. to 3*l*. per year per acre to 10*l*. to 15*l*.

The two factors on which the efficiency of a mechanised farm depends are the system of farming and the standard of machinery maintenance. According to the Director of the National Institute of Agricultural Engineering, Mr. W. H. Cashmore, the most efficient farmers plan their system by selecting the minimum amount of labour on which they are prepared to run the farm, and arranging the cropping and stock to make the best use of the available labour. The machinery requirements will follow from these initial decisions, and the machinery must be selected for the farm as a whole, and not for individual processes, so that labour will not be idle at any time of the year. From the farmers' point of view, the efficiency of the farm organisation is often more important than the equipment itself. In any event, the combined cost of labour and machinery should not exceed 40 per cent. of the total turnover.

The cost of machinery repairs and replacement is high, varying from 10 to 20 per cent. of the initial price each year, according to the extent to which repairs can be carried out on the farm. The life of the machine also depends on the care and treatment it receives, and may vary from four to ten years. When depreciation costs are added to maintenance costs, it is obvious that the cost of machinery which is not well cared for can easily become crippling. Taking an extreme case, where the machinery was very badly looked after, incurring the maximum repair cost (20 per cent.) with the minimum life (four years), the annual cost of the machinery would amount to 45 per cent. of its total value (25 per cent. depreciation and 20 per cent. repairs). Taking the other extreme, of maximum life and minimum maintenance costs, the total machinery costs would only amount to 20 per cent. of its value. On an "average" farm, with an investment in machinery of 20*l*. per acre, the difference between good and bad care of machinery could be 5*l*. an acre—a sum which would make a vast difference to the profitability of the farm.

It follows that a reduction in machinery costs by a better standard of maintenance on the farm (and more attention to reliability, on the part of the manufacturers) is essential to the improvement of the efficiency of British agriculture. At the moment, British farmers spend 45*l*. million a year on machinery (including parts and accessories), and Mr. Cashmore concludes that "this figure for the home market can be reduced considerably, and must be for economic agriculture." The implications for the agricultural-machinery industry are not favourable; at a time when important export markets are putting up restrictions, the industry might be excused if it looked to the home market to take up some of the slack. No increase in home demand can be expected from the present drive to increase both agricultural production and agricultural efficiency; the main source of demand will probably be replacements.

With a tractor population in the United Kingdom of 325,000 agricultural wheeled tractors and 41,000 horticultural tractors, the replacement demand can reach substantial proportions. In 1951, the home market took 29,530 agricultural tractors; allowing an average life of ten years for a tractor, replacements probably accounted for a substantial proportion of the purchases of agricultural tractors, even in that year. The replacement demand for agricultural tractors should continue to increase over the next few years (as the tractor population has only just ceased to rise) and if it reaches 10 per cent. of the tractor population, as can reasonably be

Fig. 1.
UNITED KINGDOM: PRODUCTION OF TRACTORS.

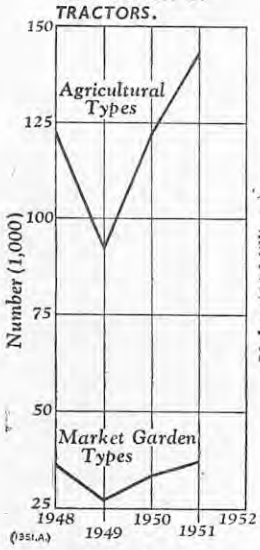
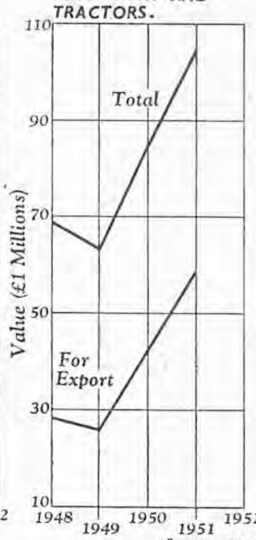


Fig. 2.
TOTAL DELIVERIES OF AGRICULTURAL MACHINERY AND TRACTORS.



expected, it should be sufficient to maintain home demand at its present level.

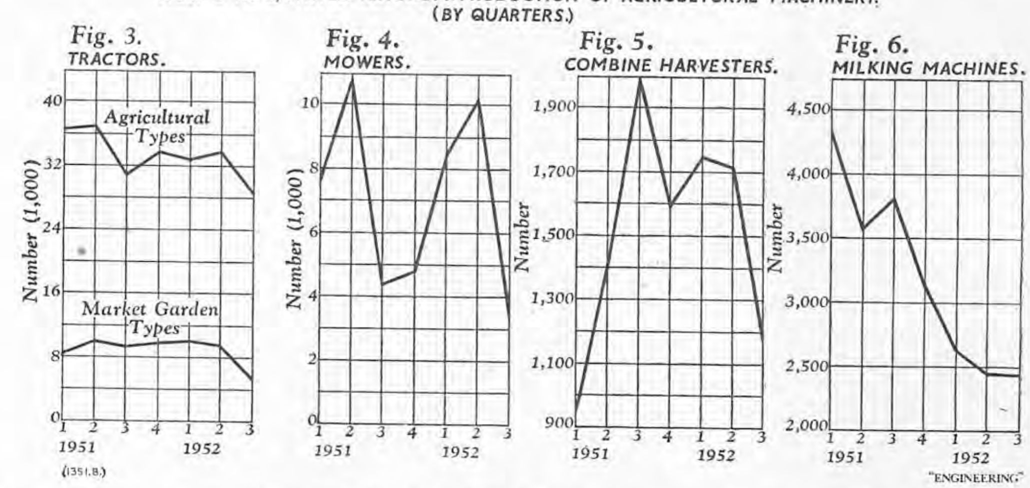
The demand for horticultural tractors (under 10 h.p.) is a much more recent development; Exports of these machines are relatively unimportant, accounting for about 10 per cent. of the production in 1951. The sharp fall in output which occurred in the third quarter of 1952 was due, therefore, to a decline in the home demand. This is not surprising in view of the difficulties of the horticultural industry, most sections of which have experienced falling profits in recent years. At present, the industry is suffering a period of enforced retrenchment, and cannot be expected to maintain a high demand for expensive machinery, however necessary it may be to reduce unit costs of production. The industry's future depends on Government action to regulate the imports of fruit and vegetables, to prevent prices falling to uneconomic levels. This could be done by raising the existing specific import duties from their present pre-war level. Without a radical change in the industry's prosperity, however, there is little prospect of a sustained home demand for horticultural tractors.

The most likely source of an increased demand for agricultural machinery from British farmers is the introduction of improved methods of handling and conveying—the application of factory principles to farm operations. The principles of mechanical handling are, of course, already incorporated in such machines as the combine harvester and the pick-up baler, but there are numerous other handling operations (whether of crops, seedlings or manure) in which expensive labour might profitably be replaced with machinery. In addition, the switch of emphasis to meat production offers scope for the extension of barn machinery and labour-saving devices that go with stock-feeding. Another probable development is the extension of controlled grazing of stock by the use of electric fencing.

The efficient mechanisation of the small farm is a problem of long standing, and one to which machinery manufacturers may be expected to give more attention as market conditions become more difficult. An interesting development of 1952 was the formation of a new company, the Alpema Agricultural Development Company, Limited, specialising in equipment designed for farms of 50 to 200 acres. Most of the machinery designed will be dual-purpose. The first three items to be produced were a mobile grass drier, a portable air heater suitable for all types of grain drying, heating greenhouses and defrosting orchards, and a fertiliser distributor which can be used for any powdered fertiliser, and for corn or grass seed.

The Ministry of Agriculture working party on grain drying and storage estimated that 6,000 more combine harvesters were used for the 1952 harvest than in 1950. At the same time, only one in every ten of the farmers who buy combines buys a recognised type of grain drier at the same time. Even in 1950, the existing grain-drying facilities of the Ministry of Food and of the grain-using industries

FIGS. 3 TO 6, UNITED KINGDOM: PRODUCTION OF AGRICULTURAL MACHINERY. (BY QUARTERS.)



were employed to capacity during the 10 weeks of harvest, so that there must exist already a serious deficiency in grain-drying plant, which is bound to limit the extension of combine-harvesting. Although the output of combine harvesters in the first three quarters of 1952 was as high as in the corresponding period of 1951, there was a significant fall in the third quarter—the peak period of 1951, (Fig. 5). The working party recommend that the price range for wheat should be adjusted between harvest and January to induce farmers to instal and operate drying and storage plants. The extension of Government storage is not advocated, but special measures such as loans, preference for building licences, and special income-tax allowances are recommended for the erection of grain-drying and storage plant by farmers, merchants and ultimate users.

FALLING TRACTOR EXPORTS.

In recent years, the agricultural-machinery industry has depended for 55 to 60 per cent. of its sales on export markets. It is in these markets that the long-term outlook is most favourable, but, during 1952, the short-term difficulties had a greater influence on events, and this will probably apply also to 1953. This was certainly true of tractor exports, which were hit by import restrictions in some of the principal Commonwealth markets. The contrast between the long-term and short-term prospects was brought out by a statement by Mr. Harry Ferguson in October, 1952, when the Standard Motor Company were reducing their tractor output. "The demand for British tractors abroad is greater than ever and is growing rapidly," said Mr. Ferguson. He considered that the cut in tractor output was due to currency problems, adding that "overseas distributors of our tractors have tens of thousands of orders on their books which they cannot meet owing to Governments cutting their allowances of sterling." Various export statistics are given in Tables I to III.

The "currency problems" referred to by Mr. Ferguson are closely related to commodity prices, particularly in Australia, where the spectacular rise in wool prices after the outbreak of the Korean war caused a sharp increase in the internal price level. This was responsible for the increase in imports which continued after wool prices had fallen, resulting in a balance of payments deficit.

TABLE I.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL TRACTORS, BY COUNTRY OF DESTINATION.

—	1950.		1951.		1952.	
	No.	Value (£1,000).	No.	Value (£1,000).	No.	Value (£1,000).
Union of South Africa	6,940	2,144	12,177	4,269	3,977	1,517
Southern Rhodesia	847	314	1,428	604	564	272
British East Africa	935	456	1,107	487	1,045	550
India	3,131	1,208	5,465	2,149	912	414
Australia	21,173	7,156	21,515	7,111	13,364	4,307
New Zealand	6,861	2,361	7,006	2,525	6,696	2,451
Canada	4,622	1,739	6,399	2,226	6,385	2,362
Other Commonwealth countries	1,071	424	2,090	834	2,818	1,265
Irish Republic	1,934	565	3,419	1,017	3,062	1,169
Finland	1,222	445	3,366	1,255	5,407	2,167
Sweden	6,848	2,223	8,130	2,899	10,850	4,422
Norway	1,135	365	3,154	1,005	3,969	1,323
Denmark	5,283	1,578	7,436	2,448	11,121	4,086
Netherlands	1,534	479	2,240	780	2,508	952
Belgium	1,221	418	1,464	551	2,009	838
France	3,984	1,355	4,096	1,618	4,525	1,947
Spain	686	278	1,313	646	942	562
Italy	1,326	478	1,487	638	3,795	1,746
Greece	298	191	373	207	388	194
Turkey	920	329	8,067	3,822	8,263	4,789
Algeria	1,032	375	725	320	981	485
Egypt	1,179	323	2,309	712	199	69
United States of America	4,039	937	1,088	127	2,259	318
Cuba	720	212	596	249	386	164
Brazil	491	235	1,674	788	1,420	621
Uruguay	1,189	523	551	241	1,324	616
Argentine Republic	596	341	99	40	208	161
Other foreign countries	2,748	974	3,435	1,474	5,565	2,569
Total	83,965	28,426	112,659	41,132	104,942	42,336

To correct this, the Australian Government imposed import cuts in March, 1952, designed to reduce total imports by approximately half. No specific quotas were laid down for agricultural and horticultural machinery, which were placed in the " third category " of goods to be dealt with administratively, but United Kingdom exports of tractors to Australia fell from 21,000 in 1951 to 13,000 in 1952.

India was also adversely affected by the fall in commodity prices during 1951 and 1952. Vegetable oils and oilseeds, hides and skins and shellac all fell to less than half their peak price, and the terms of trade deteriorated by about 10 per cent. during 1951-52. In addition, the Indian Government have been pursuing a disinflationary policy, and imports are strictly controlled. This policy has been successful as far as the Indian balance of payments is concerned, the deficit in the first six months of 1952 being reduced to 59*l*. millions, compared with 69*l*. millions in the second half of 1951. For British tractor manufacturers, however, the policy of the Indian Government has meant a fall in exports from 5,000 to 1951 to 1,000 in 1952.

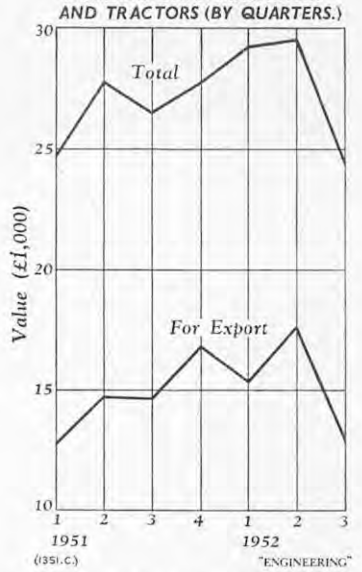
Another important Commonwealth market, South Africa, has also sharply reduced imports of British tractors in 1952, again because of the balance of payments. The only important Commonwealth markets which maintained their imports in 1952 were Canada and New Zealand, and the total exports of tractors to Commonwealth countries fell from 57,637 in 1951 to 35,761 in 1952. In the face of these difficulties, the tractor manufacturers did well to achieve a total export figure only 6 per cent. lower in volume and slightly higher in value than in 1951. This was done by increasing exports to non-Commonwealth countries, particularly Scandinavia, so that, in 1952, these markets absorbed 65 per cent. of the total, compared with only 49 per cent. in 1951. The 1952 experience demonstrates the value of the wide dispersion of the overseas markets for tractors ; it gives the industry a reasonable chance of maintaining exports when individual markets are closed. On the other hand, of course, dispersion of markets increases distribution costs. The dispersion was further increased in 1952 ; Australia remained the largest single market, despite the import cuts, but accounted for only 13 per cent. of the total exports, compared with 19 per cent. in 1951.

PROSPECTS FOR TRACTOR EXPORTS.

The diversion of tractor exports from Australia, South Africa and India to Scandinavia and other foreign countries is a tribute to the adaptability of British tractors to widely varying conditions throughout the world. At the same time, it does not offer a permanent solution to the problem of maintaining British exports of tractors. There is a serious danger of saturation in some of the smaller markets which have taken a substantial number of tractors in recent years. Denmark, for example, has taken 18,000 tractors from the United Kingdom in two years, equivalent to the total tractor population in 1950. The United Kingdom normally supplies about half of the Danish imports of tractors, so that the rate of increase in the number of tractors on Danish farms must have been very rapid, and cannot be expected to continue on this scale. Sweden, which had 60,000 tractors in 1950, has also imported 18,000 British tractors in two years. It is obvious that the industry cannot look to these smaller countries to sustain demand for tractors indefinitely ; it is the large and relatively undeveloped countries which must provide the long-term market.

Australia, though hardly ranking as an undeveloped country, will probably remain the largest potential market for tractors for some years. The prospects there are much more favourable than they were twelve months ago, because it now seems that the Australian Government have been able to control internal inflation. The balance of payments position has improved, and some relaxation of the import cuts was announced in November, and again in February. Even more important than the correction of the balance of payments deficit

Fig. 7.
TOTAL DELIVERIES OF AGRICULTURAL MACHINERY AND TRACTORS (BY QUARTERS.)



is the recognition of the need to expand the production of primary products, which have declined in relative importance as secondary industries have developed. If present trends continue, Australia will cease eventually to be an exporter of food. The expansion of primary production should involve an increased demand for tractors. There is substantial scope for the extension of the area under cultivation in Australia, despite the low rainfall and infertility of the soil in many areas, but it is difficult and expensive to attract labour to the " outback."

In India, also, the expansion of food production is an aim of Government's policy, but there the scope for tractors is limited. There is already a surplus of agricultural labour in most parts of India, and mechanisation would create new problems of unemployment except where the displaced labour could be absorbed by secondary industries. Moreover, reform of the land tenure system would be required to increase the size of holdings before the use of tractors could become an economic proposition. At present, most of India's tractors are owned by the Central Tractor Organisation and are used for the reclamation of jungle and weed-infested areas. As reclaimed land is settled, more tractors and implements will be required for its cultivation ; this is also true of new areas brought under cultivation by irrigation. At the same time, mechanisation must be co-ordinated with other forms of agricultural progress, such as the education of peasant farmers and the increased use of fertilisers, so that progress is bound to be slow. The overriding consideration will be finance ; agricultural machinery is only one of the many types of equipment required by India, and the rate at which imports can be allowed will depend on the balance of payments position and the amount of financial assistance given by Britain and the United States.

TABLE II.—UNITED KINGDOM : EXPORTS OF AGRICULTURAL MACHINERY OTHER THAN TRACTORS, BY COUNTRIES OF DESTINATION.

—	1950.		1951.		1952.	
	Cwt. (1,000).	Value (£1,000).	Cwt. (1,000).	Value (£1,000).	Cwt. (1,000).	Value (£1,000).
Union of South Africa	85	646	92	900	77	839
British East Africa	29	303	32	382	34	482
India	110	844	78	768	37	460
Australia	108	1,199	200	2,532	191	2,716
New Zealand	70	702	71	799	92	1,292
Other Commonwealth countries	87	799	82	1,016	98	1,422
Irish Republic	79	631	117	1,060	103	1,043
Sweden	22	236	31	346	31	427
Norway	9	111	16	186	16	250
Denmark	27	282	42	456	40	504
Netherlands	51	367	37	329	27	231
France	28	346	63	915	77	1,275
Greece	18	155	7	102	6	75
Algeria	14	159	15	189	11	183
Egypt	20	161	22	178	12	103
Brazil	18	170	27	342	17	333
Uruguay	46	410	10	95	13	130
Argentine Republic	81	882	15	152	11	110
Other foreign countries ..	107	1,102	248	3,015	438	5,851
Total	1,009	9,505	1,205	13,762	1,331	17,726

TABLE III.—*United Kingdom : Exports of Agricultural Machinery, by Quantity* (1,000 *Cwt.*).

—	1950.	1951.	1952.
Types other than Tractors :			
For preparing and cultivating the soil :			
Ploughs	329	354	360
Other sorts*	—	—	370
For harvesting, threshing and sorting :			
Hay and grass mowers ..	65	70	75
Reapers, binders and threshers	25	24	23
Combine harvester-threshers*	—	136	204
Other†	—	—	166
Other descriptions :			
Sheep shearers and clipping machines ..	6	6	7
Other	584	615	126
Total	1,009	1,205	1,331
Tractors	2,620	3,260	2,940
Grand total	3,629	4,465	4,271
By Value (£1,000).			
Types other than Tractors :			
For preparing and cultivating the soil :			
Ploughs	2,444	3,079	3,374
Other sorts*	—	—	3,999
For harvesting, threshing and sorting :			
Hay and grass mowers ..	823	920	1,114
Reapers, binders and threshers	217	247	265
Combine harvester-threshers*	—	2,147	4,016
Other†	—	—	2,422
Other descriptions :			
Sheep shearers and clipping machines ..	280	282	416
Other	5,741	7,087	2,120
Total	9,505	13,762	17,726
Tractors	28,426	41,132	42,336
Grand total	37,931	54,894	60,062

* Not separately distinguished in 1950.
† The figures for 1950 and 1951 are included with " Other descriptions—Other."

Outside the Commonwealth, the most promising long-term markets may be in South America, principally Brazil, though there the British manufacturers will not enjoy the freedom from American competition which they have had in the sterling area since the war, owing to the dollar shortage. Brazil has sought from the United States a loan of 18 million dols. for rural mechanisation ; no doubt, most of this will be spent in the United States and Canada, but there may be opportunities for British exporters as well. Brazil is estimated to possess only one tractor for every 1,500 acres of cultivated land, and farming methods are said to be comparable to those of the United States 100 years ago. However, Brazil's balance of payments difficulties will probably prevent any rapid mechanisation of agriculture.

EXPORTS OF OTHER AGRICULTURAL MACHINERY.

In contrast to tractors, exports of other types of agricultural machinery recorded a further increase in 1952. The quantity exported was 10 per cent. higher (by weight) than in 1951 and the value 30 per cent. higher, indicating a substantial increase in average prices, or the export of more expensive types of machinery. Owing to changes in the statistical classifications in the trade returns, it is not clear which types of machinery are responsible for the increase, though exports of combine harvester-threshers were more than 50 per cent. greater in quantity (double in value) than in the previous year. Exports of agricultural machinery seem to be even more widely dispersed than tractor exports; in 1952, the "other foreign countries" category in the trade return accounted for a third of total exports. Exports to Australia, which was again the largest single market, were apparently not affected by the import cuts, but exports to India were halved.

Japanese competition is growing in the Asian markets for farm machinery. At present, the volume of Japanese exports is small in relation to British exports; the target for 1952 was 2 million dols., compared with the British production for export of some 150 million dols. Nevertheless, they are growing rapidly, the 1952 exports being five times as great as in 1950. The chief demand is for the more simple instruments, such as ploughs and sickles, but rice-hulling, threshing and dusting machines are also exported. The growing demand for Japanese farm equipment arises from the successful exhibition held in Rangoon in February, 1949. A steady demand for samples followed, and after successful tests, large-scale purchases were made. A similar experimental demand for tractors, cultivators and harrows was noticeable in 1951 and 1952, and substantial orders for these machines are expected to follow in due course. As the vast potential Chinese market is closed to the Japanese, the sales campaign is directed to the other south-east Asian markets and to South America.

Expansion of the British Industry.

One of the most significant developments of 1952 was the decision of the International Harvester Company to double their productive capacity in the United Kingdom. Their Doncaster factory was already employing 2,000 people and producing 4,500 to 5,000 tractors a year. It is now proposed to double the size of the factory and to extend its foundry capacity in proportion; the new plant should come into operation in about two years' time. The production of certain types of equipment, such as balers, will be increased and the range will be extended to include a crawler tractor. At present, about 80 per cent. of the factory's output is exported, and it is expected that this high export ratio will be maintained when the new plant comes into operation.

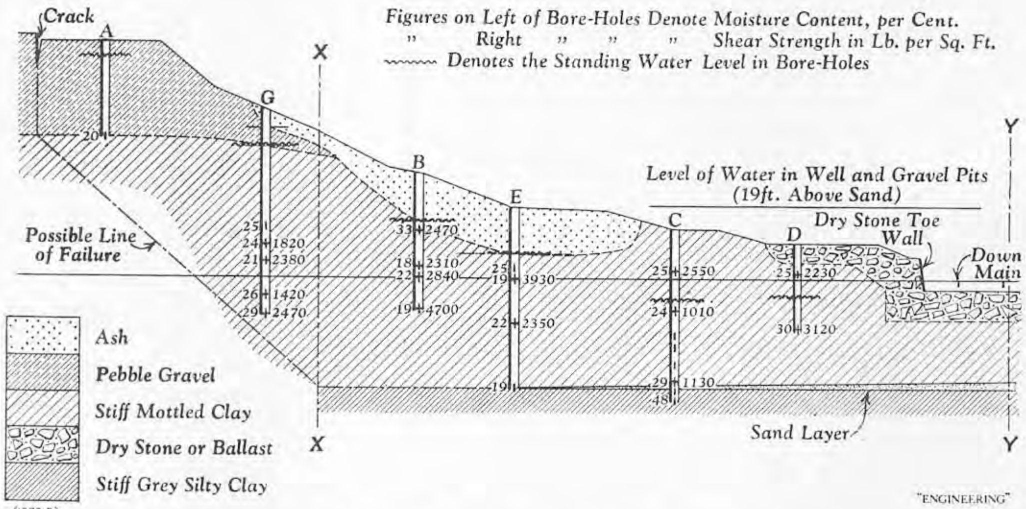
Each of the three leading North American manufacturers—Massey-Harris, Allis-Chalmers, and the International Harvester Company—now has factories in full production in the United Kingdom. Some of the equipment produced by them, principally combines and pick-up balers, is not made on a large scale by British manufacturers, but a good deal of their machinery is directly competitive. British makers have been assisted in their post-war expansion by the dollar shortage, which closed a large number of markets to American manufacturers. These difficulties have now been overcome by the production of American-designed machines in the sterling area, and the British manufacturers will have to compete against the traditional pre-war preference for American types in agricultural machinery and the well-established distributive systems of the American companies. Whether they can do this successfully, and particularly at a time when the markets are not expanding, remains to be seen.

One British manufacturer has dealt with a similar situation in the same way as the American companies. The Standard Motor Company have made arrangements for the Ferguson tractor to be made in France, to overcome the import restrictions which have prevented the company from satisfying the large French demand by exports from Britain. The annual output planned is 25,000 tractors, some of which will be exported from France. The factory will begin by assembling British-built tractors shipped "knocked-down," but eventually the complete tractor and its components will be built in France. The Standard Motor Company were also reported to be negotiating for the erection of a 5*l*. million factory in Australia for the manufacture of Ferguson tractors.

EMBANKMENT SLIP IN RAILWAY CUTTING.

Fig. 1. The Slip at Twyford.

Fig. 2. CROSS-SECTION THROUGH TWYFORD SLIP.



EMBANKMENT SLIPS IN RAILWAY CUTTINGS.

Within twelve months of each other, two large slips occurred in embankments at Twyford and Sonning on the British Railways (Western Region) main line to the West of England, where the line passes through cuttings made in the Reading Beds at a point at which the beds are thinly overlain by a pebble gravel. The object of this article is to discuss the causes of the slips, describe the measures taken to restore the embankments and to indicate the method of calculation employed. The method of calculation is applicable to the design problem of determining suitable side slope for cuttings to be constructed in low-strength strata above a known permeable layer.

The slip at Twyford, illustrated in Figs. 1 and 2, was due to the existence of a sand layer 11 ft. below rail level and 36 ft. below the original ground level. This sand layer is covered by an impermeable-clay stratum and, during the heavy rainfall early in 1951, a hydrostatic pressure was induced in it, sufficient to lower the strength of the sand to such an extent that the embankment failed. The three tracks at the foot of the slope were pushed upwards and outwards and a large crack developed at the top of the cutting. The slip was remedied by keying the slipping mass to the stable stratum below it, by excavating to a level below the sand and back-filling the holes with dry stone to form buttresses. The hydrostatic pressure was relieved by taking the sub-soil water into the track drainage before it reached a dangerous level. Slips which are due to the existence of a permeable layer subject to hydrostatic pressure and which are overlain by clay have been reported on before, but that at Twyford was the first of its kind to be encountered on the Western Region and, it is believed, the first to be reported on in this country. At Sonning, though the natural strata were very similar, the slip was not greatly influenced by the hydrostatic pressure in the sand since the pressure developed was small. In this instance, the cause of the failure was a curved sand layer, and in shape and position the failure was a typical circular slip. The remedial measures adopted were very similar to those at Twyford.

The Slip at Twyford.

The first signs of the impending slip were indicated by a movement of the nearest track, the down main from Paddington to Reading. The movement, which was immediately corrected, consisted of lifting of the track and slewing it towards the opposite side of the cutting. This was accompanied by movement of a dry stone wall, the extent of which, up to March, 1952, is shown in Fig. 1. Inspection of the top of the slope showed that a crack had developed about 13 ft. back from the edge, as shown in the accompanying Fig. 2. This eventually formed a small "cliff face" about 3 ft. high. A striking illustration of the deep-seated nature of the slip was afforded by the movement of the telegraph pole within the slip area. Sighting along the line of poles, this one could be seen to lean away from the tracks, indicating that the slip plane was below the bottom of the pole.

As a preliminary investigation, a detailed geological cross-section was obtained at the wors-

EMBANKMENT SLIP IN RAILWAY CUTTING.

FIG. 3. RESTORED EMBANKMENT AT TWYFORD.

Fig. 4. INFLUENCE OF HYDROSTATIC HEAD ON THE SAND STRENGTH.

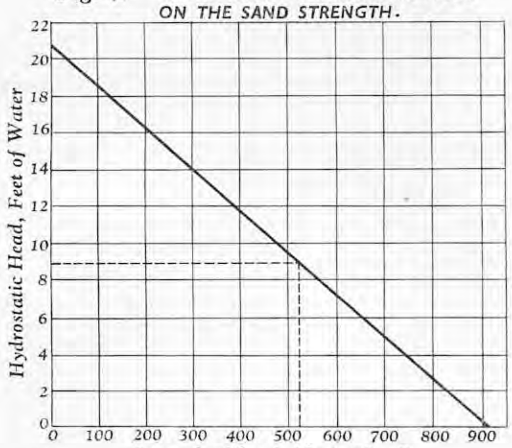
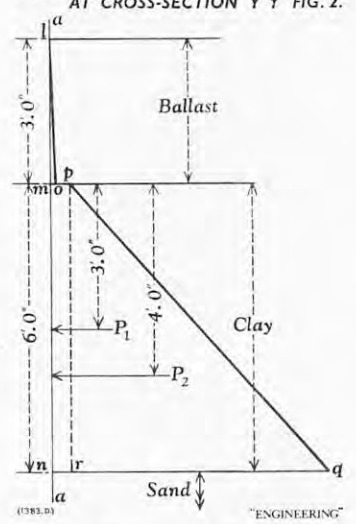


Fig. 5. EARTH PRESSURE DIAGRAM AT CROSS-SECTION Y Y FIG. 2.



point in the slip. The boring tool was a post-hole auger and the undisturbed samples were tested either by the simple compression test or in a triaxial-compression machine. The results of the tests are indicated in Fig. 2 at the appropriate points on the boreholes. The angle of shearing resistance of the sand was found from a shear-box test. When first constructed, the cutting had side-slopes of 1 : 3, the strata penetrated being typical of the Reading Beds, that is, alluvial material deposited during the Tertiary Era. Below the top-soil lies a 10-ft. layer of coarse gravel and sand. This is followed by a stiff, dry clay mottled in light grey, brown and green, and shot with streaks of bright red, known locally as Shepherd's Blood. At a depth of 36 ft. below ground level and 11 ft. below rail level, there is a layer of fine grey sand up to 18 in. thick. Beneath it is another stiff clay stratum, dark grey in colour which is laminated, fissured, and contains a high proportion of silt. The clay of this cutting is very suitable as puddle clay and the toe wall referred to previously was constructed to allow a siding to be built behind it to facilitate the removal of the clay, which was replaced by ash; the results of this work can be seen in the cross-section in Fig. 2.

Very heavy rainfall occurred during the early months of 1951 and a large quantity of surface water collected in the vicinity of the slip. The fields behind the slip became flooded and a ditch was dug along the top of the cutting. The flow of water in the ditch showed how much had been running into the area previously and, moreover, the track drainage, which was working efficiently, terminated in a 12-in. pipe which was running full bore. It appeared likely that water from the drains was percolating under the slipping area. The height of the ground-water table could be judged by a well on the down side and in gravel pits on the up side of the line. An indication of this level is given in Fig. 2, where the water is shown to be 19 ft. above the sand layer and 8 ft. above rail level.

Slips occurring in soil strata of this type have been recorded before. Terzaghi* mentions a similar one that happened in America in 1915 when a 40-ft. high, gentle cutting slope moved forward on a length of 1,200 ft. and heaving occurred for a distance of 300 ft. from the toe. This particular slip happened so quickly that lives were lost in a power house that collapsed because of it. The mechanism of the failure can be best understood by following the calculations given below. However, it can be stated in general terms that the hydrostatic pressure in the sand layer became sufficiently high to equal the overburden. At this stage, the clay mass could be said to be "floating" on the sand layer. The stability of the slope then depended on the passive resistance at the toe and on the strength of the clay.

This type of slip normally reaches the limit of its movement very quickly, and it was fortunate that none of the tracks had to be closed to traffic. After the first movement, the hydrostatic pressure was relieved and further rapid sliding did not occur, but the plane of failure became a great source of weakness and slow movement continued until arrested by the remedial measures adopted.

The stresses in the clay at the moment that movement first took place must have been slightly greater than its strength, and this condition can never be achieved again without further movement. Some assumptions therefore have to be made in attempting to explain the cause of the slip and the calculations which follow show that, on the fulfilment of certain reasonable assumptions, failure could have taken place in the manner described. Other possible explanations have been investigated but it was found that they required the strength of the clay to be even lower before failure could have taken place and are, therefore, unacceptable. The effect of the hydrostatic pressure on the strength of the sand is illustrated by the graph in Fig. 4, on this page. The internal shearing resistance was found by experiment to be 34 deg., and the weight of the overburden 130 lb. per cubic foot. The hydrostatic head observed at the time of the investigation was less than at the time of failure, since, as already mentioned, it had been relieved by the movement of the slip, but, at this head, the shear strength of the sand layer would have been 520 lb. per sq. ft. The maximum possible value of the hydrostatic pressure corresponded to the weight of the overburden, for a higher head would have had the effect of lifting the clay mass, the pressure increasing only sufficiently to overcome the resistance of the clay mass to distortion.

It was assumed that the worst possible condition applied when failure first took place, that is, when the strength of the sand layer was zero. This assumption was justified by the level of the ground-water observed in the well and the gravel pits, and which, at the time of the investigation, stood approximately 19 ft. above the sand layer.

The position of the plane of failure, where it passed through the clay stratum, and the shear strength corresponding to a factor of safety of 1 were determined, by a process of trial and error, assuming a wedge-type failure. The section X-X in Fig. 2 was assumed to be unsupported, and a conventional wedge-failure analysis was applied; the shear strength of the clay at the moment of failure was found to be 1,580 lb. per square foot.

Two other forces remained to be taken into account. One was the passive resistance of the clay between the ballast and the sand stratum, the other, the active pressure of the ballast. These forces were assumed to act at the cross section marked Y-Y in Fig. 2. The assumed pressure distribution is shown in Fig. 5, on this page. The intensity of pressure, $m\,p$, due to the overburden, is $W\,h\,\dfrac{(1-\sin\phi)}{(1+\sin\phi)}$, where W = unit weight of the ballast (90 lb. per cubic foot), h = depth of the ballast, 3 ft., and ϕ = angle of shearing resistance of the clay (approximately zero).

Hence, $P_1 = 90 \times 3 \times 6$ lb. = 1,620 lb.

The passive resistance P_2, equivalent to the force that would be exerted if there were no overburden of ballast, is given by

$$P_2 = \frac{H}{2}\left[\gamma\,H\tan^2\left(45+\frac{\phi}{2}\right)+4c\tan\left(45+\frac{\phi}{2}\right)\right]$$

where H is the thickness of the clay stratum, 7 ft., γ is the density of the clay, 130 lb. per cubic foot, and c is the cohesive strength of the clay, assumed to be 1,250 lb. per square foot.

Substituting these values in the expression above gives P_2 = 20,700 lb. The active pressure, determined from a nomograph,* was found to be negligible. The total passive earth resistance, $P_1 + P_2$, equals 22,320 lb. When failure actually occurred, the horizontal forces acting on sections X-X, Y-Y, must have been equal to this figure and the average shear strength of the clay across the plane of failure was therefore 1,250 lb. per square foot, agreeing with the figure assumed above.

The remedial measures will be described in detail in the second instalment of this article, but an illustration of the restored bank is given in Fig. 3, above.

(*To be continued.*)

* K. Terzaghi and R. B. Peck, *Soil Mechanics in Engineering Practice*, pages 366 to 370, (1948).

* H. R. Reynolds and P. Prolopapadakis, *Practical Problems in Soil Mechanics*, (1948).

STEAM TURBINE RESEARCH AND DEVELOPMENT.

(*Continued from page* 427.)

We conclude below an abridged report of the discussion on the four papers which were presented at the morning session of the Conference on Steam Turbine Research and Development, held at the Institution of Mechanical Engineers on March 6. The titles (and authors) of the papers, which were summarised on page 362, *ante*, were: "Facilities for Full-Scale Testing of Marine Turbine Machinery" (Dr. T. W. F. Brown); "The Development of Marine Steam-Turbine Design" (Mr. H. G. Yates); "The Measurement of Specific Steam Consumption" (Mr. M. H. Petty); and "Back-to-Back Testing of Marine Reduction Gears" (Dr. A. Cameron and Mr. A. D. Newman).

Mr. R. C. McLeod said that he did not agree with Mr. Yates about partial admission. Twenty years ago, he had designed a turbine for a paper mill, which had to work initially with a reduced rate. It was designed for the final condition, with blocked nozzles in the diaphragms to give the initial condition. It was designed to have equal heat drops per stage in the final condition, but in the initial condition the nozzles and the diaphragms were blocked to give the same heat drops per stage in the initial condition. It was tested both ways, and it was more efficient in the final condition at the reduced rate. The authors had talked about impulse turbines, but, though designers did not agree about how to apply vortex flow, every turbine must have it. Would Mr. Yates state what percentage of heat drop happened in the blades? Presumably he had some reaction, though he had not said so.

Mr. McLeod also suggested that the coupling sleeve was exceedingly heavy; for a similar job, he would make it ½ in. thick, for an industrial back-pressure turbine. He noted, also, that the internal teeth were not ground in oil; in his experience, there was a tendency for them to fret unless they had a lip at the end, below the root diameter of the tooth, so that the coupling ran in hot oil.

Mr. F. Dollin, B.Sc. (Eng.), quoting the remark of Mr. Yates, that there was a strong incentive to obtain in marine turbines a level of efficiency which would be economically justifiable in land power generation only when dealing with units of much greater power, asked whether that was actually achieved. Apparently, the mean rating of Mr. Yates's sets was about 7,000 h.p. In the case of a 5,000-kW land turbine, operating with the steam conditions stated—450 lb. per square inch, 750 deg. F., and 28·5 in. vacuum—the normal level of turbine efficiency would be about 78 per cent. Would Mr. Yates indicate how the efficiency of his marine turbine stood in comparison with that? The marine-turbine designer was much more hedged about than the land-turbine designer by limitations of weight and space and arrangement, but the element which militated most against the efficiency of the marine turbine was the astern wheel. The windage when running ahead was the least of its offences. The sudden and drastic change in the temperature distribution throughout the turbines when changing from ahead to astern running reacted very adversely on the clearances, and the mere presence of the astern wheel, unless separately housed, restricted the effective exhaust area obtainable in a casing of a given total length. It might come to be considered desirable to exploit the advantages of the reheating cycle in marine steam turbines, in which case it was practically essential to avoid reversing the turbines. One way of doing that was to employ electrical transmission, which was adopted for the Beaver class of cargo liners, of the Canadian Pacific Line, and had enabled them to employ reheating with conspicuous success. If electrical transmission was not acceptable, was serious consideration being given to the development of alternative forms of reversible transmission?

Mr. Yates had said that, in the development of the designs, the main emphasis had been laid on constructional methods, leaving the designer to use his ingenuity to make such methods give the result desired; and that the design then chosen was a two-cylinder arrangement with a high-pressure turbine of all-impulse type and a low-pressure cylinder having one impulse stage followed by a number of reaction stages. Subsequent development had been in the direction of fewer reaction stages and a gashed disc-form rotor for the low-pressure as well as the high-pressure turbine. He questioned whether the man-hours involved in the manufacture of that kind of turbine were less than they would be for a Curtis reaction turbine of equal efficiency, with drum-type rotors and no diaphragms. One characteristic of the disc and diaphragm arrangement was that the thermal inertia of the cylinder was much greater than that of the shaft, and, if rapid changes of load or steam temperature occurred, considerable differential expansion in the axial direction was to be expected.

In the double-casing arrangement adopted in recent designs, there was an annulus plate by which the steam inlet branch on the inner casing was connected to the outer casing. When that construction was adopted for a high-pressure turbine, what material was employed for the diaphragm, and what was the order of the deflections and stresses involved?

With reference to Mr. Petty's paper, the provision of a central observation platform might be more convenient for the observers, and might reduce the total number required. The longer pressure-pipes connecting the test gauges to the plant under test (especially on tests of short duration) involved static height corrections; these could be calculated, but were not necessarily correct if the pipe lines were not full of condensate. The normal approach in power-station testing was generally the opposite, the normal operation gauges being grouped on a panel and the special test equipment being mounted as near as possible to the tapping point on the turbine or plant under test.

With regard to Mr. Terrell's paper, he supported with emphasis the importance of avoiding priming. The evil effects of priming were dire and manifold and might well include a leaky horizontal joint due to the permanent distortion of the casing, rubbing at the blade and gland seals, resulting in a permanent reduction in efficiency and perhaps a bent shaft, and failure of the thrust bearing. It was interesting to note that Mr. Terrell had a decided preference for springing plate supports instead of slides and guides. The latter might be more convenient for erection and adjustment, and, if properly arranged, worked quite satisfactorily. The springing support might not be easy to arrange with more than one cylinder in line.

Mr. J. S. Hall, B.Sc.Tech., referring to the designs described by Mr. Yates, observed that the 1953 design of high-pressure casing of the two-cylinder machine departed considerably from tradition, in order to maintain better alignment between the fixed and moving parts. It seemed a little odd, however, that such a result should be achieved by making the connection between bearings and glands through the medium of a third outer structure, subject to its own distortion, rather than through properly-designed direct supports of a more orthodox type. The construction adopted must surely be more expensive, and it introduced a congestion of joints at the gland mouths and at the passage of the various connections through the outer casing to the working cylinder. An illustration in Mr. Terrell's paper seemed to suggest that the Pametrada designers laboured under the disadvantage of a gland leakage loss of 10 per cent. If so, it was worth taking a lot of trouble to overcome the difficulty. There was a recent turbine design in service, using steam at 950 deg. F., which employed conventional methods of support, arranged to maintain concentricity, and operated with diaphragm gland clearances in the high-pressure cylinder of about 0·008 in. radially. The machine had three cylinders, and was notably compact. The blading was all of the impulse type. The high-pressure and intermediate-pressure cylinders followed conventional lines, with radial key connections between cylinders and bearing pedestals. The high-temperature nozzle boxes were of the floating type inside the cylinders. All interconnecting pipes were beneath the turbines. The low-pressure turbine exhaust and condenser shell were made in one piece. The low-pressure casing also carried the astern element. The structure did not hog; in fact, it tended to bend downwards.

The Pametrada diaphragm construction described was interesting. It was stated that the diaphragm lay in its groove with an axial clearance of 0·010 in., but there was also a lip, affording encastré support. The radial clearance on both sides of the lip must be very small for the encastré support to be effective. He asked the author for more details of the fit of the lip in the cylinder groove, and whether he had any experience of the troubles that might be expected; namely, crushing due to differential thermal expansion; failure to float against the sealing face, due to binding; and difficulty in removing the diaphragm when required. Was the better thermodynamic performance of the diaphragm attributed to the better shape of the blade forms, also to the better shape of the inlet to the diaphragm passage?

Mr. T. W. Bunyan, B.Sc., referring to the statement, in Mr. Yates's paper, that, in one turbine, there was a loss of 18 per cent. of the available ahead power owing to internal windage, thought that an alarming figure, serving to show what highly dangerous conditions might be produced by so simple a defect as a leaky manœuvring valve. Eighteen per cent. of the full-ahead power represented an enormous amount of localised heat, and he asked what was the condition of the blading when it was opened up. Mr. Yates had assured them about the stresses which might occur at runaway speeds. There was a further reassurance, in that, with electric propulsion, experience had shown that the alternator rotor flew apart before the turbine rotor. In several T.2 tankers that did happen; the reason given was that the machinery was operated for long periods without altering the throttle setting. That produced an ideal condition for "stiction" and frettage in the governor linkages, which caused the governor to be inoperative when the main breaker was tripped during manœuvring on reaching port. A simple instruction that small speed changes should be made at least every second watch appeared to have overcome that rather spectacular phenomenon. He agreed entirely with Mr. Yates regarding the advantages of keeping the low-pressure rotor inertias low, to prevent tooth separation occurring at torsional-vibration criticals. Did "gash" construction cause any embarrassment from the point of view of whirling criticals? The straightening of a gashed rotor was, of course, a complex problem, but a bent rotor was a not infrequent occurrence.

He was disappointed that no mention was made of the claw coupling connecting the turbine to the gearing. The tendency to-day was to adopt the fine-tooth claw coupling. Given good alignment and lubrication, that type of coupling might be expected to give many years of trouble-free service, but he had had to deal with many cases which did not come up to that standard. In nearly all of those cases, the frettage which rapidly developed looked much more serious than it actually was; the claw coupling was an ideal lubricating-oil centrifuge, which would ensure that the products of the frettage, together with any other solid matter in suspension, would be collected in the working space between the male and female claws or at the roots of the teeth. He thought that, with a little ingenuity, the oil could be separated in the coupling before it reached the working faces of the claw. He had heard of a design which embodied a U-shaped hollow ring, rigidly attached to the female housing which received the lubricant. The height of the lip of the ring was adjusted to ensure that the claws ran flooded with oil, while the unwanted solid matter in the lubricant was centrifuged out towards the outer periphery of the ring.

Mr. J. Caldwell said that he would refer mainly to the activities at Pametrada of which he obtained personal knowledge while attending tests of prototype marine turbines designed by his firm, the English Electric Company. Dr. Brown had described the considerations determining the layout of the turbine test house. His main criticism was that the spaces surrounding the machinery under test were too cramped, particularly with regard to head-room. It was regrettable that a few of the worst features of a ship's installation had been reproduced in providing for shore tests, when the adoption of some of the better constructional features of a power station would have greatly improved accessibility. The large brake was a striking feature of the test-house equipment, but recent tests had shown that, for turbines in the power range of 4,000 to 20,000 h.p., a much smaller brake was required to obtain the necessary accuracy, particularly at low percentage powers. Dr. Brown and Mr. Petty had described the provision made for determining steam consumption rates. Testing a complete set of ship's machinery, using the actul, components to be employed on shipboard, was advantageous from a functional point of view, but usually meant that delays arising from adjustment to any one component delayed the tests on all of them. Thus, from the point of view of the individual manufacturer of the turbines and other parts of the set, the tests were generally very time-consuming.

The accuracy-assessment chart shown in Mr. Petty's paper was interesting, as he himself had recently prepared a similar assessment, not knowing that Mr. Petty was about to put one forward. He found Mr. Petty's figures very optimistic, but they might apply to a larger unit. For a set of 15,000 h.p., tested on the large brake at Pametrada, his estimate, based on the precision of readings recorded at Pametrada, showed at full load a tolerance of $\pm 0 \cdot 9$ per cent., and at 5 per cent. load, $2\frac{1}{2}$ per cent. on the values for steam consumption. The scatter on the actual consumption readings was considerably more, so that for lower-powered turbines there was room for considerable improvement in the accuracy of steam consumption measurement. Mr. Petty's statement regarding the quality of the pressure gauges employed seemed to be misleading. Test-quality gauges were generally understood to be gauges conforming to paragraph 30*a* of B.S. 1780 : 1951, with an accuracy of $\pm\frac{1}{4}$ per cent. of the maximum scale reading. He had not seen such gauges employed at Pametrada. Mr. Yates had developed a new type of diaphragm which apparently enabled him to compress a great many turbine stages into a short axial length. The elastic deflection of the diaphragm was reduced by the construction employed, but it would be interesting to know if there was a corresponding reduction of stresses. If not, for a diaphragm used at higher temperatures the construction might not show any advantage in reducing the tendency for permanent deflection due to creep. He did not agree with Mr. Yates's statement that his construction, by employing rolled nozzle sections, was likely to show an improved efficiency over milled nozzles. There appeared to be greater opportunity for leakage in that design.

Commander Green wondered whether the turbine users—the shipowners—were making sure that the gains offered in thermal efficiency were not subsequently lost by inattention to running and maintenance. He had in mind, for example, the use of the nozzle box as a metering device. It should be possible to provide a chart, based on the careful measurements, showing the pressure to be expected in the main turbine nozzle-boxes for all combinations of draught, state of bottom and weather conditions. That would require the subsequent co-operation of the shipowners, as it might be considered outside the scope of Pametrada itself; the propeller-law curve was no law at all once the ship was in service, and that variation became very serious in the smaller ships.

Once such a ship chart were established, the interest of the sea-going engineers would be aroused, and defects such as leaking astern manœuvring valves would be more readily diagnosed. Might that not be one of the main causes of variation in results on service, mentioned by Commander Baker? He suggested that early diagnosis of leaking astern valves was a better method than providing a double shut-off valve, as mentioned in Mr. Yates's paper. If such a valve were fitted, or if astern nozzle valves were fitted, another small shut-off valve on the drain pipe would enable a check to be made on each occasion of raising steam or shutting down. Frequent tests of that nature would eventually eliminate undesirable designs of manœuvring valve.

Dr. Brown, replying to the discussion, said he proposed merely to refer briefly to the remarks of Commander Baker and Captain Tyndale-Biscoe. Commander Baker said that he wanted more and more research, and that performance tests were justified. Dr. Brown wholly agreed. Commander Baker had spoken of eight turbine-engined ships of Pametrada design. He did not know whether Commander Baker regarded them as a good or a bad legacy, but they were certainly started under his predecessor, and enormous difficulty had been encountered in trying to get one of the Pametrada designs adopted. The designs finally chosen were a compromise, and not what they had desired to put forward. Commander Baker had spoken of varying consumptions in turbine-engined ships and had also spoken of different clearances. Obviously, that was not under the control of the designer. One of the vital matters in the operation of turbine-engined ships was to look after the auxiliaries, which often had more influence on performance than might appear. Another point raised by Commander Baker was on the subject of money. In Pametrada, the marine industry had set up a central research department which had been recognised by the Government, and, under the Department of Scientific and Industrial Research, provided that the industry first of all contributed so much money, and then received direct grants. If more and more research was encouraged and the fruits of it got into the product it had to be paid for somewhere. The question of shipowners' representatives was being considered by the Administration and Finance Committee. Bluntly, one of the difficulties was that what would suit Commander Baker's fleet might not suit a tank ship or one carrying passengers on the Western Atlantic. Once they got a shipowner's representative in, he might not represent shipowners at all, and that was where the difficulty lay. However, the Council were looking into the matter and they were completely sympathetic to the idea.

Captain Tyndale-Biscoe had said that only naval machinery had been tried out on the full scale. That was not so. The first turbine on which they had tried their hands was fitted in the merchant ship Duquesa. Some serious mistakes had been made with it, but the naval machinery which had followed had benefitted from their experience. Since then, they had never been able to couple it to their own brake. If one worked continuously, at weekends and on overtime, to get through Admiralty machinery, with one set treading on the heels of another, it was difficult to say where to insert which machinery. However, he could give an assurance that they would couple it to their own brake as soon as they got it back, which would be some time later in the year. Gas-turbine machinery came first; if there was any gap in the naval programme, the Council, who were well aware of the position, had undertaken to find some merchant machinery.

Individual Authors' Replies.

Mr. Yates thought that his reference to the difference between mercantile and naval machinery had been misunderstood. He had not meant to imply that all experience with naval ships was completely irrelevant to the design of merchant machinery; merely that merchant design should not be prejudiced or biased by facts which were known to suit naval machinery. If a United States naval design were found to be the best possible for the merchant service, in a debased form, it was not the best possible for its prime function of propelling a naval vessel. Commander Joughin, speaking of blade vibration, had said that the first thing was to eliminate discontinuities and the second was to keep the stresses low. Mr. Yates disagreed. The first step was to ensure that the discontinuities could not seriously vibrate the blades. They had an opportunity of reducing stress by 5 or 10 to 1. Where they had followed that line, in the turbines described, they had been virtually free from blade failures. The case which Commander Joughin had quoted was well known to Mr. Yates. They had tried to apply their criteria of blade safety to it, without success. In other words, if the blades had been designed in the light of present knowledge, the failures would not have occurred.

Mr. Petty, replying to Mr. Dollin's comments on the height of the observation platform, said that this method could not be used where the error introduced by such a height was very small in proportion to the actual pressure being measured. It was necessary to ensure that no water whatever collected in the lines. He agreed with Mr. Caldwell on the question of running trials of machinery with as low a total power in proportion to the brake as possible.

Dr. Cameron, replying to Commander Baker's comments on the high-power efficiency curves, said it did not necessarily follow that curves would steady out or would go on rising as the oil inlet temperature was increased. That the information on pitting did not go very far was due to the fact that it was obtained from the naval machinery and, at the time, they were not in a position to give further information. On Commander Baker's third point—about a survey of hardness—Dr. Cameron said that a hardness survey was difficult to carry out, before the gear had been tested to destruction. It was difficult to get the instrument into place. They had carried out a systematic survey of hardness after destruction, however, and had not found any large differences along the gear. On the question of surface-finish measurements, they could not agree with Mr. Winstanley's experiences that there was no significant difference between hardened and ground gears, and soft gears. They had found great differences, affecting the coefficient of friction. Speaking of helix-angle correction, Dr. Cameron said that firms who had applied that correction had not complained much about pitting. Hand filing after damage had been done was a retrograde step. If the helix correction could be applied before the damage was done, it was obviously a good thing.

(*To be continued.*)

AERONAUTICAL INFORMATION CONFERENCE.

Since its inception in September, 1951, the Aslib Aeronautical Group of information officers and librarians serving the aviation industry has occupied a unique place in the Aslib organisation, because it was established by spontaneous demand from within the industry, and from the outset it had a fairly clear idea of the tasks which required to be done. Within its first 18 months of existence, the Group is able to recommend certain courses of action on abstracting services and indexing of aerodynamic data to those who control the finance necessary to initiate them. This year the Group has achieved the distinction of being the first of the Aslib groups to co-operate with the North Atlantic Treaty Organisation, a sub-committee of which attended the second annual conference of the Aslib Aeronautical Group, held at the College of Aeronautics, Cranfield, from Friday, March 27, to Monday, March 30. Following the conclusion of the Group conference, the N.A.T.O. Advisory Group for Aeronautical Research and Development (A.G.A.R.D.) held a closed meeting to discuss the recommendations.

Some 70 people attended the Group conference, representing 45 different organisations and eight countries—Australia, Canada, France, Holland, Italy, Sweden, the United States, and the United Kingdom. The first working session was devoted to the Group's annual general meeting, followed by the reports of the working parties on the union catalogue of periodicals and reports, on abstracting services, and on the Universal Decimal Classification.

Abstracts and Universal Decimal Classification.

On hearing the report of the abstracts working party, the Group recommended that the latter should endeavour to arrange for *Index Aeronauticus*, the bulletin prepared and at present issued in limited numbers by the Ministry of Supply, to be printed and sold by H.M. Stationery Office, thus making it available to a much wider circle of readers; the possibility of producing abstracts on catalogue cards is also to be considered further. The working party on the Universal Decimal Classification has, with the approval of the conference, become absorbed in a panel of the British Standards Institution, which proposes to re-organise completely the section concerned with aircraft engineering.

INDEXING AERODYNAMIC DATA.

Sixteen papers were written for the Conference, and the discussions on Saturday afternoon and Sunday centred around short summaries presented by the authors. Most of the papers were concerned with various aspects of national aeronautical information services in the countries represented at the conference, but two of the three papers discussed on Saturday afternoon dealt with indexing aerodynamic data and one with punched-card techniques, the main topic of discussion being the Nationaal Luchtvaartlaboratorium (N.L.L.) card-system catalogue of aerodynamic measurement, introduced by its author, Dr. A. C. de Kock.* The Group's working party, set up to consider the N.L.L. scheme, which consisted mainly of aerodynamicists, concluded that, in addition to a subject classification covering the whole field of aeronautics, the satisfactory documentation of aerodynamics required also a detailed subject index from which specific aerodynamic data, both experimental and theoretical, could be located; and data sheets, for the use of experimental and design staff, presenting the results of analysis of theoretical and experimental reports in the form of simple formulæ or charts. The N.L.L. scheme, which at present is confined to wind-tunnel data, goes a long way towards providing the detailed subject index required by the aerodynamicists, and is generally welcomed by them. Some of the librarians present, however, took a conservative view of Aslib's responsibilities towards the technicians they serve, and appeared to regard with suspicion the suggestion that new techniques of documentation should be introduced into the library. Nevertheless, the scheme received the backing of the Group and a resolution was passed giving full encouragement to any step the Nationaal Luchtvaartlaboratorium may take to initiate their scheme.

Although the emphasis at the conference was on aerodynamic data, the detailed subject index for tracking down particular data clearly should have applications in other fields. The Dutch are already considering the problems of indexing corrosion and fatigue data, but here the problem is slightly different since many fields of engineering other than aeronautics are also interested in such data. Considerable interest has been aroused in Australia by the N.L.L. scheme, and there is a tentative proposal to construct a similar scheme for aircraft structural data.

INTERNATIONAL CO-OPERATION IN AERONAUTICAL INFORMATION.

On Sunday, as already mentioned, the discussion was concerned with national techniques of aeronautical documentation and the problems encountered. To the fundamental problem, that of discovering what information is available, there appears to be no easy solution, since many reports that are not classified under security regulations are still restricted in circulation by their originators. The other principal problem, that of availability of reports that are known to exist, shows promise of solution, and the conference recommended to A.G.A.R.D. that, since the more important series of unclassified reports cannot be printed by the originating agency in sufficient numbers to meet legitimate requirements, the possibility should be investigated of making a master copy available to some other agency for preparing future copies; this resolution also contained a clause recommending that a maximum size for report literature should be established, and that stiff card covers using a standard layout should be adopted.

Two other recommendations to A.G.A.R.D. arising out of the Group's discussions were that further consideration should be given to the question of including index cards with reports, and that A.G.A.R.D. should consider the formation of a committee to investigate the possibility of obtaining international agreement on the first- and second-order subject classification headings in aeronautics.

* "The N.L.L. Card System Catalogue of Aerodynamic Measurements," by A. C. de Kock and A. I. van de Vooren. Report F.125. Nationaal Luchtvaartlaboratorium, Amsterdam, Holland. (Available gratis to approved applicants.)

METAL RECTIFIER FOR ENGINE STARTING.

EDISON SWAN ELECTRIC CO., LTD., LONDON.

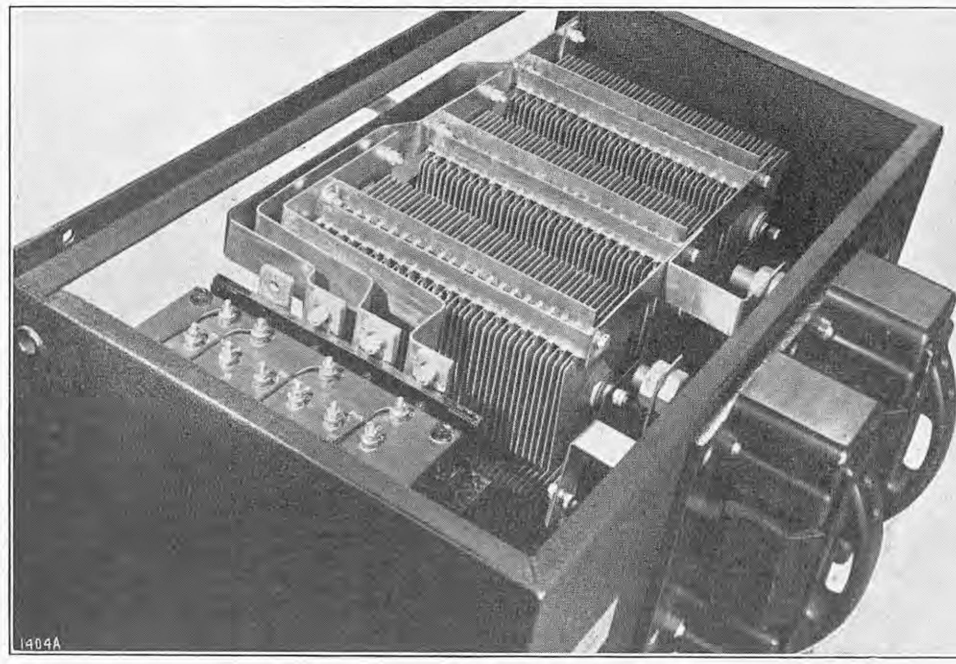
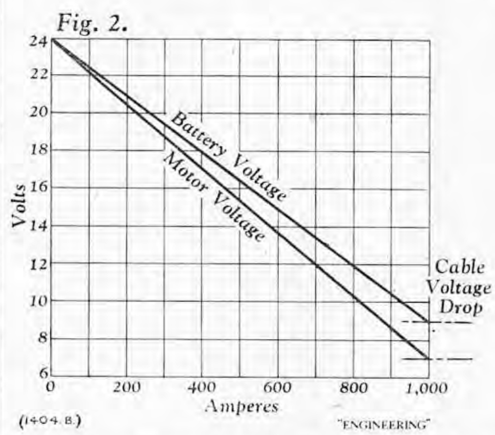
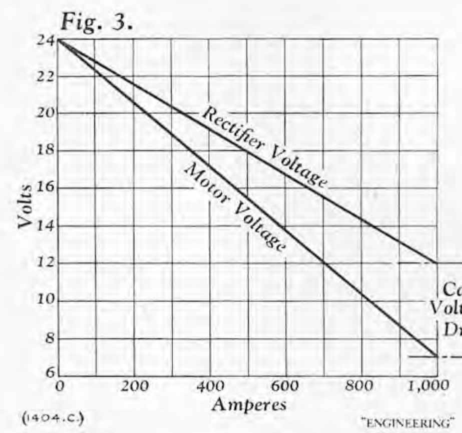


FIG. 1.





RECTIFIER FOR ENGINE STARTING.

THE electric motors which are now in common use for starting internal-combustion engines of all types, as well as gas turbines, must be designed to provide sufficient power to run the unit up to full speed. On most kinds of heavy road vehicle a 6-h.p. 24-volt motor is adequate for this purpose, but the source of supply must be such that a peak current of about 1,000 amperes can be provided; and on aircraft engines, especially gas turbines, the current required may be substantially greater. In the past secondary batteries have generally been used for supplying the necessary power, but now metal rectifiers are being increasingly employed as their forward, or output, current is limited solely by their final temperature rise. Where a long rest follows a short operating period they can therefore be operated at several times their normal continuous current rating. The associated transformer can also be similarly up-rated, thus increasing the compactness of the equipment.

Fig. 1 illustrates a rectifier, which is being manufactured by the Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2, for the direct starting of Diesel engines undergoing test. It is designed for operation from the 400-volt three-phase mains through a transformer and has a direct-current output of 500 amperes at 24 volts. As switching is effected on the primary side of the transformer it has been possible to omit the contactors which are necessary in the motor circuit when batteries are used, their place being taken by a starter provided with magnetically-operated trip coils. As the primary transformer current is only a small fraction of the output current, this also considerably simplifies the switching arrangements. Remote control can be effected by including push-button switches in the contactor coil circuit. A number of individual circuits can be provided for connection in series or parallel. Several similar sets can also be interconnected, thus enabling the starting equipment on a test bed to be added to as the capacity of the plant increases.

The overall efficiency of a rectifier equipment is higher than that of a battery, since for a true comparison the losses in the charging apparatus, necessarily used with the latter, must be taken into account. As regards operation, Fig. 2 shows a characteristic curve for a 6-h.p. starter motor supplied from a battery and Fig. 3 that for a similar motor fed from a rectifier. It will be seen that for corresponding values of load current the terminal voltage of the motor is the same in both cases, but that the output voltage of the rectifier is higher than that of the battery. This excess voltage is necessary to overcome the greater drop in the direct-current circuit, owing to the fact that the rectifier is normally installed further away from the engine than the battery. This is, however, no disadvantage since the rectifier characteristic output can be designed to have any desired slope.

The rectifier equipments now being manufactured for engine starting have outputs of 600 amperes at 90 volts and of 2,000 or 200 amperes at 24 volts. The battery most generally used for the same purpose has a capacity of 300 ampere-hours at 24 volts, but voltages up to 120 with a wide range of capacities have also been employed.

DIESEL ENGINE OF 108 B.H.P. FOR COMMERCIAL VEHICLES.

F. PERKINS, LTD., PETERBOROUGH.

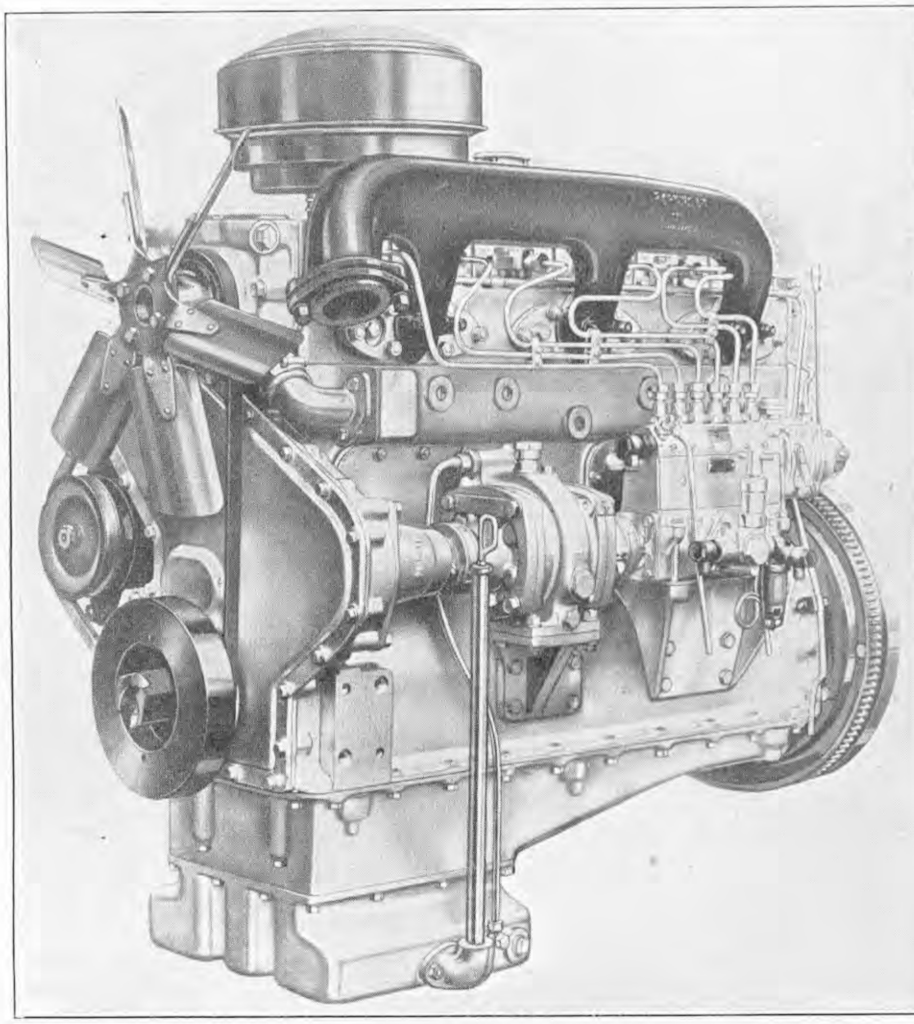
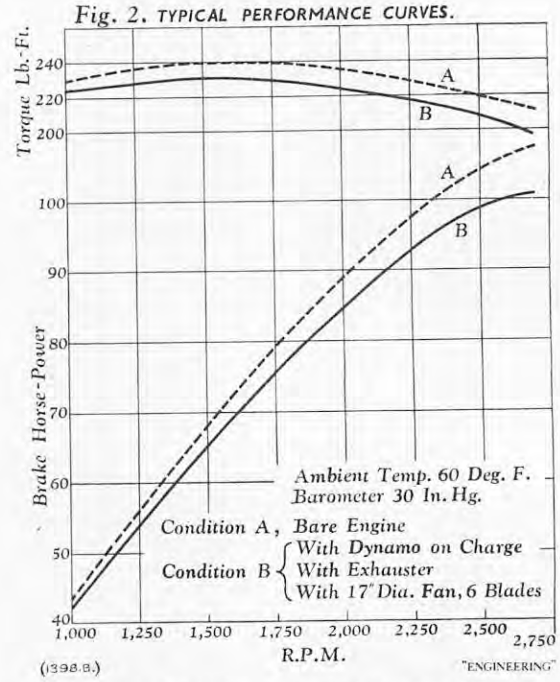


FIG. 1.

Fig. 2. TYPICAL PERFORMANCE CURVES.



DIESEL ENGINE OF 108 B.H.P. FOR COMMERCIAL VEHICLES.

A NEW six-cylinder Diesel engine, the R6, shown in Fig. 1, has been introduced by F. Perkins, Limited, Peterborough. It has been designed for goods and passenger vehicles which are not so restricted in weight and maximum speed as are vehicles in this country, and it is therefore particularly suitable for vehicles which are to be used in overseas markets. The bore and stroke are 4 in. and 4½ in., respectively, giving a mean piston speed of 2,025 ft. per minute at the maximum speed of 2,700 r.p.m. The maximum torque is 240 lb. ft. at 1,600 r.p.m., as shown in Fig. 2, along with other details of the performance; this corresponds to a brake mean effective pressure of 106 lb. per square inch. At the maximum engine speed of 2,700 r.p.m., the gross brake horse-power is 108, with a brake mean effective pressure of 93 lb. per square inch. The R.A.C. rating is 38·4 h.p. The weight, dry, with flywheel, is 914 lb. and the compression ratio is 17·5 to 1. The design is based on that of the firm's smaller P6 engine, which was introduced in 1937 for British lorries of the then 50-cwt. unladen-weight class.

At a ceremony at the May Fair Hotel, London, on Wednesday this week, Mr. F. A. Perkins, chairman and managing director, stated that the new R6 engine had been thoroughly tested at home and abroad during the past two years. Speaking of the work of the firm generally, he said that there were now 257 applications for Perkins Diesel engines and another 170 possible applications were being investigated. One project was to use Diesel engines in London-type taxi-cabs. Tests had shown that, on mileages of 800 or 900 per week, the fuel consumption was 33 or 34 miles a gallon.

Mr. A. W. Gosling, B.Sc.(Eng.), A.M.I.Mech.E., chief engineer, in a written statement on the design, said that experience with the P6 and other Perkins engines had established the fact that the firm's "Aeroflow" combustion system would operate efficiently from the lowest speed up to well over 4,000 r.p.m., and was equally satisfactory with bores from 6 in. down to 3 in. or less. The design obviates the use of masked valves or other restrictive methods of producing swirl, so that the largest possible valves can be used and high volumetric efficiency, which is essential for high output at high speeds, is achieved. Furthermore, the combustion chamber will continue to operate satisfactorily under the most adverse conditions of operation and maintenance. This type of combustion chamber has therefore been adapted for the new engine. The cylinder block and crankcase are cast in one piece. Dry-type press-fit liners are used. The pistons are of light alloy and carry three compression rings and two scraper rings. The piston has a generous top land and adequate bearing surface on the skirt. The liner has been carried well down to reduce withdrawal of the piston at the bottom of the stroke to a minimum. The connecting rods are high-tensile alloy-steel stampings.

The crankshaft, of heat-treated chromium-molybdenum steel, is carried in seven bearings and all journals are induction-hardened. All main and big-end bearings are of the thin-wall pre-finished lead-bronze strip type, which simplifies bearing replacement during overhaul. With multi-cylinder engines, increase in speed always brings in the problem of torsional vibration. For a six-cylinder vehicle engine of this type the frequency is usually about 15,000 vibrations per minute, which produces a sixth-order critical at about 2,500 r.p.m. This has been overcome by fitting an 8-in. viscous-type damper at the front end of the crankshaft. The high camshaft which is characteristic of the P6 engine has been retained and is made of Monikrom. The tappets are carried in the one-piece cast-iron cylinder head and the short push rods are designed to enable tappet adjustment to be made with a spanner and screwdriver.

The fuel-injection pump is similar to that used on the P6 engine, but has slightly larger pump elements and modified delivery valves. The vacuum governor has also been retained, but in view of the higher speed of the engine a cam-operated idling damper has been fitted to eliminate surge at low engine speeds. The new design of C.A.V. paper filter is standardised on the R6 engine. It gives finer filtration than could be achieved with felt-type filters. The element has a life of 15,000 to 20,000 miles before it becomes choked by gum extracted from the fuel; it is then thrown away and replaced by a new element. The exhauster is exactly the same as that on the P6 engine, but as pressure braking is now being used to a greater extent, provision has been made for a compressor to be fitted instead of the exhauster when required. Lubrication is by a conventional gear pump fitted below the front main bearing cap.

A conventional V-belt drive with a water pump mounted on the front of the cylinder head, and a swinging dynamo, has been adopted. The water pump circulates about 30 gallons per minute at the maximum speed and the pump shaft is carried in two ball bearings. The cooling problem on a Diesel engine is not quite the same as with a petrol engine; the Diesel engine is subjected to a much higher compression ratio, and the top of the cylinder head, as well as the combustion space, is momentarily exposed to a much higher temperature, which falls rapidly as the piston descends. Consequently, the main concern is to ensure a brisk circulation around the atomiser and the combustion chamber to avoid local over-heating. This is achieved by taking the pump delivery to a gallery in the block, which distributes the water through ports into the cylinder head. For continuous operation under high load, a water temperature of about 170 deg. F. is about right. It is not, however, critical, and the cooling system can be considered satisfactory in service provided boiling never occurs. Thus, with the engine running at the maximum-torque speed in a low gear, the radiator should be designed to hold the maximum temperatures to about 130 deg. F. above ambient for temperate conditions, and to not much over 100 deg. F. for tropical conditions. Provision has been made for a separate housing containing twin thermostats to be fitted to the water pump when necessary.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Coal Position.—With an improvement of 1,700 in the number of wage earners on the colliery books, the weekly coal production in Scotland, during the first three months of this year, averaged 477,500 tons, an increase of 1,500 tons compared with the corresponding period in 1952. The output, on two occasions, exceeded 490,000 tons a week, a level not attained in the first quarter last year. The best performance to date was 494,000 tons in the last week in March. The total distributed stocks also improved, reaching 1,043,000 tons at March 21, against 1,014,000 tons last year. Industrial undertakings, however, held only 382,000 tons, against 408,000 tons last year, iron and steelworks notably having 74,000 tons, against 86,000 tons.

Water Supply of Kirkcaldy and Greenock.—With the cessation this week of Fife County Council's supply of 1,500,000 gallons per day to Kirkcaldy, the town's water position had become desperate, said Mr. Robert Ritchie, water engineer, on April 3. The daily consumption is just under 2,500,000 gallons. The total amount of water in the town's reservoirs on March 28 was 259,994,000 gallons, which was 634,193,000 gallons less than on the corresponding date last year. The Corporation, added Mr. Ritchie, were investigating measures to alleviate the situation. Greenock Corporation have approved of the erection of new filters and the installation of a tank capable of holding 2,000,000 gallons to improve their water-filtration plant at Whinhill, it was stated at a luncheon, held on April 1, after the annual water inspection. The cost of the scheme is estimated to be 300,000*l*. The Town Council have already approved, in principle, the construction of a tunnel through the hill to carry water from Loch Thom to the filters.

Purchase of Wind-Blown Scottish Timber.—British Railways are to purchase some 1¾*l*. million worth of soft wood from the wind-blown area of Scotland. The timber will be supplied over the next two years at prices which have been agreed as reasonable by both the Railway Executive and the Home Timber Merchants' Association of Scotland, between whom the negotiations have been conducted. The soft wood will be in the form of wagon timbers, sleepers, and crossing timbers. Other timbers will also be purchased as demands arise, in addition to the 1¾*l*. million of soft wood, but the quantity of beechwood is expected to be small, as this timber has very limited use for railway purposes. British Railways have offered reduced rates to the Forestry Commission for the conveyance of other wind-blown timber.

Water-Supply Valves, Glasgow.—The installation of two very large water-supply valves was completed in Glasgow on March 28 by the Corporation Water Department. The valves, which have been fitted to the new east and west mains, are 48 in. in diameter. Each of the valves, manufactured by Glenfield and Kennedy, Ltd., Kilmarnock, weighs six tons.

Heat-Insulating Fibres.—The Cape Asbestos Co., Ltd., of London, announce that they have completed arrangements for the production of inorganic fibres from a natural rock, of which there are considerable deposits in Scotland. William Kenyon & Sons, Ltd., of Dukinfield, Cheshire, heat-insulation engineers, rope and textile manufacturers, who have carried out extensive investigations into the manufacture and utilisation of this new product, will act as sole distributors of the material, which will be marketed under the registered trade name of "Rocksil." The fibres manufactured from this indigenous material have a silken appearance, possess a very high tensile strength, and the long staples, when made up into the form of mats, offer a high resistance to the transmission of heat, cold and sound. They will withstand temperatures of up to 1,400 deg. F. and will accordingly cover a very wide range of requirements in the heat-insulation industry. Factory premises and land have been acquired in Stirling.

The Late Mr. J. D. Inglis.—Mr. James Denny Inglis, for many years a director of the Glasgow shipbuilding firm of A. and J. Inglis, Ltd., Pointhouse, died in Glasgow on March 28, aged 82.

CLEVELAND AND THE NORTHERN COUNTIES.

Rapid Discharge of Iron Ore on Tees-side.—On March 25, the S.S. Ormsary, the first of the fleet of special ore-carrying vessels to be built for the British iron and steel industry, completely discharged, at the South Bank wharf of Dorman, Long & Co. Ltd., Middlesbrough, 8,514 tons of crushed Swedish iron ore in 12 hours and 55 minutes.

The Late Sir Arthur M. Sutherland, Bt.—The death occurred on March 29 at his home at Jesmond, Newcastle-on-Tyne, at the age of 85, of Sir Arthur Munro Sutherland, Bt., the Tyneside shipowner. He was chairman of B. J. Sutherland & Co., Ltd., shipowners, Donkin & Co., Ltd., engineers, and President of the Newcastle and Gateshead Chamber of Commerce. Sir Arthur began as a shipowner at the age of 26 when he bought his first ship. Three years later, with 50,000*l*. capital, he founded the Sutherland Shipping Co. During his lifetime, it is estimated, he gave away 368,000*l*. His gifts included 100,000*l*. for the rebuilding of King's College Medical School, 12,500*l*. for a new dental hospital, 50,000*l*. for the equipment of a dental school and 20,000*l*. for a Y.M.C.A. centre at Gateshead. Sir Arthur was elected to Newcastle City Council in 1910, was Sheriff in 1916 and Lord Mayor in 1919. He was High Sheriff of Northumberland in 1943, chairman of the Tyne Improvement Commission from 1935 until 1945 and was formerly President of the Shipping Federation.

The Late Mr. T. S. Simpson.—The death has taken place at Wallsend, at the age of 73, of Mr. Thomas Stobart Simpson, general manager of William Gray & Co., Ltd., West Hartlepool shipbuilders, from 1927 until 1946, when he retired.

Export Trade Problem.—The annual report of the Tees-side and South-West Durham Chamber of Commerce states that the change-over from the sellers' to the buyers' market was completed in 1952, and during the year the intense fight began for world trade, a struggle which Britain must not lose if the country's economy were to be stabilised. Orders had been lost by Britain because of the policy of many foreign countries of assisting their export trades by adopting import restrictions.

Industrial Change in Cumberland.—Addressing members of the Library Association at Cockermouth, Cumberland, Lord Adams, of the West Cumberland Industrial Development Co., Ltd., referred to the industrial change which had occurred in Cumberland. At one time, he stated, 70 per cent. of the employment was in coal, iron and steel. To-day, only 30 per cent. of the population were engaged in those industries and 70 per cent. were working in more than 60 diversified new industries using 120 new kinds of processes.

LANCASHIRE AND SOUTH YORKSHIRE.

B.I.S.R.A. Centre.—Most of the chief plant and machinery at the Sheffield Research Centre of the British Iron and Steel Research Association, in Hoyle-street, has been installed. An experimental wire-drawing machine, the last major item, is due to be installed this month. The three divisions of steel-making, mechanical working and metallurgy are now moving in at the Centre and it is expected that all the buildings will be completed and occupied before the end of the summer. Mr. C. N. Kington, M.B.E., hitherto chief engineer and local administration officer, now occupies the new post of Group Manager.

Additional Opencast Sites.—A rich seam of opencast coal has been located on the fringe of Sheffield on an eminence known as Sky Edge. Its working will displace a number of allotment holders. Opencast-coal operations are also due to be commenced at Sitwell Park golf course, near Rotherham.

Colliery Record Outputs.—In Easter "bull" week, some noteworthy output records were achieved at South Yorkshire collieries. At the Dinnington Pit, a 22-year-old record was beaten with an output of 17,022 tons, and Askern and Brodsworth also had their best weeks since 1940. Five pits, namely, Rockingham, Silkstone, Wentworth, Dodworth and Kilnhurst, had their best totals since the industry was nationalised.

Education Schemes for Steelworks Employees.—Success is attending the education schemes fostered at several Sheffield steelworks. Mr. T. H. Hawkins, the Steel, Peech and Tozer works education officer, points out that several successes have been gained this year by persons taking evening classes, and even by employees on shift work. The firm has 350 employees taking weekly part-time and evening classes, for which they are given a weekly day off. During the past year, 104 employees have gained examination successes, and one technical apprentice, 19-year-old W. B. Cowley, has now been sent to Durham University by the firm for a three-year course in mechanical engineering.

THE MIDLANDS.

Development of Worcester as Inland Port.—The Docks and Inland Waterways Executive have in hand large developments for Diglis Dock, Worcester. This dock is already used extensively as a depot for waterborne cargoes of petroleum products from South Wales and Avonmouth, and the present extensions will double its handling capacity. Worcester is the highest point on the River Severn which can be reached by 400-ton barges, and goods are unloaded there for road transport to Birmingham and the Black Country, about 30 miles away. Facilities for handling non-liquid cargoes are also being improved at Diglis.

Works Training School.—The Brierley Hill, Staffordshire, works of Richard Thomas and Baldwins Ltd. are to be provided with new buildings to house the firm's training school, which at present operates from temporary premises. The school trains new employees, particularly press operators, tool-setters and apprentices, and was started in 1949 as an experiment. It has proved so successful that it is not only to be put on a permanent basis, but is to be extended. The school will provide training facilities for all the four works which comprise the company's Midland section.

Showroom for Overseas Visitors.—At their Worcester factory, Heenan and Froude, Ltd., have completed a permanent showroom for the display of automatic machines. This showroom, which has been built primarily for visitors to the United Kingdom, will have a full range of the firm's automatic machine tools, installed in time to demonstrate their applications to overseas visitors who will be in this country for the British Industries Fair.

Ferguson Tractors for Denmark.—The 20,000th Ferguson tractor, built in Coventry by the Standard Motor Co. Ltd. in the last six years, for the Danish market, was shipped from Hull to Copenhagen on April 4. Nearly 1,000 Ferguson tractors were imported into Denmark in March by the firm's distributors, Nordisk Tractor Co. A/S., which is responsible for more than 70 per cent. of all tractors imported from the United Kingdom. Danish farmers use mainly petrol-driven tractors owing to there being a rebate of petrol tax for agricultural purposes.

Rail-Passenger Transport Plan.—The Birmingham Junior Chamber of Commerce have been studying the problem of passenger transport by rail in the Midlands, and have now announced their suggestions. They recommend the use of fast Diesel units serving Birmingham and the towns and villages in the neighbourhood, and suggest the opening of 56 new stations.

Machine-Tool Showroom in Birmingham.—The Rockwell Machine Tool Co., Ltd., have recently opened new premises in Birmingham giving them, for the first time, showroom facilities in the Midlands. The premises are situated on the corner of Cateswell-road and Stratford-road, Hall Green, Birmingham.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Absorption of Redundant Tin-Plate Operatives.—Efforts to introduce new industries into the western area of the South Wales Development Area, to absorb men unemployed by the closing of old type tin-plate works, are being made by the Board of Trade, it has been reported at a meeting of the Welsh Board for Industry. Captain H. K. Oram, Controller for Wales of the Board of Trade, told the meeting that they had been aware of the redundancy problem for some time but the reason that new industries could not be introduced before had been that there would have been no employees for them. It was reported that one firm making pre-cast building units was erecting a factory in the area which would employ 300 men. Ministry of Labour reports to the meeting showed that between 2,200 and 2,300 operatives had become redundant in the tin-plate industry, some hundreds of whom, however, had been reabsorbed in the Margam and other sheet and tin-plate works. Fewer than 300 were registered as still unemployed on March 16.

Cardiff Shipping Industry.—Cardiff shipowners have made negligible progress in replacing losses caused to their fleets in the late war, according to the annual report of the Cardiff and Bristol Channel Shipowners' Association. In 1938, there were 41 shipowning companies at Cardiff, possessing, between them, 145 ships, aggregating 528,847 tons gross. In 1948, the number of firms had dropped to 23, with 61 ships, making together 281,327 tons gross. By last year there had been little improvement; the 23 firms owned 63 ships, totalling 268,301 tons gross. There were five new vessels on order or under construction for Cardiff owners.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

Institution of Electrical Engineers.—*Radio Section:* Monday, April 13, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Relative Merits of Broad-Band Transmission by Beam Cable and Waveguide," opened by Mr. E. C. H. Organ. *North-Eastern Centre:* Monday, April 13, 6.15 p.m., Royal Station Hotel, Newcastle-upon-Tyne. Annual General Meeting and Conversazione. *Mersey and North Wales Centre:* Monday, April 13, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Annual General Meeting. *Measurements Section:* Tuesday, April 14, 5.30 p.m., Victoria-embankment, W.C.2. (i) "Digital Computers at Manchester University," by Dr. T. Kilburn and others. (ii) "Construction and Operation of the Manchester University Computer," by Mr. B. W. Pollard and Mr. K. Lonsdale. (iii) "Universal High-Speed Digital Computers: A Decimal Storage System," by Dr. T. Kilburn and Mr. G. Ord. (iv) "Recent Advances in Cathode-Ray Tube Storage," by Professor F. C. Williams. *North-Western Centre:* Tuesday, April 14, 6.15 p.m., Engineers' Club, Manchester. "The London-Birmingham Television-Cable System," by Mr. T. Kilvington, Mr. F. J. M. Laver and Mr. H. Stanesby. *East Midland Centre:* Tuesday, April 14, 6.30 p.m., Offices of the East Midlands Electricity Board, Derby. "The First Stage of the Electrification of the Estrada de Ferro Santos a Jundiai (late Sao Paulo Railway)," by Mr. R. J. B. Chatterton and Mr. D. H. Rooney. *Southern Centre:* Wednesday, April 15, 6.30 p.m., Chamber of Commerce, 46, Commercial-road, Portsmouth. Discussion on "Economies in Wiring Practice," opened by Mr. Forbes Jackson, Mr. P. McKearney and Mr. A. V. Milton. *Utilization Section:* Thursday, April 16, 5.30 p.m., Victoria-embankment, W.C.2. "The Technique and Development of Automatic Winding in Mine Shafts," by Mr. B. L. Metcalf and Mr. G. Cuttle.

Illuminating Engineering Society.—*Sheffield Centre:* Monday, April 13, 6.30 p.m., The University, Western Bank, Sheffield. Annual General Meeting. "Horticultural Applications of Light," by Mr. A. E. Canham. *Society:* Tuesday, April 14, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Sports Lighting," by Mr. M. W. Peirce. *Birmingham Centre:* Friday, April 17, 6 p.m., Regent House, St. Philip's-place, Colmore-row, Birmingham. "Discharge Lamps for Particular Purposes," by Mr. E. H. Nelson.

Institution of the Rubber Industry.—*Merseyside Section:* Monday, April 13, 7 p.m., Electricity Supply Showrooms, Liverpool. Annual General Meeting. Discussion on "Plantations." *Preston Section:* Monday, April 13, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. Annual General Meeting and Film Display. *London Section:* Tuesday, April 14, 6.30 p.m., Royal Society of Tropical Medicine and Hygiene, 26, Portland-place, W.1. (i) Annual General Meeting. (ii) Films on "Basic Principles of Lubrication" and "Krillium." *Scottish Section:* Tuesday, April 14, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual General Meeting. "Bonding Rubbers to Synthetic Fabrics," by Mr. T. H. Messenger and Dr. W. C. Wake. *Leicester Section:* Friday, April 17, 7.30 p.m., Bell Hotel, Leicester. Annual General Meeting.

Institute of Welding.—*Sheffield Branch:* Monday, April 13, 7.15 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield, 1. Annual General Meeting. *Liverpool Branch:* Tuesday, April 14, 7 p.m., College of Technology, Byrom-street, Liverpool. Annual Meeting and Film Display. *East Midlands Branch:* Tuesday, April 14, 7.15 p.m., Victoria Station Hotel, Nottingham. Annual General Meeting and Film Display. *Wolverhampton Branch:* Wednesday, April 15, 7.30 p.m., Victoria Hotel, Wolverhampton. Annual General Meeting and Film Display.

Junior Institution of Engineers.—*Sheffield Section:* Monday, April 13, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. Film Display. *Institution:* Friday, April 17, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Graphic Reproduction," by Mr. J. F. Trusty.

Institute of British Foundrymen.—*Sheffield Branch:* Monday, April 13, 7.30 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield. Annual General Meeting. "Internal Stress in Castings," by Mr. M. M. Hallett. *Coventry Students' Section:* Tuesday, April 14, 7.15 p.m., Coventry Technical College, Coventry. Annual General Meeting, and Film on "Production of Castings for National Engines."

Institute of Road Transport Engineers.—*Scottish Centre:* Monday, April 13, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Carburation," by Mr. L. J. Spencer. *Midlands Centre:* Tuesday, April 14, 7.30 p.m., Crown Inn, Broad-street, Birmingham. Annual General Meeting and Film Display. *Yorkshire Centre:* Thursday, April 16, 7.30 p.m., Hotel Metropole, King-street, Leeds. Annual General Meeting.

Institution of Production Engineers.—*Western Graduate Section:* Monday, April 13, 7.30 p.m., Grand Hotel, Broad-street, Bristol. Lecturette Competition. *Birmingham Section:* Wednesday, April 15, 7 p.m., James Watt Memorial Institute, Birmingham. "The Contribution of Human Skills to Increased Productivity," by Mr. W. D. Seymour. *Cornwall Section:* Wednesday, April 15, 7.15 p.m., Cornwall Technical College, Trevenson Park, Pool. "Application of Induction Heating," by Mr. S. R. Tomes. *Southern Section:* Thursday, April 16, 7 p.m., Polygon Hotel, Southampton. "Engineering Problems of Aircraft Operation," by Mr. B. S. Shenstone.

Institution of Civil Engineers.—*Structural and Building Engineering Division:* Tuesday, April 14, 5.30 p.m., Great George-street, S.W.1. "Design of a Reinforced-Concrete Factory at Brynmawr, South Wales," by Mr. O. N. Arup and Mr. R. S. Jenkins. *Works Construction and Railway Engineering Divisions:* Thursday, April 16, 5.30 p.m., Great George-street, S.W.1. "The Reconstruction of French Railways," by Mr. R. Miot.

Institute of Marine Engineers.—Tuesday, April 14, 5.30 p.m., 85, Minories, E.C.3. "New Designs of Large Two-Stroke Marine Diesel Engines," by Mr. W. A. Kilchenmann.

Institution of Mechanical Engineers.—*Automobile Division:* Tuesday, April 14, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "The Jaguar Engine," by Mr. W. M. Heynes. *South Wales Branch:* Tuesday, April 14, 6 p.m., Mackworth Hotel, Swansea. "Potentialities of Hydraulic Transportation of Coal," by Mr. G. H. Wauchope. *Institution:* Friday, April 17, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. James Clayton Lecture on "Materials Handling," by Mr. J. R. Bright.

Institution of Chemical Engineers.—Tuesday, April 14, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "The Fractionation of Liquid Air: A Study of Design Methods for Three-Component Mixtures," by Mr. L. E. A. Clare, Mr. G. G. Haselden and Mr. R. A. Nottle.

Institution of Sanitary Engineers.—Tuesday, April 14, 6 p.m., Caxton Hall, S.W.1. "Cathodic Protection of Buried and Submerged Pipelines," by Mr. K. A. Spencer.

Institution of Structural Engineers.—*Scottish Branch:* Tuesday, April 14, 6 p.m., Ca'doro Restaurant, Glasgow. Annual General Meeting. *Wales and Monmouthshire Branch:* Tuesday, April 14, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Timber Structures," by Mr. J. R. M. Poole. *Midland Counties Branch:* Tuesday, April 14, 7 p.m., Welbeck Hotel, Nottingham. "Notes on Designing to British Standard 449," by Mr. V. H. Lawton. *Institution:* Thursday, April 16, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Economy in the Use of Structural Materials," by Mr. G. A. Gardner and others.

Incorporated Plant Engineers.—*London Branch:* Tuesday, April 14, 7 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Maintenance of Process Plants," by Mr. G. C. Allfrey. *East Lancashire Branch:* Tuesday, April 14, 7.15 p.m., Engineers' Club, Manchester. "Vibration in Buildings and Structures," by Mr. F. de Bass. *Western Branch:* Wednesday, April 15, 7.15 p.m., Grand Hotel, Bristol. "Generation of Industrial Power from Process Steam," by Dr. E. G. Ritchie.

Royal Society of Arts.—Wednesday, April 15, 2.30 p.m., John Adam-street, W.C.2. "Materials Handling and Processing: Past and Present," by Mr. L. Landon Goodman.

Newcomen Society.—Wednesday, April 15, 5.30 p.m., Science Museum, S.W.7. Various papers on "Windmills," by Mr. Rex Wailes and others.

Institution of Locomotive Engineers.—Wednesday, April 15, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Running Tests of a 500-h.p. Diesel-Mechanical Locomotive," by Mr. Brian Reed.

Société des Ingénieurs Civils de France (British Section).—Wednesday, April 15, 6 p.m., Iron and Steel Institute, 4, Grosvenor-gardens, S.W.1. "Flexural Plasticity in Mild Steel," by Mr. A. Lazard.

Women's Engineering Society.—*Manchester Branch:* Wednesday, April 15, 6.30 p.m., Engineers' Club, Manchester. "The Mass Spectrometer," by Miss Winifred Hall.

Institution of Mining and Metallurgy.—Thursday, April 16, 5 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. (i) "Frothing Characteristics of Cresylic Acids in Flotation," by Professor Shiou-Chuan Sun; and "A Review of American Progress in Geo-Chemical Prospecting, and Recommendations for Future British Work in this Field," by Dr. J. S. Webb.

British Institution of Radio Engineers.—*Scottish Section:* Thursday, April 16, 7 p.m., The University, Edinburgh. "The Telescribe," by Mr. C. A. Gilbert.

PERSONAL.

Sir William S. Farren, C.B., M.B.E., M.I.Mech.E., F.R.Ae.S., F.R.S., has been elected President of the Royal Aeronautical Society, 4, Hamilton-place, London, W.1, and will take office on May 7.

Sir John Duncanson has announced that he is retiring from the position of deputy chairman of Lithgows Ltd., Port Glasgow, R. Y. Pickering & Co. Ltd., and the Ayrshire Dockyard Co. Ltd., and from the position of chairman or director of several other companies.

Sir Philip Johnson is relinquishing his position of managing director at the St. Peter's Engine Works, Newcastle-upon-Tyne, 6, of R. & W. Hawthorn, Leslie & Co., Ltd., as from April 30, but will retain the deputy-chairmanship of the company. Mr. John Bulman is succeeding Sir Philip as managing director of St. Peter's Works, and Mr. D. G. Ogilvie, at present works manager, will be made general manager.

Mr. C. L. Hill, for some years deputy chairman of Heenan and Froude Ltd., has been elected chairman in place of the late Mr. A. P. Good. Mr. F. J. Fielding, the managing director, has also been appointed deputy chairman.

Mr. C. E. Prosser has been appointed chairman of the Metals Division of Imperial Chemical Industries, Ltd. He succeeds Mr. H. E. Jackson, who relinquished the chairmanship on March 31. Mr. Jackson is retiring from the Metals Division on June 30, at the termination of his year of office as President of the British Non-Ferrous Metals Federation.

Mr. Albert Parkinson, M.B.E., has relinquished the post of joint managing director of Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2, but remains chairman of the company.

New appointments have been made in the works of Henry Meadows Ltd., Wolverhampton. Mr. E. H. L. Cooper is to be general works manager; Mr. J. R. Threlfall, production manager; Mr. G. Metcalfe, production controller; Mr. D. E. Mallet, chief inspector; and Mr. H. D. Prescott, assistant chief inspector.

Professor R. D. Haworth, Ph.D., D.Sc., F.R.S., has been elected a vice-president of the Chemical Society, Burlington House, London, W.1.

The consulting engineering partnership between Mr. A. K. Jeffrey, A.M.I.P.E., Mr. E. P. Peregrine, B.Sc., A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., and Mr. W. A. Turner, M.I.M., hitherto conducted at the Manor House, Royston, Hertfordshire, under the style of Peregrine and Partners, has been dissolved by mutual consent. Mr. Peregrine is now operating new practices under the same style as formerly from the Manor House, Royston, Herts., and in association with Mr. H. S. Crabtree, M.A., A.F.R.Ae.S., at 9, Ovington Gardens, London, S.W.3.

Mr. J. A. Owen has retired from the position of managing director of the Consolidated Pneumatic Tool Co. Ltd., 232, Dawes-road, London, S.W.6, after 50 years of service with the company, but remains a director and technical consultant. His successor, as managing director, is Mr. Norman Readman.

Mr. C. N. Kington, M.B.E., B.Sc., A.M.I.Mech.E., A.M.I.E.E., chief engineer and administration officer at the British Iron and Steel Research Association's Sheffield laboratories, has been appointed group manager in addition.

Mr. James Houghton, M.Sc.Tech. (Manc.), A.M.I.Mech.E., has been appointed assistant research engineer in the new division recently created at Leyland Motors Ltd., for long-term development and research.

Mr. Bertram White, technical director of the Federation of British Industries, 21, Tothill-street, London, S.W.1, has resigned, as from March 31, to take up an industrial appointment. Dr. J. E. G. Harris, B.A. (Cantab.), has succeeded him temporarily as acting technical director.

Mr. B. H. Mears, director of Associated British Oil Engines (Export) Ltd., and National Oil Engines (Export) Ltd., has been appointed sales director of Mirrlees, Bickerton and Day Ltd., Stockport, a member of the Brush ABOE Group.

Mr. J. L. Collins, who has been secretary and legal adviser of Turner and Newall Ltd., since 1934, is retiring from the position of secretary but retains that of legal adviser. Mr. A. D. N. Jones, at present assistant secretary, has been appointed secretary as from April 1.

Mr. F. H. Williams, B.Sc.Tech. (Manc.), M.I.C.E., M.I.E.E., retired on March 31 from the position of hydro-electric engineer, South-West Scotland Division, British Electricity Authority.

Mr. L. J. Windridge has been appointed secretary to W. B. Dick & Co. Ltd., in place of Mr. G. Bowyer, who has resigned. Mr. Windridge will continue to act as an assistant secretary of C. C. Wakefield & Co. Ltd., 46, Grosvenor-street, London, W.1. Mr. W. Bowen is assistant secretary to W. B. Dick & Co. Ltd.

A RANGE OF AGRICULTURAL TRACTORS.

A COMPLETE range of tractors for farmers—light, medium and heavy machines (both wheeled and tracked)—is now made by David Brown Tractors, Limited, Meltham, Yorkshire. They claim to be the first British manufacturers to offer farmers such a range, which comprises three new models and three existing models which have been improved and renamed. Fig. 1 shows one of the new designs—the "25" light tractor with a petrol/paraffin engine or petrol engine. The second and third new designs are the 30C and 30D, these two vehicles being standard wheeled types of medium horse-power with a petrol/paraffin or petrol engine and a Diesel engine, respectively. The 30C is shown in Fig. 2. By developing this range of tractors, the firm enable users to standardise on one make, with advantages in respect of maintenance, etc.

The light tractor (Fig. 1) is fitted with a standard David Brown $3\frac{1}{2}$-in. bore engine, a two-position hydraulic lift, a sliding drawbar and a six-speed gearbox. It is intended to be an economical tractor in point of first cost and running costs, and will enable small farmers to use their existing trailed implements until such time as they invest in mounted equipment. It weighs about 30 cwt., but, nevertheless, has sufficient weight to handle binders, pick-up balers, etc., even on steeply-sloping land. For large-scale farmers it is believed that the "25" tractor will be a useful general-purpose machine, and as its road speed is high (over 17 miles an hour) it will be suitable for haulage work, for which purpose it is provided with a permanently-attached drawbar.

The four-cylinder overhead-valve engine develops 31·7 brake horse-power on petrol/paraffin, and 37·5 brake horse-power on petrol, running at 2,000 r.p.m. It has coil ignition and an automatic variable-speed governor. A hot-spot arrangement ensures complete vaporisation, even when the engine is idling, thereby reducing fuel consumption and preventing over-dilution of lubricating oil. The carburettor, which is pre-set, has needle-roller bearings on the throttle spindle, thus ensuring instantaneous reaction of the governor and improved fuel economy. Though it is a light machine, the "25" tractor has a twin-range gearbox with six forward and two reverse speeds. The lowest forward speed is only one mile an hour, which facilitates operation on difficult slopes, as well as slow planting, precision hoeing, etc. The drawbar is of a new self-contained type which pulls out and fits on to drop links. When not in use it slides under the rear axle. All parts required for the linkage are carried permanently on the tractor, thereby enabling the change from mounted to trailed implements to be made without unnecessary delay.

The foot-operated steering brakes operate on the transmission half-shafts, and can be applied together or independently. A valuable feature of the clutch control is the provision of a hand lever at the rear of the machine. The accessories which are available with the "25" tractor include a two-speed power take-off, a two-speed belt pulley, agricultural-type lighting, an overload release and oversize tyres.

The medium tractor type 30D is driven by a 30-h.p. Diesel engine of $3\frac{5}{8}$ in. bore and 4 in. stroke. Instead of the aluminium brake shoes previously fitted, heavier cast-iron shoes are now provided as they have greater inertia and prevent brake shudder and squeal. In the design of the linkage a thrust bearing on the drop arm now facilitates the operation of the levelling lever when under load and prolongs the life of the unit. The type of gear pump now fitted to all David Brown tractors with power-lift equipment incorporates a "hold" position which enables the linkage to be locked in the raised position at any height, thus relieving the pressure on the pump which then returns the oil to the gearbox. As a result, the pump is only working under pressure while the control lever is in the raised position, thereby reducing wear on the parts and maintaining viscosity of the oil. The advantage of this arrangement is particularly apparent when using implements such as buck rakes, on which heavy loads are carried for considerable distances. Other improvements in the design include stronger bronze bushes in the front-axle trunnion, closer toleranced steering components, improved double fuel filters, necked engine valves which improve heat dissipation, and an improved adjustable drawbar. Independent hand turning brakes on both wheels enable short turns to be made. A two-speed power take-off and pulley are coupled to the gearbox and the accessories which are available with this machine include agricultural-type lighting, universal lighting, an overload release, and outsize tyres.

The 30C tractor (Fig. 2), which is of generally similar design, has a petrol/paraffin engine developing 37·6 brake horse-power at 2,300 r.p.m., or a petrol engine of 41 brake horse-power at 2,300 r.p.m. It has a built-in hydraulic lift. The renamed David Brown standard tractors are the 50D (formerly the Cropmaster Diesel 50); the 30T and 30TD (formerly the Trackmaster and Trackmaster Diesel); and the 50TD (formerly the Trackmaster Diesel 50), all of which have been improved in detail recently. The tracked vehicles are available with tracks of various widths.

LIGHT AND MEDIUM AGRICULTURAL TRACTORS.

DAVID BROWN TRACTORS, LTD., MELTHAM, YORKSHIRE.

FIG. 1. THE LIGHT "25" TRACTOR.

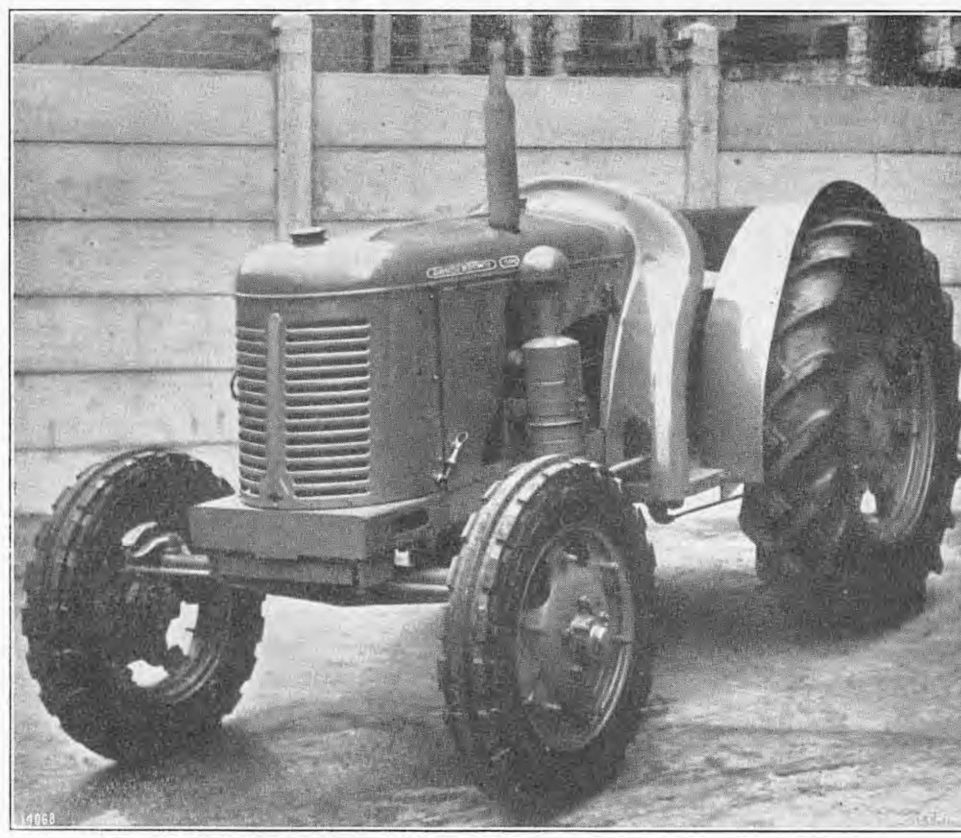


FIG. 2. THE MEDIUM "30C" TRACTOR.

ENGINEERING

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ENGINEERING

FRIDAY, APRIL 10, 1953.

VOL. 175. No. 4550.

RESEARCH PROGRESS REPORT.

THE Department of Scientific and Industrial Research maintains research establishments dealing with building, chemistry, fire protection, food, forest products, fuel, geological survey, hydraulics, mechanical engineering, pest infestation, radio, roads, water pollution, and the variety of subjects covered by the activities of the National Physical Laboratory. In addition, it makes grants to, and keeps in touch with, 43 research associations and four other bodies whose procedure bears on research. In view of this extensive range of activity and interest, the annual report* of the Department is necessarily a lengthy document covering such a wide field that any attempt to comment, even briefly, on the main part of the material presented would result in little more than a list of contents. Even confining attention to the engineering field would make little difference, as the proceedings of some ten of the research establishments and about half of the research associations are of professional interest to the readers of this journal.

It is less necessary to refer in detail to the accounts which are given of the work of, say, the Fuel Research Station, or the Mechanical Engineering Research Laboratory, as the material presented is naturally a summary of the individual reports of the two establishments; these appear annually and deal in greater detail with work in progress than is possible in a report covering the whole of the activities of the Department. The individual reports are reviewed in these columns as they appear. These remarks are not intended to suggest that this general report is lacking in interest and value. For one thing it clearly shows the extent to which industry in general has come to realise the value of research. It was the impact of the first World War which resulted in the setting up of the Department of Scientific and Industrial Research and did something towards directing the attention of industrialists to the importance of cultivating a more scientific attitude of mind and applying scientific methods to industrial problems. One result of the impact was the setting-up of some research associations, but the movement did not quickly reach its present range. Of the 43 research associations now in existence, only twelve date from the years 1918 to 1923.

The advent of the second World War, with its shattering effect on the financial standing of this country, was apparently necessary before those who conduct many branches of industry came fully to realise the important part which scientific research could play in increasing the efficiency of their proceedings. The reaction was such that 25 research associations were formed between 1943 and 1949; another was added in 1952. Although the engineering industry, with its many branches, has a good record in research and in the application of results, it cannot claim to have set a main example in adopting the system of co-operative research which is practised by the research associations. Of the twelve associations set up by 1923, only four were of a specifically engineering nature. Others dealt with such matters as boots, leather, linen and wool. It is probable, however, that the engineering industry was a "pioneer" in research conducted by individual firms in their own interests.

As already indicated, the report is largely made up of summaries of the work carried out by the Departments' establishments and by research associations, and, in a sense, its most important part is the introductory section signed by Professor Sir Ian Heilbron, chairman of the Advisory Council, and by Sir Ben Lockspeiser, secretary of the Department. This reviews the whole field of work with which the Department is concerned, and dwells on the impediments, financial and other, which are limiting the activities of all the organisations it operates or assists. A post-war programme of development prepared by the Department was approved by the Government in 1946 as "the minimum necessary to enable D.S.I.R. to play its part in ensuring that science made its full contribution to national problems and particularly to increasing industrial efficiency." The "approval" has not led to action and the Department finds itself "reviewing the relation between our scientific needs and our scientific resources with steadily deepening concern."

The post-war programme covered much new building and equipment and it was stated in the report for 1950-51 that the most urgent items were the completion of the Mechanical Engineering Research Establishment, the construction of the Hydraulics Research Station, and the re-housing of the Water Pollution Research Laboratory. Some progress had been made with the Mechanical Engineering and Hydraulics Stations by the end of the year covered by the report, and since that time a start has been made with the new Water Pollution Research Laboratory at Stevenage; it is scheduled to be completed next year.

It is, however, not only in connection with building work that the Department is dissatisfied with the present position. The Treasury embargo on increase of staff is hampering many desirable activities; as an example, it is stated that owing to shortage of staff the compilation of 6 in. to the mile geological maps for the 33,000 sq. miles of the country, estimated at the outset to take about

* *Department of Scientific and Industrial Research Report for the Year* 1951-52. H.M. Stationery Office. [Price 8*s.* net.]

30 years, will, at the present rate of progress, take more than a hundred. Another point, referred to many times in the report, is that basic long-range research is perforce being neglected owing to the present necessity for dealing with *ad hoc* problems. There is no suggestion that research applied to the immediate problems of industry is unnecessary or undesirable. The point is that fundamental research should not be neglected in its favour. It is quite certain that a basic research cannot be carried on satisfactorily if the activities of those engaged on it are liable at any time to be diverted to the solution of immediate industrial problems.

The report gives its blessing to what has come to be known as "operational research," pointing out correctly, however, that "it is by no means new or unusual in industry." Satisfaction is expressed that the research associations are becoming more and more interested in the analysis of industrial operations. As an example, it states that the Iron and Steel Research Association is carrying out a survey to assess the optimum size of ships which can be handled at the principal ports from which iron ore is dispatched to this country. It would appear to be not unlikely that full information on this matter is already possessed by shipping firms who handle iron ore. If it is not, it ought to be, and if shipping firms and any other industrial organisations are ignorant of some of the essential data on which their activities are based it is all to the good that their attention should be directed to the matter by research associations. Dr. W. H. Glanville, in the course of a lecture arranged for by the Manchester Joint Research Council in 1949, said operational research is "perhaps 20 or 30 years old; market research, social survey and methods research are all aspects of it." Research associations may by their example influence trade associations towards realising that something is to be gained by analysing their own activities with scientific dispassion, and if such example is more likely to be followed when the activity is called "operational research" the term is to be welcomed.

The introductory section of the report devotes some space to the matter of technical-information services and states that although the right kind of scientific work is being carried out it is questionable if "the arrangements for placing the results before industry are satisfactory." It is not suggested that they are unsatisfactory but it is suggested that they might possibly be improved as there are many firms who could profit by the information available but never seek it. That large sections of industry are aware of the value of scientific research is made clear by the fact that the number of inquiries addressed to the research establishments and research associations totals some 200,000 a year and that the number is steadily increasing.

One specific example of the organisation of technical information services is presented in connection with chemical engineering. In 1949, a committee was appointed by the Advisory Council to look into the question of chemical engineering research. In its report,* it recommended the setting up of a chemical engineering research station. The D.S.I.R. report states that the chemical engineering report has received close study but does not make any recommendation about the setting-up of a research station. In view of the many demands on the financial resources of the Department, such a recommendation, at the present time, would be useless. The suggestions made in the chemical-engineering report for the establishment of a central organisation to collect, interpret and distribute information relating to chemical engineering is, however, commented on favourably and it is stated that the matter has been discussed with the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association.

* See ENGINEERING, vol. 173, page 49 (1952).

NOTES.

GRANTS TO GRADUATES TO ATTEND I.MECH.E. SUMMER MEETING.

SELECTED graduates and students of the Institution of Mechanical Engineers are to be awarded minor grants from the James Clayton Trust Fund to enable them to attend the summer meeting, which is to be held at Sheffield from July 1 to 3 this year. The scope of the engineering profession is now so wide that many young men will welcome this opportunity of seeing workshops and laboratories outside the confines of their own apprenticeship and education. The hospitality which is invariably shown by the firms who act as hosts during the summer meetings is always a memorable feature, and the informal intercourse between members adds to their breadth of knowledge and outlook. The April issue of the Institution *Journal* states that the amount of the grants will not cover the whole of the costs involved, but will meet a considerable proportion of the expenses for travel and hotel accommodation. Graduates and students who are interested should apply to the honorary secretary of their senior branch committee (whose addresses are given in the *Journal*), setting out any details in support of their applications. Arrangements for selection will be made by the branch committee. Those who accept minor grants will be required to submit to their branch secretaries, after the meeting, a short report based on technical data brought to their notice during visits to works or by means of the addresses and papers read during the meeting.

BRITISH PLASTICS CONVENTION, 1953.

The programme of the second British Plastics Convention, to be held in conjunction with the British Plastics Exhibition, in the National Hall, Olympia, London, W.14, has now been issued. This convention is being arranged by a committee of representatives from the British Plastics Federation, the Plastics Institute, the plastics and polymer group of the Society of Chemical Industry, and the monthly journal *British Plastics*, and will take place from Monday, June 8, to Wednesday, June 17. On the present occasion, the aim of the convention will be to meet the needs of plastics technologists, although many of the papers to be presented will attract a much wider attendance. The convention will open with an inaugural address by the Earl of Halsbury, F.R.I.C., to be delivered on June 8 at 4 p.m. On the following days of the convention, there will be morning sessions, commencing at 10.15 a.m., on Tuesday, June 9, Wednesday, June 10, Thursday, June 11, Friday, June 12, Tuesday, June 16, and Wednesday, June 17. Afternoon sessions, commencing at 2.30 p.m., will take place on Tuesday, June 9, Wednesday, June 10, Thursday, June 11, Monday, June 15, and Wednesday, June 17. Papers to be read and discussed at these sessions will include "Problems Related to the Manipulation of Unplasticised Polyvinyl Chloride," "Industrial Applications of Unplasticised Polyvinyl Chloride," "Recent Commercial Developments in Melamine and Guanamine Resins," "Moulded and Extruded Polyamides and Polyesters," and "Silicones in the Plastics Industry," on June 9; "Surface Chemistry and Adhesion of Glass and Plastics," "Plastics Containing Asbestos as a Reinforcing Filler," "A Critical Survey of Commercial Low-Pressure Laminating Resins," "Some Considerations in the Design and Manufacture of Structures in Glass Reinforced Plastics," and "Some Problems Associated with the Design and Manufacture of Asbestos Reinforced Plastics," on June 10; "The Durability of Plastics under Post Office Conditions," and "The Durability of Adhesives for Wood," on June 11; "Merchandising Polyvinyl-Chloride Film and Related Products," "Marketing Melamine Tableware," "Plastics in the Toy Industry," and "Designs in Plastics," on June 12; "A Study of the Problems Involved in High-Quality Injection Moulding," on June 15; "The Economics of Large Moulding Machines," on June 16; and "Plastics in the Telecommunications Field," "The Metallisation of Plastics by Vacuum Evaporation for Functional and Scientific Purposes," "Plastics in the Footwear Industry," and "Flameproof Conveyor Belting," on June 17. Admission to the convention will be available to all interested persons. Copies of the programme and tickets of admission may be obtained, free of charge, from the organisers, *British Plastics*, Dorset House, Stamford-street, London, S.E.1. Applicants are asked to specify the sessions it is desired to attend.

BRITISH ASSOCIATION MEETING AT LIVERPOOL.

As previously announced, the British Association for the Advancement of Science is to hold its annual meeting this year at Liverpool under the Presidency of Sir Edward Appleton, G.B.E., K.C.B., F.R.S., whose address, entitled "Science for its Own Sake," will be delivered at the Inaugural General Meeting on the evening of Wednesday, September 2. This meeting will be held in the Philharmonic Hall, Hope-street, Liverpool, and will be preceded by a special Graduation Ceremony. The President will also deliver, this year, a special address for the benefit of student members and will speak on "Finding Things Out with Radio and Rockets." The address will be delivered in the Philharmonic Hall on Thursday, September 3, at a time to be announced later. Evening discourses on "Continuous Creation," by Sir Harold Spencer Jones, F.R.S., and on "Everest," by Mr. Eric Shipton, will be delivered in the Philharmonic Hall on September 4 and September 7, respectively. The preliminary programme for the meeting has now been issued to members, and others wishing to obtain particulars of the meeting can obtain a copy of this programme from the offices of the Association, Burlington House, London, W.1. An attractive programme of social events, general and sectional excursions has been arranged and some particulars of them together with an outline of the work of the sections will be found in the preliminary programme. Section G, Engineering, will meet in the Walker Engineering Laboratories, and the President of the Section, the Rt. Hon. Lord Dudley Gordon, will deliver his address in the morning of September 3. A discussion on the utilisation of digital computing machines will follow the President's address. Other subjects to be dealt with in the Section during the course of the meeting include new sources of energy, electronic switching, colour television, time and motion study, and district heating. As is usual, one session will be devoted to the presentation and discussion of papers by young engineers. The Recorder of Section G is Professor W. Fisher Cassie, King's College, Newcastle-upon-Tyne, 1. Dr. E. C. Cherry and Mr. R. Hiscock are secretaries and Mr. E. B. Cole is local secretary.

INSTITUTION OF ENGINEERING DRAUGHTSMEN AND DESIGNERS.

At the Ceremony of Awards and general meeting of the Institution of Engineering Draughtsmen and Designers, held on March 31, at the Waldorf Hotel, London, six aircraft designers were honoured: Mr. R. E. Bishop, for the de Havilland Comet, Mr. S. D. Davies, for the Avro Vulcan, Mr. G. R. Edwards, for the Vickers-Armstrongs Viscount, Mr. H. Knowler, for the Saunders-Roe Princess, Mr. A. E. Russell, for the Bristol Britannia, and Mr. R. W. Walker, for the Gloster Javelin. The Institution's challenge cup was awarded to Mr. L. B. Archer, and the Founder Column to Mr. J. A. Marsh. Before the presentation, the President of the Institution, the Rt. Hon. Lord Westwood of Gosforth, O.B.E., J.P., gave a speech of welcome, followed by the guest of honour, Mr. S. Scott-Hall, C.B., who spoke on "Recent Developments in Aircraft Design." With the advent of the jet engine and the speeds thereby made possible, said Mr. Scott-Hall, wings had to be swept back in order to prevent the sharp rise of resistance at high subsonic speeds and beyond. They also had to be thinner. This led to severe structural problems and the need for much research work on control at low speeds. New conditions of stability had to be catered for. Aero-elasticity, the inter-relation between the elastic characteristics of the structure and the aerodynamic loading, became more critical.

Controls had to be much more powerful without calling for more physical effort on the part of the pilot, which led to the development of controls powered by hydraulic equipment. The body of the aircraft had to become a pressurised container in order that crew and passengers could live in the stratosphere. This led to a new approach to the structural design, the development of pressurising equipment, and much work on transparent materials for windscreens and windows which could be used safely under pressure. For military aircraft, in case of catastrophic damage by the enemy, the crew had to be protected from the effects of sudden decompression and forcibly ejected from the aircraft from which they could not otherwise emerge. Because of the high fuel consumption, an enormous fuel tankage was necessary if the aircraft was to have a useful endurance. The life of civil aircraft in modern times was much longer than formerly, and they were continuously subjected to intense vibration and oscillation due to the turbulence of the atmosphere. Much research work had been necessary before the designer could be sure that his aircraft was completely safe from fatigue. There was no easy solution by using heavier components. This rapid survey gave a yardstick of the aircraft designers' achievements and of the progress which had been made. Broadly speaking, the operational heights and speeds of our military aircraft had been more than doubled since the war, and we led the world in the civil field with turbine-powered air liners. In conclusion, he emphasised the importance of sound detail design. It was in the details that every designer and draughtsman had a vital part to play.

UNITED STATES ZINC INDUSTRY.

The production of slab zinc in the United States, during 1952, totalled 961,200 short tons. This output was higher by 3 per cent. than that for 1951 and was second only to the high-record production of 1943, when 990,524 tons were made available. It is pointed out in a report issued by the United States Bureau of Mines that, of the 1952 total, 661,023 tons were smelted from home-produced ores, in Montana, Idaho, Oklahoma, New Jersey, and other States, and that 450,500 tons of zinc ores and concentrates were imported during the year. Of these, 44 per cent. came from Mexico, 33 per cent. from Canada, and 10 per cent. from Peru. In addition to the home production of the metal, 114,200 tons of slab zinc were imported during 1952. Canada was the chief source and was responsible for 61 per cent.; Mexico was second with 16 per cent., and smaller quantities were supplied by Western Germany, Belgium, Italy, the Netherlands, and Yugoslavia. Exports of slab zinc from the United States totalled 55,000 tons in 1952, compared with 36,510 tons in 1951. The United Kingdom was the chief purchaser, taking 70 per cent. of the total exports, France was second with receipts of 16 per cent., Brazil was third, having taken 7 per cent., and India fourth with purchases equivalent to 4 per cent. The official London price of zinc is quoted as having fallen from 190*l*. per long ton at the commencement, to 110*l*. per ton at the close, of 1952, and it is stated that owing to the rising world production of zinc all restrictions on its use, in the United States, were removed on June 27, 1952.

COMPETITIONS ON APPLICATIONS OF THE OXY-ACETYLENE FLAME.—The rules for two competitions sponsored by the Commission Permanente Internationale de l'Acétylène, de la Soudure Autogène et des Industries qui s'y Rattachent have now been issued. One competition is for a paper, and the other for a cinema film, both dealing with "The Applications of the Oxy-Acetylene Flame." The papers must be written in English or in French and, excluding illustrations, must not exceed 20 typewritten pages measuring 21 cm. by 29·7 cm. The films must be of the 16-mm. silent, black-and-white or coloured type, with titles and sub-titles in English or French. The maximum showing time is 15 minutes. The films must be accompanied by a synopsis. Entries for both competitions should be addressed to the general secretariat of the Commission, 32, Boulevard de la Chapelle, Paris 18e, and must reach their destinations not later than 6 p.m., Central European Time, on December 31, 1953. The total prize money available for each competition is 500,000 French francs and the minimum value of each prize will be 50,000 francs.

OBITUARY.

DR. GUTHLAC WILSON.

WE have learned with regret of the death of Dr. Guthlac Wilson, senior partner in Scott and Wilson, consulting civil engineers, 47, Victoria-street, London, S.W.1. Dr. Wilson and his wife were among the 13 passengers and members of the crew who were killed when the Viking airliner belonging to Central African Airways crashed near Dar-es-Salaam, East Africa, on March 30. At the time of his death, Dr. Wilson was returning from Hong Kong, where he had been advising the Government on the projected Kai Tak Airport, and was visiting the extensive works, including road, air-port and water-supply installations, for which his firm are responsible in East Africa.

Guthlac Wilson was born on May 21, 1902, and was educated privately before going to East London College (later Queen Mary College), where he graduated B.Sc.(Eng.) with 1st class honours in 1921; he was also the David Alan Low Prizeman at the College for that year. He received his first practical training under Mr. Kerr Lockhead, M.I.C.E.,

THE LATE DR. GUTHLAC WILSON.

with Sir Robert McAlpine and Sons, Limited, before joining the Bombay office of Messrs. Braithwaite and Company in 1924. Mr. Wilson—he did not obtain his doctorate until 1951—remained in India until early 1938, being responsible for the design and construction of a number of important works, including the Tawi Bridge, Jammu, the Dunja Gali Reservoir and the Inchcape and Dharaut bridges for the Bombay and North Western Railways. In 1935, he made the necessary calculations for the secondary stresses in the New Howrah Bridge and he also undertook the design of the foundations. He had been elected to associate membership of the Institution of Civil Engineers in 1928 and was transferred to full membership ten years later.

In 1938, Mr. Wilson went to Harvard to study soil mechanics, and there he was awarded the degree of S.M. and a fellowship for a further year to continue his studies; but, with the outbreak of war, he declined the fellowship and returned home. His first appointment during the war was with Sir Alexander Gibb and Partners, with whom, as Divisional Superintendent (Designs), he was responsible for the Royal Ordnance Factory No. 5. In 1943, Lord Reith, then Minister of Works and Buildings, appointed Mr. Wilson to be Director, Constructional Design, in the Ministry and, in this capacity, Mr. Wilson served on a number of research boards and British Standards Institution committees. During 1944, while continuing in an advisory capacity with the Ministry, he began to engage in private practice and, a year later, with the late Mr. W. L. Scott, M.I.C.E., founded the firm of Scott and Wilson; he became the senior partner on the death of Mr. Scott in 1950. Among the many civil engineering works of note for which the firm were responsible for the structural work were the British Nylon Spinners factory at Pontypool; the Royal Festival Hall, London; the City of Westminster Pimlico Housing Scheme; rebuilding at Coventry; the reconstruction, in conjunction with Mr. J. H. Jellett, M.I.C.E., Docks and Inland Waterways Executive, of the Union Castle Terminal Shed, Southampton; and the British European Airways' hangars at London Airport.

In 1951, he was awarded the degree of D.Sc.(Eng.) by the University of London, and during the post-war years he was the author of six papers published in the *Proceedings* of the Institution of Civil Engineers. Dr. Wilson had been on the board of the Structural and Building Division of the Institution of Civil Engineers and he was chairman of the Division during the year 1950-51. He had been a member of Council of the Institution for the past three years and, at the time of his death, had been nominated for a further period of office as from next November. Apart from serving on many *ad hoc* committees of the Institution, Dr. Wilson served on the Ministry of Works National Consultative Council for the Building and Civil Engineering Industries, the Ministry of Supply Joint Committee on Soils and on the Road Research Board. He was a member of the Institution of Structural Engineers and of the American Society of Civil Engineers, as well as a member of Council of the Association of Consulting Engineers.

THERMAL EFFICIENCIES OF BRITISH POWER STATIONS.

THE British Electricity Authority announce that the overall average thermal efficiency of their steam power stations, nearly 300 in all, for the calendar year 1952, was 22·61 per cent., compared with 21·79 per cent. in 1951. The improvement in thermal efficiency of 0·82 per cent., represents not only a saving in coal consumption of some 1,300,000 tons, but also an economy in cost of over 3,000,000*l*.

The following are the 20 steam power stations of the Authority with the highest overall thermal efficiencies for 1952:

Littlebrook B, Dartford, Kent	29·95
Dunston B II, Newcastle-upon-Tyne	29·65
Portobello (high pressure), Edinburgh	29·46
Skelton Grange, Leeds	29·19
Bromborough, Cheshire	28·88
Stourport B, Worcestershire	28·84
Battersea B, London	28·71
Poole, Dorset	28·31
Braehead, Renfrew	27·79
Agecroft (high pressure), Salford	27·20
Blackwall Point, London	26·66
Clyde's Mill (high pressure), Glasgow	26·66
Fulham, London	26·63
Cliff Quay, Ipswich	26·63
Stuart Street (high pressure), Manchester	26·47
Brimsdown B (high pressure), near Enfield	26·41
Hams Hall B, near Birmingham	26·24
Llynfi, near Bridgend, South Wales	26·23
Staythorpe, Newark	26·18
Croydon B, Surrey	26·02

Three stations, namely, Brunswick Wharf, North Tees C, and Huncoat, which did not operate throughout the whole year, achieved thermal efficiencies for their periods of commercial operation of 28·41, 26·93 and 26·60 per cent., respectively.

It is pointed out that new power stations and new plant in older stations make a highly-important contribution to national fuel economy. Well over one-tenth of the Authority's present total output capacity is provided by plant over 25 years old. The replacement of these old machines will save substantial quantities of coal and money. The present plant programmes of the Authority aim to reach an overall average thermal efficiency of 26 per cent. in 1960.

DEVELOPMENTS IN ELECTRICAL INSULATING MATERIALS.

(*Continued from page* 437.)

THE papers read at the meeting on Tuesday evening, March 17, included one on the "Experimental Investigation of Factors Influencing the Electric Strength of Potassium Chloride Crystals," by Messrs. J. H. Calderwood, R. Cooper and A. A. Wallace. It was pointed out that the electric strength of potassium chloride was not significantly affected by the choice of electrode material. It was, however, considerably increased by treatments that introduced structural defects, associated with residual strains, caused by plastic deformation. Structural defects of this sort could be created very easily, and great care was therefore required to obtain measures of electric strength for strain-free crystals. The electric strengths of strain-free crystals were the values suitable for comparison with existing theoretical predictions and they might be as much as 50 per cent. less than those usually quoted for the alkali halides at room temperature.

INSULATION FAILURE.

In a paper on "Some Mechanisms of Insulation Failure," Messrs. H. F. Church and C. G. Garton pointed out that the well-established causes of failure in solid insulation were: intrinsic, or electronic, breakdown; thermal instability; slow erosion by gaseous ionic bombardment at comparatively low stresses; electrochemical deterioration; and chemical deterioration. Two further causes, for which evidence was accumulating, but which were not yet established, were rapid penetration of gaseous discharges into solids at high stresses and electronic bombardment in impregnated insulation. The chief aim of the paper was to show the increasing certainty with which these effects could be separated and controlled. Attention was, however, also drawn to the wide gap between intrinsic electric strength and average working stresses. The highest stresses now used in cables could not be greatly increased if a margin of strength were left to meet impulse conditions. If a substantially higher working stress became possible, it might be economic to prevent surges entering the cables. In insulation generally, and in capacitors, there was a possibility of further increase of working stress, if designs could be developed which minimised secondary causes of failure.

A first step in the evolution of new designs was a clear distinction between the various causes of failure, several of which were usually in progress at different rates. Most of the causes had become clear during the past twenty years, but some remained obscure and further basic research was needed to explain them. A second step was the development of methods to eliminate the secondary causes of failure. This required close co-operation between the research and design by development staffs. Recent examples of the success of such co-operation were the performance of high-frequency polythenic cables from which the effects of discharges had been almost eliminated, and the development of capacitors stabilised against electrochemical attack. The value of organised research on such problems was emphasised by the fact that most causes of failure were vaguely recognised long ago and their subsequent classification had resulted mainly from long-term work by the very few groups of investigators free to spend considerable time on them.

ELECTRICAL DISCHARGES IN AIR GAPS.

"Electrical Discharges in Air Gaps Facing Solid Insulation in High-Voltage Equipment," was the subject of a paper by Messrs. E. Friedlander and J. R. Reed. In any electrical equipment which operated at voltages in excess of about 1,000 volts, said the authors, there might be places where solid or liquid insulation was stressed in series with a gas-filled gap. Because this insulation was usually stronger than the gas and, in particular, stronger than air at atmospheric pressure, the ultimate responsibility for withstanding the electrical stresses usually rested upon the solid insulation. A breakdown of the gas would then not cause a total failure, but a local and limited discharge which might be tolerated under certain conditions, as, for instance, in equipment subjected to overvoltage tests. In considering such composite insulation questions arose as to how long the material would withstand discharges caused by partial breakdown and how this time could be increased. Considerably more knowledge was needed of the physical processes involved before it would be possible to forecast the performance of such composite insulation with accuracy, and the authors therefore instigated an investigation as the result of observing discharges in the overhang of high-voltage alternators.

It was found that the performance of such machines under over-voltage conditions was materially improved by applying an insulating sheathing to exposed parts of the base earthed metal. Other phenomena observed with discharges between insulated electrodes were then considered, including, in particular, the increase of discharge current with rising voltage and the origin of the long discharge-free range in the decaying part of the alternating-current voltages. Both these observations could be explained by the loss of some of the surface charges left from earlier discharges due to local reversals of the electric field. Some of the explanations of the probable mechanism by which charges were lost must, however, be considered tentative and more experimental evidence was needed to clarify the processes involved.

"The Electrical Breakdown of Air Between Insulators" was dealt with in a paper by Mr. W. L. Harries. By the use of a cathode-ray tube it could be shown that the alternating-current breakdown current in a glass vessel with external electrodes consisted of a number of separate pulses, because once a breakdown occurred charges collected on the glass walls and produced reverse fields which stopped the discharge. These wall-charge fields also determined the phase when pulses occurred. Ionisation by collision of the molecules of the gas and secondary emission of electrodes from the inner surfaces of the glass wall were fundamental processes in the discharge. The breakdown conditions were similar to a direct-current discharge between metal electrodes.

TRANSFORMER-OIL BREAKDOWNS.

The "Electric Breakdown of Transformer Oil" was the subject of a paper presented by Messrs. P. K. Watson and J. B. Higham. In this a description was given of an experimental equipment which had been designed to determine the mechanisms of electric breakdown in insulating liquids under various conditions. This consisted of a transparent pressure chamber with an internal glass test vessel, which enabled the liquid under test to be subjected to hydrostatic pressures up to 500 lb. per square inch and peak voltages up to 100 kV. A protective circuit, which incorporated a triggered spark gap, limited the duration of the breakdown currents to a few microseconds. With this equipment a wide range of breakdown strengths had been obtained, varying from 500 kV peak per centimetre with a one-microsecond impulse to below 100 kV root mean square per centimetre for an oil contaminated with fibres under alternating current test conditions. The removal of the fibres raised the alternating-current strength of otherwise untreated oil to 400 kV root mean square per centimetre.

As the result of the experiments made with this apparatus it was concluded that the breakdown of transformer oil in its normal state could result from a number of mechanisms. There appeared to be three regions corresponding to various conditions: one in which breakdown was similar to that in pure liquids and which was operative for impulses of microsecond duration; a second region in which cavitation-initiated (pressure-dependent) breakdown took place; and, finally, a region in which particle impurities took effect, owing to the long duration of the applied voltage. An example of the latter would probably occur in the standard testing of used transformer oil. The alternating-current breakdown voltage would be determined primarily by the fibre content of the oil, but the actual breakdown mechanism might involve a cavitation process initiated in the high field region at the ends of fibres.

ELECTRICAL BREAKDOWNS IN A VACUUM AND ORGANIC LIQUIDS.

"Electrical Breakdown in Vacuum" was the subject of a paper presented by Dr. D. Leader. This described experiments in which direct and impulse voltages were applied to an electrode system contained in a vacuum of about 10^{-5} mm. of mercury. It was found that with a needle and sphere system the breakdown voltage was considerably higher than that obtained with a normal sphere gap with the same electrode spacing, especially when a very fine needle was used. Oscillograms were taken of the current during a breakdown in vacuum and of the collapse of voltage across the gap. With the fastest time sweep available the current rise and voltage collapse were found to take place in 0·1 microseconds. A longer sweep showed that there was a minimum stable current below which a continuous breakdown would not occur; if conditions limited the current to below this value it would only flow intermittently. This might account for the difficulty experienced by some workers in making measurements of breakdown in vacuum with direct voltages.

In a paper on "Electrical Breakdown in Organic Liquids" Dr. T. J. Lewis dealt with the electric strength of simple hydrocarbons under direct voltage and showed that if the discharge was limited by a quick-acting electronic by-passing device the dispersion of results was considerably reduced. In using direct voltage for the tests time-dependent effects were allowed to operate. If the liquid was highly purified and the electrodes were clean, thermal effects produced by conduction currents would be small and essentially an electric strength would be obtained, which was representative of the liquid under conditions where space charge and electrode surface-layer effects were operative, but where thermal effects were negligible. Factors influencing the breakdown processes, using *n*-hexane, were also investigated, particular attention being paid to the behaviour at the electrode surfaces. In addition, the electric strengths of the normal paraffin, pentane to decane, as well as cyclohexane and benzene, were measured at various gap widths and over a range of temperatures.

Previous investigations had indicated that the time of breakdown in pure liquids was so short that the mechanism was essentially electronic in nature. A pure non-polar liquid exhibited a very low conductivity, which increased with the field strength until, when the breakdown field was reached, it lost its insulating properties in a catastrophic manner. Any theory of dielectric breakdown of liquids must consider first the initial supply of electrons and, secondly, the way those electrons were multiplied in the liquid to produce breakdown. It was probable that the initial supply of electrons would depend on setting up a gradient at the cathode sufficient for appreciable emission. There would appear, however, to be no marked dependence on cathode material, a possible reason for which was electron multiplication in the liquid. Electron emission from the cathode did not in itself constitute breakdown. It was necessary that considerable multiplication of charge carriers should occur in the liquid to render it fully conducting. For this multiplication a certain field strength would be required and the cathode gradient was then such that emission would occur freely. On the other hand, dependence on cathode material was likely if the threshold of field emission was only just reached with fields which were already overstressing the liquid. This mechanism involved the formation of an electron avalanche in the liquid and subsequent bombardment of the anode.

INSULATION BREAKDOWN BY DISCHARGES.

In a paper on "Breakdown of Insulation by Discharges," Mr. J. H. Mason pointed out that the principal factors limiting the safe working strength of modern low-loss insulation were electrochemical deterioration and breakdown caused by internal or surface discharges. Investigations on the breakdown of impregnated paper insulation by internal discharges showed that there was a close correlation between its life and the ratio of the applied voltage to discharge inception voltages. The same applied to polythene insulation, discharges in the voids of which caused slow erosion and deposition of a transparent resin in the small pits that were formed. Subsequently, the discharges concentrated in deep uncarbonised pits surrounded by a layer of resin. When these pits attained a critical length, partially-carbonised channels developed at their ends which either precipitated total breakdown or caused the discharges to be short-circuited so that deterioration ceased. As regards surface discharges, thin sheets of organic insulation underwent chemical deterioration owing to absorption of the chemically-active gases produced, although the extent of this deterioration was not directly correlated with the probability of breakdown. After many hours of exposure to discharges, breakdown, however, occurred at stresses considerably below the intrinsic electric strength. The discharge sequence and the rate of dielectric deterioration were both affected by the amplitude, frequency and wave form of the applied voltage.

The numerous factors which affected the electric strength of insulation emphasised the need for tests which simulated service conditions. The thermal and impulse electric strengths could be determined with some certainty, but there was no reliable test for the maximum safe operating stress in the presence of internal or surface discharges. The principal factors affecting the rate of deterioration and time to breakdown were: the ratio of the applied voltage to the discharge inception value; the waveform and frequency of the applied voltage; the magnitude and energy of the discharges; the resistance of the material, first to erosion and breakdown caused directly by the discharges, and secondly to chemical attack by by-products generated by the discharges; and the electrical and chemical characteristics of the ambient medium. The rapid decrease in life with voltages above the inception value showed the danger of alternating over-voltage proof tests, which although indicating no defect might cause considerable deterioration by discharges. To ensure infinite life, equipment should be operated at alternating voltages below the inception value, but this might be too conservative for economic operation.

BREAKDOWN OF POLYTHENE AND POLYSTYRENE.

A paper on "The A.C. Breakdown of Polythene and Polystyrene" was presented by Mr. H. G. Riddlestone. This gave accounts of tests made to determine the electric strength of polythene when subjected to a 50-cycle alternating electric stress at temperatures between — 196 deg. C. and 17 deg. C., and of polystyrene at temperatures between — 196 deg. C and 70 deg. C. The alternating-current breakdown strengths were found to be lower than the corresponding intrinsic strengths at room temperature and above, particularly with polythene, but no difference was observed at low temperatures. In measurements in which this lowering occurred the results were dependent on the duration of the stress application.

A paper by Dr. B. Salvage on "The Impulse Breakdown of High Voltage Cables of the Solid and Gas-Cushion Type" stated that the impulse strength of both solid and gas-cushion cables was about 1,000 kV per centimetre and, in both cases, was practically independent both of the insulation thickness and the conductor size. In gas-cushion cables, it was also independent of the gas pressure. Evidence further showed that the impulse breakdown voltage of solid-type cables had large margins over the usually specified impulse withstand voltages and that reductions in impulse strength were unlikely to be serious under normal operating conditions. On the other hand, the impulse breakdown voltages of gas-cushion cables had a much smaller margin over the usual impulse withstand levels, owing to their higher working stresses; and in the design of cables of this type adequate impulse strength could be a limiting feature. Reasons were given for supposing that the impulse strength of both types of cable was primarily dependent on the impulse strength of the impregnating compound in the gap between adjacent turns of the first paper tape and was independent of the insulation thickness and conductor size.

(*To be continued.*)

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 406.)

WE continue below our report of the 1953 Spring Meeting of the Institution of Naval Architects, held on board the Wellington, headquarters ship of the Honourable Company of Master Mariners, Temple Stairs, London. On the conclusion of the address delivered by the President (Viscount Runciman of Doxford), the first of the nine papers was presented and discussed. It was presented by Dr. J. F. C. Conn, Mr. H. Lackenby, M.Sc., and Mr. W. P. Walker, and dealt with "The B.S.R.A. Resistance Tests on the Lucy Ashton." A summary of the paper is given below.

RESISTANCE TESTS ON THE "LUCY ASHTON."

The paper dealt primarily with the correlation of the measured full-scale resistance of the ship with the results of tests carried out on a series of six geometrically-similar models, ranging in length from 9 ft. to 30 ft. (The length of the actual ship was 190 ft. 6 in.) The translation of the model results to those of the full-scale ship was effected in the usual manner, using Froude's skin-friction coefficients, and also by several more recent skin-friction methods of formulation, namely, the Schoenherr skin-friction line, the Prandtl-Schlichting skin-friction line, and the Telfer extrapolator. The scope was restricted to correlation on the basis of resistance for the four naked-hull conditions under which the resistance of the ship was measured, these being with sharp seams and a surface of red-oxide paint (which was the normal service condition of the hull); with faired seams and a coating of red-oxide paint; with sharp seams and a coating of bituminous aluminium paint; and with faired seams and aluminium paint. The last-mentioned was the smoothest of the four hull surfaces tested. The paper contained a discussion of the various corrections which had to be applied to the ship results, and also an analysis of the measurements of the hull surface roughness made on the actual ship. Full details of both the ship tests and the model results were given in an appendix, these including a tabulation of the full-scale ship results, a tabulation of the model results, and the correction of the model results for tank-boundary effects.

On the basis of Schoenherr's formulation, the results for the 9-ft., 12-ft., 16-ft. and 20-ft. models showed a good correlation among themselves, except that those for the 9-ft. and 12-ft. models were slightly high at low speeds. The results for the 24-ft. and 30-ft. models also came into line on this basis, but only after correction for tank-boundary effects and, in the case of the 30-ft. model, after a small additional correction for the effect of shallow water on the wave-making resistance. It was pointed out that the tank-boundary effect was encountered only in the tests made at No. 1 tank at Teddington, which is 30 ft. wide and 11 ft. 6 in. deep. "Subject to the above," the authors stated, "all models give, within the limits of experimental error, a unique smooth-ship prediction on the Schoenherr basis"; generally less than the measured full-scale resistance in all four hull conditions. The roughness allowance which had to be made was not constant over the speed range, but showed a general rise up to a speed of about 13 knots and then fell away. Even in the case of the smoothest surface (faired seams with aluminium paint) it amounted to 0·00013 of the frictional resistance coefficient, showing that the hull was not hydraulically smooth. The allowance for sharp seams and red-oxide paint was 0·00030; the American Towing Tank Conference, the paper recalled, recommended 0·00040 for "clean, new, vessels." The shell-plate butts in the Lucy Ashton however, were finished flush. The Schoenherr predictions from the individual models, compared with the full-scale resistance, were about 10 per cent. high for all except the 9-ft. and 12-ft. models, which were 19 per cent. and 14 per cent. high, respectively.

In the case of the Prandtl-Schlichting formulation, the smooth-ship predictions were almost identical with those derived by the Schoenherr method. When using the Telfer formulation, the authors stated, "the model results do not follow Telfer's basic two-dimensional extrapolator but align themselves on an extrapolator of noticeably less slope, which appears to be in conflict with Telfer's views on this subject"; extrapolating to the full ship, using the extrapolator slope suggested by the model, gave a smooth-ship prediction somewhat higher than the Shoenherr result. With Froude's formulation, it was found that, at speeds below about 11 knots, there was a wide variation in the predictions from the various models; generally, they over-estimated the measured ship resistance by amounts from 3½ to 20 per cent., compared with the smoothest-ship condition (faired seams and aluminium paint). The scatter of the predictions was "appreciably greater" than with the Schoenherr method. With increasing speed, however, the variation in the predictions became less and, except for the 9-ft. model, followed the full-scale resistance closely. The predictions for the 16-ft. and 20-ft. models were almost identical and, at 12 knots and over, agreed with the measured ship resistance (faired seams and aluminium paint) to within about 1 per cent. For sharp seams and red-oxide paint, the ship results were about 5 per cent. higher than for the model—i.e., about as much as the allowance normally used for a clean painted ship surface in predicting resistance from model tests. The effect of the standard trip-wire on the model resistance was generally small, the maximum being 2 per cent. The use of a trip-wire, ½ in. in diameter, on the actual ship had shown an increase of about 3 per cent. in the resistance at low speeds and about 1½ per cent. at higher speeds. The correlation between model and ship for the effect of the trip-wire was very close. Analysis of the roughness records taken on the two paint surfaces used (aluminium, and red oxide) indicated that there was no simple roughness parameter which could be used to define the surface.

In their general conclusions, the authors said that "the parallelism of the cross-curves of constant Froude number on the extrapolation diagram would appear to indicate that, as far as the family of geometrically similar models is concerned, Froude's law of comparison has been vindicated as regards the scaling-up of wave-making resistance in the usual manner," and that "this can be extended to include the measured ship resistance, subject to the acceptance of the roughness allowances discussed," implying that, over the range of models tested, the interference between skin-frictional and wave-making resistance was negligible. It appeared, however, that the skin friction of models and ships was not the same as that of a corresponding plane surface of equal length and wetted area; a subject which was "considered sufficient to warrant serious consideration." Of the skin-friction formulations used, those of Schoenherr and Prandtl-Schlichting appeared to be the most compatible. The effect of tank boundaries seemed to be greater than was generally realised "and merits more rigorous investigation"; in effect, it limited the length of models to 20 ft. at the No. 1 tank at Teddington, if the effect on resistance was not to exceed 1 per cent. The authors concluded that the results recorded in ship-and-model correlation applied particularly to ships of about the length of the Lucy Ashton; for generalisation, it would be necessary to confirm the results from similar experiments on ships of other lengths. They added: "It is hoped that further investigations on these lines will be carried out in due course."

DISCUSSION.

Mr. V. G. Shepheard, the Director of Naval Construction, Admiralty, who opened the discussion, complimented the authors, Sir Maurice Denny, the British Shipbuilding Research Association, and all who had contributed to the excellent work described in the paper, saying that it marked an epoch, in the *Transactions*, on the subject of ship-model correlation, which was opened by Froude's experiments on the Greyhound, 80 years before. There were still some problems to be solved, but there was no doubt that this comprehensive paper represented a considerable stride forward. The Lucy Ashton tests were carried through with great precision in the full light of all the developments in theory and experience since the pioneer investigation of Froude. The conclusion that Froude's law of comparison had been vindicated as regards wave-making resistance and, subject to the roughness allowance, as regards skin friction, was noteworthy. Few would quarrel with the complete consolidation of the fruits of experience since Froude's day. It was a wonderful tribute to the work of that great pioneer—published, appropriately, in the year in which the Institution had taken steps to arrange for a memorial to be erected to his memory and genius. It was instructive to compare the authors' conclusions with those derived from the Greyhound. Froude claimed* that: "The comparison therefore between the Greyhound ship and the Greyhound model certainly throws no doubt on, if it does not conclusively verify, the law of comparison between ships and models, the discrepancy which it presents being only such as might arise in comparing the performances of any given ship under two different conditions of skin." One distinguished contributor to the discussion at that time had remarked that the law of comparison was shown to be "pretty nearly accurate"; the authors of the present paper had shown how remarkably true the law was. Froude's reference to the importance of the condition of hull surface was prescient. The effect of the deteriorated condition of the hull surfaces of the Greyhound was not so large as was implied by the 1874 paper. Shortly after the trials, Froude arranged for two sets of model experiments. One disposed of the suggestion that the mutual reaction of the towing ship Active had any sensible influence on the true resistance of the towed ship Greyhound; the other was to test the importance of the surmise that the resistance of Greyhound had been augmented by the shallowness of the water. The test proved this was so, and to an appreciable extent. Neither of those uncertainties arose in the Lucy Ashton test.

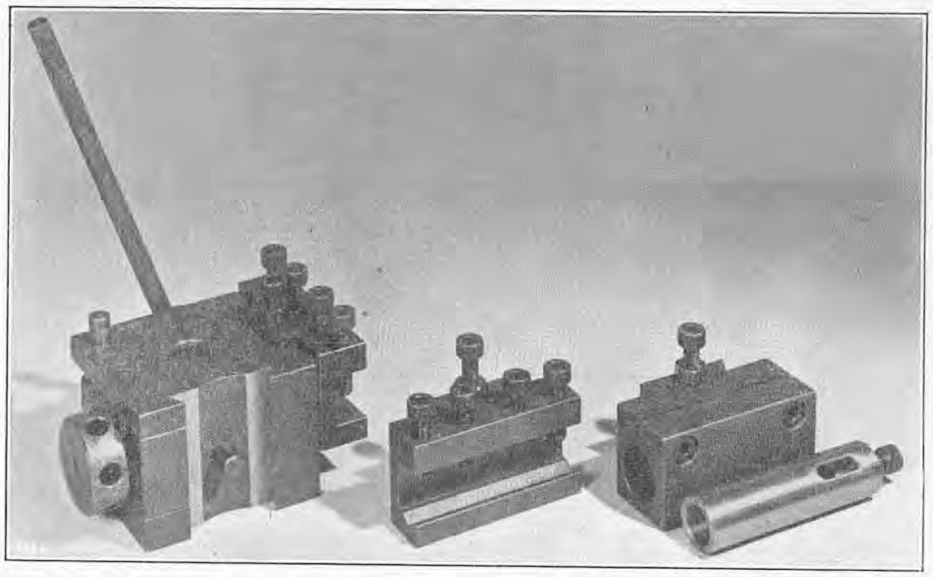
A third point, perhaps of less importance, had recently come to the speaker's notice. The bilge keels were removed for most of the trials on Greyhound, to compare with the condition of the model. Unfortunately, no record could be found of the constructional details of the keels, but apparently the practice was for the bilge keels of sheathed ships to be made of wood, and for the solepiece adjacent to the hull to be of greater thickness than that of the hull sheathing. It was probable, therefore, that when the keels were removed there remained a small projection over the general line of the hull surface, which might have resulted in some increase of resistance due to flow of water across the exposed edges of the solepieces. The information on the roughness measurements of the hull of Lucy Ashton was very complete and the correlation with the resistance measurements was one of the most useful aspects of the paper. The smooth surface obtained with aluminium paint appeared to be of a high standard, but it would be helpful if the authors could give any information as to the standard of smoothness for ships generally, and the scope for improvement. Presumably, if it were practicable for the hull surface to be refined and maintained similar to that of a propeller, the skin friction would be appropriate to the smooth turbulent line and an appreciable reduction in hull resistance would follow. The authors had sounded a note of warning against generalisation of the results, pending confirmation for ships of different lengths. The Greyhound was launched in 1859 and the Lucy Ashton nearly 30 years later. Both were ships of old types and both were short. The Lucy Ashton was tested at a relatively high speed, but many ships were longer and faster. Mr. Shepheard strongly commended the suggestion that the work be followed by tests of ships of other sizes and speeds, but had to admit that he did not know where the money for the work could be found.

(*To be continued.*)

RECORD FORD OUTPUT.—During March the Ford Motor Co., Ltd., Dagenham, produced 20,082 vehicles, which represents 100 units built in every hour of each working day and is the highest output ever achieved by this company. Nevertheless, they claim that this rate of production is still insufficient to meet their incoming orders from both the home and export markets.

* Trans I.N.A., vol. 15, page 36 (1874).

LATHE TOOL-POST FOR MULTIPLE TOOLS.



LATHE TOOL-POST FOR MULTIPLE TOOLS.

THE "Bar-Mor" precision tool-posts for lathes with centres from $3\frac{1}{2}$ in. to $15\frac{3}{4}$ in., one of which is shown in the illustration herewith, are made in France, and the agents in this country are Equipu Machine Tool Company, Limited, 27, Chancery-lane, London, W.C.2. It was exhibited by them at the Factory Equipment Exhibition mentioned in our issue of March 27, on page 404. The tool-post has been designed to save time in tool setting, changing and re-setting, and it is claimed that the holder gives increased accuracy of work and enables a large number of tools to be kept ready for any operation without the need for completely resetting the tool, thereby assisting in reducing production times and costs.

The tool-post is made of high-tensile steel and is hardened and ground on the working faces. A hole through the centre is provided for bolting the post to the compound rest, and two dovetail slots, one on each of two adjacent faces, carry the tool holders. The bearing surfaces of the slots are finely ground and at the centre of each slot is a fixed pin on which the height adjusting screw of the tool holder locates. On the side of the holder next to the slot is a loose piece hinged at one corner; through the centre of it is a clamping screw with six holes drilled in the head to facilitate turning with a tommy bar. One-sixth of a turn of the clamping screw is said to be sufficient to move forward the loose piece that comprises the greater part of one edge of the dovetail slot, so that it secures the tool holder. The two dovetailed slots are for tools mounted at right angles to each other. It is intended that the compound rest, or a plate specially fitted to it, shall be drilled to ensure correct relocation of the tool-post, and should the post have to be removed after setting-up a locating pin is provided for re-locating; this pin can be seen in the left-hand corner of the tool-post in the illustration, in a raised position; it is normally pressed down into the locating hole prepared for it.

Tool holders for most types of tools are made; the standard holder is similar to the box type of holder, and four "Allen" type screws are used to hold the tool in position. An Allen screw with a lock-nut is screwed into the rear of the dovetail, as shown in the illustration, and its nose rests on this fixed pin; adjustment of the Allen screw gives the height adjustment of the tool. A number of tool holders can be prepared with duplicate tools before starting a turning job. The position of the tool post is not altered, so that no wear takes place on it and the tools will always be maintained at the same setting. For boring bars and round tool shanks, bushes are made with an adjusting screw at one end to assist in setting. The tool-post illustrated is for lathes of $5\frac{1}{2}$-in. to $6\frac{1}{4}$-in. centres.

THE IRON AND STEEL INSTITUTE.

THE 84th annual general meeting of the Iron and Steel Institute will be held on Thursday and Friday, April 30 and May 1, at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1. It will be preceded, on Wednesday, April 29, by a special meeting, on "Boron in Steel," which was to have been held on February 18 but was postponed. This meeting has been arranged by the Institute at the suggestion of the Ministry of Supply, acting in conjunction with the Organisation for European Economic Co-operation (O.E.E.C.).

The special meeting on boron opens at 9.45 a.m. on April 29, when Dr. H. Rohl will present, in full, a paper on the "Manufacture of Boron Steels." This will then be discussed from 11.15 a.m. to 12.45 p.m. After the luncheon interval, at 1.45 p.m., a paper on "The Use of Boron Steels" will be presented, in full, by Mr. H. B. Knowlton, and a second paper on "The Effect of Boron on the Mechanical Properties of Low-Alloy Steels," will be presented in summary by the author, Mr. R. Wilcock. From 3.15 until 4.45 there will be a discussion on the use of boron-bearing steels.

On the first day of the annual general meeting of the Institute, Thursday, April 30, the proceedings will commence at 9.45 a.m., when the report of Council and statement of accounts will be submitted and the Bessemer Medal and other awards will be presented. At 10.30 a.m., the retiring President, Captain H. Leighton Davies, C.B.E., will induct the new President, Mr. James Mitchell, C.B.E., into the chair and the new President will deliver his presidential address. Two papers will then be presented, namely: "Train Arrivals, Handling Costs and the Holding and Storage of Raw Materials," by Mr. M. D. J. Brisby and Mr. R. T. Eddison, and "Railway Traffic of the Appleby-Frodingham Steelworks," by Mr. E. R. S. Watkin.

At the afternoon session, from 2.30 to 5 p.m., five papers will be discussed. These comprise "Developments in the Rolling of Broad-Flange Beams at the Cargo Fleet Iron Company, Limited," by Mr. G. Barry Thomas; "The Speed Dependent Variables in Cold Strip Rolling," by Mr. R. B. Sims and Mr. D. F. Arthur; "Performance of Hydrodynamically Lubricated Roll-Neck Bearings," by Mr. R. B. Sims; "Control of Strip Thickness in Cold Rolling by Varying the Applied Tensions," by Mr. R. B. Sims, Mr. J. A. Place and Mr. P. R. A. Briggs, and "Works Trial of the 'T' Method of Automatic Gauge Control," also by Mr. R. B. Sims, Mr. J. A. Place and Mr. P. R. A. Briggs.

At 7 for 7.30 p.m., a members' dinner will be held at Grosvenor House, Park-lane, London, W.1.

On the second day of the annual general meeting, Friday, May 1, six papers will be presented at the morning session, from 10 a.m. to 1.15 p.m., namely: "The Quench-Ageing of Iron," by Dr. A. L. Tsou, Dr. J. Nutting and Dr. J. W. Menter; "Effect of Quench Ageing on Strain Ageing in Iron," by Professor A. H. Cottrell and Dr. G. M. Leak; "Review of Literature on Temper Brittleness," and "Some Aspects of Temper-Brittleness," both by Mr. B. C. Woodfine; "Temper-Brittleness in Some High-Purity Iron-Base Alloys," by Mr. A. Preece and Mr. R. D. Carter; and "Effect of Arsenic and Antimony on Temper Brittleness," by Professor G. W. Austin, Mr. A. R. Entwisle and Mr. G. C. Smith.

At the afternoon session, from 2.30 to 4.30, five papers will be presented, namely: "The Formation of Bainite" and "Effects of High-Temperature Heating on the Isothermal Formation of Bainite," both by Dr. T. Ko and Dr. S. A. Cottrell; "Thermal Stabilisation of Austenite in Carburising Steels," by Dr. H. M. Otte and Dr. T. Ko; "Line-Broadening of Martensite in Nickel Steels," by Dr. R. A. Smith; and "The Deformation of Austenite in Relation to the Hardness Characteristics of Steel," by Mr. G. R. Bish and Professor H. O'Neill.

THE INSTITUTE OF METALS.

(*Continued from page* 438.)

We continue below our report of the symposium on "The Control of Quality in the Melting and Casting of Non-Ferrous Metals and Alloys," arranged by the Metallurgical Engineering Committee of the Institute of Metals and held on Wednesday, March 25. The discussion was based on six papers, and abstracts of the first three of these appeared last week. We now deal with the last three papers and with the discussion.

Control of Quality in Melting and Casting Non-Ferrous Materials.

The fourth paper in the symposium, on "The Control of Quality in the Production of Brass Ingots and Billets," was by Dr. Maurice Cook and Mr. C. L. M. Cowley, of Imperial Chemical Industries, Limited, Metals Division, Birmingham. These authors stated that the successful control of quality depended vitally on the adequacy of supervision, the object of which was essentially to ensure that agreed and defined procedures were, in fact, meticulously carried out. Virgin metals, at present, were of such uniform quality and purity that it sufficed to take representative samples from each delivery for the determination of impurities by suitable analytical methods. The raw material most likely to give rise to compositional variation and excessive impurities in the cast product was scrap brass, which was extensively used. Most of the brass produced for manufacture into wrought forms was now melted in low-frequency furnaces. Units having melting capacities of from 600 to 2,400 lb. per hour were in common use, and, recently, furnaces of 10,000 lb. per hour capacity had been built.

In the majority of brass alloys, defects arising from the inclusion of oxides in the molten metal were not of common occurrence. Alloys containing additions of elements such as aluminium and silicon, however, were exceptions, and care was necessary at all stages to avoid turbulence or other conditions liable to result in the formation of the oxides of these metals and their inclusion in the molten bath. Surface quality, structure, and, to a large extent, the internal soundness of a casting were determined by the conditions which existed before, during, and immediately after the casting operation. These conditions, such as pouring temperature, type and condition of the moulds, mould dressing, rate of pouring, and method of feeding, were determined for each alloy by metallurgical considerations and by the form and size of the castings.

Mr. R. G. Wilkinson and Mr. S. B. Hirst, of Magnesium Elektron, Limited, Manchester, were the authors of the next paper, entitled "The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working." They dealt with the three principal types of alloy used for wrought purposes, namely, the magnesium-manganese, the magnesium-aluminium-zinc-manganese, and the magnesium-zirconium-zinc alloys, and stated that, as in many other industries, the control of quality rested very largely upon the employment of experienced and conscientious operatives. All operatives concerned were paid on time rates only. The functions of control and inspection were the responsibility of the metallurgical research department.

The sixth, and last, paper of the symposium dealt with "The Control of Quality in the Casting of Zinc and Zinc-Alloy Rolling Slabs and Extrusion Billets." It was by Mr. C. W. Roberts and Mr. B. Walters, of the Imperial Smelting Corporation, Limited, Avonmouth, who stated that the ideal requirements of zinc rolling slabs included, in the first place, uniformity of composition throughout the slab. Secondly, the composition must be such that the required properties can be obtained in the final product. Thirdly, the composition must be such that mechanical working can be carried out with the maximum efficiency. Fourthly, the slab must be free from impurities that cause high-temperature embrittlement. Other requirements were that the slabs must be free from dissolved gas and internal defects and their surfaces must be continuous and also free from defects. It appeared that a greater variety of methods were employed for the production of rolling slabs in zinc than in any other metal. The method of casting most commonly employed in the zinc-alloy industry, however, was that involving the open-top horizontal mould. Nevertheless, other methods of casting, such as those involving a vertical mould, allowed of a higher degree of control in the casting operation, and consequently, such methods were adopted when consistency in slab quality was of primary importance.

Virtually, all the extrusion billets cast in this country were used for the production of rod which was subsequently drawn to wire for use in the zinc-spraying process or, in finer gauges, for the production of woven brake linings. From the point of view of the control of quality, the main problem in billet casting was to prevent the occurrence of secondary piping, namely, piping in the lower portions of the billet. Primary piping could be prevented usually by feeding from a hand ladle, an operation that required some degree of skill.

Mr. N. I. Bond-Williams, who acted as *rapporteur*, said that no one in industry could overrate the importance of the control of quality in manufacturing operations. Regardless of its other attributes, no product could be sold unless the consumer was satisfied that its quality was suitable to his need. Subsequently, he would consider price and availability, but above all, the quality must be right.

In his paper, "The Principles of Technical Control in Metallurgical Manufacture," Dr. A.R.E. Singer had dealt with the overriding considerations of quality control. Having established that control of quality could be effective only when the elements of quality had been standardised and rendered capable of numerical measurement, he showed that the fixing of tolerances had a most important bearing on the economics of the manufacturing process, a concept stated most concisely in a British Standard specification, B.S. No. 600, which defined the level of control thus: "The level of control specifies quantitatively the nature of a statistically uniform variation to which the quality of the material or manufactured article is subject. In a manufactured article it is dependent on the producer's mastery over technical processes of manufacture and the economic factors governing their exercise."

Turning to the other papers, Dr. Cook and Mr. Cowley attached importance to the control of composition, inclusions, gas absorption, temperature, metal losses during melting, and the control of mould dressing and the method of feeding during casting. Mr. Sykes emphasised the control of furnace atmospheres and temperatures, the control of oxygen content in the molten metal and the timing of additions in melting, the quality control of the mould-dressing material, the control of the liquid stream and the avoidance of turbulence in casting, and the details of the final quality test, namely, conductivity measurements under standardised conditions. Mr. Roberts and Mr. Walters emphasised crystal orientation as a major quality factor, allied with freedom from porosity and accurate shape, with smooth surfaces. They suggested that control was essential to reduce turbulence in feeding, to prevent shrinkage and to regulate the direction and rate of heat flow in the mould. Mr. Staples and Mr. H. J. Hurst applied all the usual controls, such as those for composition and temperature, but paid most attention to the control of gas absorption in the furnace, turbulence, and the pick-up of oxide and other non-metallic inclusions. Mr. Wilkinson and Mr. S. B. Hirst were almost equally interested in the control of turbulence, but concentrated even more on the control of fluxes and protective gases during melting, and described an unusual method of producing and controlling the zirconium content of magnesium-zinc-zirconium alloys. It was interesting to note that, in the paper on magnesium, D.T.D. specifications were referred to as a matter of course; in the paper on aluminium, British Standard numbers; in the zinc paper, a series of commercial and proprietary alloys; in the copper paper, international annealed copper standards for conductivity; and in the brass paper, commercial alloys only.

In addition to the discussion of control of quality, there were some novel and interesting metallurgical theories which would certainly attract attention. One in particular was the contention of Mr. Staples and Mr. Hurst in favour of duplex melting furnaces, long tranquil holding periods, and the elimination of the now customary degassing treatment of aluminium alloys. In some respects this seemed to be supported by Mr. Wilkinson and Mr. Hirst, who took great care to avoid oxide inclusions by reducing turbulence at every stage. Mr. Sykes revealed that the problem of melting copper in Ajax-Wyatt furnaces had been overcome. He might be questioned on his omission of casting methods for chromium-copper, an alloy of growing importance to which he referred at one point in his paper. There was one thing on which all the authors were agreed, namely, the effect of the skilled man's activities on the success or failure of the processes. Although more of a management subject than a metallurgical one, it was interesting to see that detailed attention was being paid to process manuals, operator's instructions, the organisation and control of people as well as of equipment, and their education and training.

Discussion.

Mr. Christopher Smith, who opened the discussion, stated that he agreed with Dr. Singer that metallurgists could not afford to ignore the importance of statistical analysis, and indeed the histogram had become a fashionable and useful adjunct to their technique. It was doubtful, however, whether it was feasible or practicable to apply, to a range of manufacturing operations involving the human factor, a system which worked satisfactorily in a purely mechanical process such as the production of turned parts in a capstan lathe. The cost of assembling all the relevant facts would be prohibitive. It was to be expected that during this discussion some reference would be made to craftsmanship. Surely this had some place in the general scheme of things related to quality control? In the field of toolmaking for extrusions, for example, the quality of the products largely depended on the deftness and instincts of the toolmakers. It was interesting to observe that supersonic testing had not yet invaded the brass industry. It was clear from the paper by Dr. Cook and Mr. Cowley that here was a metal which was relatively easy to cast, but one with which control was none the less essential for high quality and economic production. Mr. Sykes referred to the difficulties arising from segregation effects in producing castings for cadmium-copper products. He said that the cadmium-copper must be poured hot. He (Mr. Smith) would have thought that this would accentuate the extent of the segregation, and that the lowest practicable temperature would be preferable.

To all employed in aluminium foundries, the control of gas content and of oxides or other non-metallic impurities was of prime importance. As one who had hitherto had faith in the need for a specific de-gassing treatment, he was reluctant to believe that keeping the metal for a prescribed period in a holding furnace would make it possible to produce castings entirely free from porosity. In the case of rolling slabs, for example, the presence of even minute amounts of porosity might have quite disastrous effects.

Mr. G. L. Bailey stated that a variable could only be directly controlled if it could be directly measured. What was wanted was an ingot of good surface and of the right grain size, and the only variable which could be directly measured and corrected appeared to be composition. Mr. Staples and Mr. Hurst had shown how the direct-reading spectrograph was used in the aluminium foundry, and there was every prospect that, in the very near future, the same type of instrument, suitably modified, would be used in copper and copper-alloy foundries; but to use this instrument regularly it was necessary to have fairly large melts and to be able to hold them for a few minutes while checking the composition and putting it right if it were wrong. Moreover, it was necessary to have large outputs to justify the expense of an instrument which cost something like 30,000 dols.

Mr. E. A. Bolton said that several speakers had already referred to control at the early stages, and that was of great importance, because, at the casting stage, comparatively little had been spent on the product. At that stage, therefore, a great deal more could be spent on inspection than at later stages, so as to ensure that defective castings were not passed forward. He would like to have the opinion of members on what form that inspection should take.

Dr. W. G. Hiscock said that while he would in no circumstances detract from the excellent work which was in progress in improving quality by better technological practices in manufacture, by research, by better methods of examination or by the use of statistical quality control in inspection, his view was that the first essential was to produce in the manufacturing teams the highest morale possible, with the attendant desire in all concerned to produce the highest possible quality.

Mr. F. Kasz stated that an impressive feature of all the papers lay in the fine limits to which the impurities were controlled on an industrial scale. The light alloys were no exception. It was a little surprising, in view of the admitted importance of temperature, that there was no mention in the papers of thermostatic control, which was commonly practised in the light-alloy industry. It was true that the restrictions of former years on different types of furnace for melting aluminium had disappeared with growing knowledge. Equally satisfactory quality could now be produced from a wide variety of furnaces.

Mr. J. E. Newson stated that in his own experience, extending over about thirty years, an endeavour had always been made to control, with a fair measure of success, the chemical composition of the melt, the structure of the ingot, the properties of the ingot, and the external characteristics of the ingot. Considerable attention was given to such details as rate of pouring, temperature of pouring, and mould dressing, to secure the result desired. That was not to say that there was no scope for considerable further improvement beyond the reasonably high standard which had now been achieved in the casting process. He had found great difficulty in getting a suitable sheath for a continuously-immersed thermocouple, of the type mentioned by Dr. Cook and Mr. Cowley. The difficulty was to find one sufficiently robust to stand up to continuous immersion. The authors used a sheath of iron-chromium alloy containing 28 per cent. chromium, but even with this alloy the life seemed to be relatively short. Did any serious iron contamination of the melt arise from this source? For billet moulds his firm had gone over entirely to water-cooled copper-lined moulds, and the results had been remarkable.

Dr. Singer, replying, said that it might be possible to clear up doubts which had been voiced by some of the speakers. It should be explained that his paper was essentially looking to the future. By that he meant that all the data put forward and all the suggestions made were not necessarily applicable straightaway to metallurgical industry, but after some thought and a little development work there was the possibility that different methods of control could be used in very many instances.

(*To be continued.*)

LABOUR NOTES.

A public investigation is to be made into the dispute between the National Union of Vehicle Builders and the Austin Motor Company, Limited. The Minister of Labour, Sir Walter Monckton, announced in the House of Commons on April 2 that he had decided to set up a court of inquiry and that the chairman of the court would be Sir John Forster, Q.C., the chairman of the Industrial Court. The other members, Sir Walter stated, would be Mr. A. J. Espley, formerly managing director of Messrs. Timothy Whites and Taylors, Limited, and Mr. A. G. Tomkins, general secretary of the National Union of Furniture Trades Operatives. It was announced on Wednesday that the court would commence its sittings in London next Tuesday and that its evidence would be taken in public.

Requests for the formation of a court of inquiry into the dispute were originally made to the Minister by the National Union of Vehicle Builders. Courts of this nature, established in accordance with the provisions of the Industrial Courts Act, 1919, have power to take evidence on oath, but they cannot make binding decisions and their recommendations are open to acceptance or rejection by the parties to a dispute. It may be recalled, however, that when the union's request was first received by the Minister, conciliation officers from the Ministry immediately approached the Trades Union Congress General Council and the Austin Motor Company for their views. No doubt the replies of these bodies were such as to encourage the Minister to proceed with the setting up of a court of inquiry.

Some 2,300 members of the N.U.V.B., employed at the Austin Motor Company's Longbridge works at Birmingham, came out on strike on February 17, owing to the alleged refusal of the company to re-employ a shop steward. This man was one of 750 employees dismissed on redundancy grounds last September. The strike had the support of the men's union and many thousands of employees at Longbridge belonging to other unions were rendered idle. During the first five weeks of the dispute, several hundred vehicle builders returned to work, which materially reduced the overall unemployment. On March 27, the company dismissed the remaining 1,583 vehicle builders, on the ground that they had ignored an ultimatum to return, and announced that it considered the strike to be at an end. A mass meeting of these men was held in Birmingham on Wednesday.

The wide differences which exist in the earnings of engineering employees throughout the country have led to repeated demands for a new wage structure in the industry. In September, 1948, for example, a court of inquiry into a dispute in the industry expressed the opinion that the establishment of a new and simplified wage structure, consolidating basic rates and bonuses, was highly desirable. In 1949, the Confederation of Shipbuilding and Engineering Unions put the case for a new wage structure to the Engineering and Allied Employers' National Federation. The Confederation's proposals would have meant substantial increases and were, therefore, not too well received by the Federation. Before detailed negotiations could take place, however, both sides became involved in a claim for higher wages all round.

Since 1948, time rates have been consolidated, by the merging of basic rates and bonus additions into one wage rate, and the differences between district rates have been reduced. There are now minimum time rates of 6*l*. 16*s*. 4*d*. for skilled men and of 5*l*. 18*s*. 4*d*. for unskilled men for a week of 44 hours. The skilled pieceworker of average ability should be able to earn at least 45 per cent. above the old basic rate of 3*l*. 6*s*., plus 1*s*. 2*d*. an hour for bonus additions, which amounts to 7*l*. 7*s*. 1*d*. for a week of 44 hours. Unskilled pieceworkers of average ability should be able to earn 45 per cent. above their basic rates of 2*l*. 11*s*., plus 1*s*. 2*d*. an hour, which gives them a return of 6*l*. 5*s*. 4*d*. for 44 hours. There are many differences between districts, however. In London, for instance, the skilled time-worker receives 4*s*. 7½*d*. above the minimum, and the unskilled time-worker, 3*s*. 1½*d*. above the minimum. Pieceworkers in London get corresponding amounts above the minimum basic rates.

The labour correspondent of *The Times*, in an article in last Tuesday's issue, refers to these matters at some length. He states that the criticisms usually made against the existing system are that piecework wages are too complicated and should be consolidated, that there are no national rates for semi-skilled employees, that the piecework incentive is too low, that the differential for skill is insufficient, and that present variations between district and district are unjustified. It has to be realised, he points out, that, in practice, relative earnings bear little relation to the structure on which they are based. The differentials for piecework and for skill are, in fact, much higher, and the differences between one district and another are much greater; while semi-skilled employees, in some cases, have agreed district rates, and, in the great majority of cases, have accepted factory rates.

The whole wage structure in the industry has been pulled out of shape by the efforts of competing employers, during and since the war, to draw scarce labour into their establishments. To consolidate piecework wages is not as simple as it appears to be. The Confederation has suggested a grading system which would include three grades for semi-skilled operators, in addition to one for labourers and two for skilled men. The employers consider that the variety of machines and of skill and dexterity is so great that they are not able to find any formula to cover them all. For similar reasons, they have rejected a grading system for women.

Attention has also been called by the employers to the immense task of re-assessing thousands upon thousands of jobs all over the country at one time. Employers seem to feel, *The Times* labour correspondent states, that the industry is obtaining its fair share of apprentices, but the fact is that there has been for many years, and still is, a shortage of skilled workpeople. In considering the case for a new wage system it is clearly necessary to ask not only whether it is desirable to change the formal wage structure, but also whether it is desirable, or practicable, to change the relation of wages in practice, a very different matter.

Demands for an immediate inquiry by the party into the inefficiency, bad organisation and indifferent management, alleged to predominate in connection with Britain's nationalised industries, were approved at the diamond jubilee conference of the Independent Labour Party, which took place in Bradford at Easter. A resolution stating that trade unionism in Britain was tending more and more to adapt itself to the requirements of "State capitalism," rather than to the needs of the employees, was also given approval.

Concern at the increasing victimisation of trade unionists, and especially at the dismissal of employees taking part in official strikes, was expressed in a resolution passed at the Easter conference of the Association of Engineering and Shipbuilding Draughtsmen, at Morecambe. The conference called upon the Association's executive committee to raise the question as a matter of urgency with the T.U.C. and the Confederation of Shipbuilding and Engineering Unions.

At its meeting in York in March, the executive council of the Confederation of Shipbuilding and Engineering Unions decided that a special meeting of representatives of affiliated unions should be summoned at an early date, in order that attention might be given to the existing wage position in the engineering, shipbuilding, and ship-repairing industries. It is understood that efforts are being made by the unions to have this conference in London on Wednesday, April 29, prior to the dates of their own conferences. This arrangement would enable them consider, at their conferences, the views of the special meeting.

LIGHT-ALLOY BODIES FOR BULK TRANSPORT.

FIG. 1. TIPPING LORRY FOR BULK GRAIN.

FIG. 2. MALT LORRY WITH CLOSED HOPPER BODY.

LIGHT-ALLOY BODIES ON LORRIES FOR BULK TRANSPORT.

THE two vehicles illustrated on this page have demonstrated that, by using light alloys for the bodies, certain commodities can be transported in bulk instead of in sacks, with consequent savings in time and labour. Also, the bodies are designed to suit the mechanical-handling equipment at the dispatching and receiving depots; the smooth and clean interior surfaces facilitate loading and unloading of the contents and do not contaminate them; and, in the case of the grain lorry shown in Fig. 1, its low weight enables it to be registered in this country in the 30-m.p.h. class instead of the 20-m.p.h. class of heavier vehicles.

Vitovis, Limited (the agricultural organisation of Hovis, Limited) are one of a number of firms who have found that their commodity can be transported cheaply in bulk. The cost of the special body is more than offset by the savings in operating and handling costs. Previously, they used flat-platform lorries for conveying sacks of grain from the farms to the mill. With the new tipper lorry (Fig. 1), which holds 7 tons, the grain is loaded through the open top, and emptied at the destination by tipping directly on to a conveyor which carries it to large storage bins. One man now does the work that formerly required three, and the elimination of sacks economises storage space at the mill. The body weighs $7\frac{1}{2}$ cwt., which is estimated to be at least 11 cwt. less than that of one of composite construction. The builders, Locomotors, Limited, Andover, have used materials produced by the Northern Aluminium Company, Limited, Banbury, Oxfordshire, namely, Noral 51S sections and Noral M57S sheet, and the body is carried on a Bedford S-type short-wheelbase chassis.

Cross-bearers, of 3-in. by $1\frac{1}{2}$-in. channel sections, support the floor, which is of 10-s.w.g. sheet. Side pillars are 2-in. by 2-in. by $\frac{1}{4}$-in. angle sections, secured with gusset plates to the cross-bearers below floor level, and joined at their other ends by the top frame members. Panelling of the sides is of 12-s.w.g. sheet and the ends are of 10-s.w.g. like the floor. The open top is bridged by tubular stiffeners, which also serve to support a canvas cover. Grain is normally discharged from the container through the trap shown in Fig. 1, the opening of which is manually adjustable to enable the rate of flow to be accurately controlled to suit the conveyor. For more rapid emptying, the lower half of the rear end is hinged at the bottom, and can be dropped like the tailboard of a lorry; above is a pair of vertically-hinged doors that can be swung wide to give clear access for loading sacks, if required. Care has been taken to maintain a clear, uninterrupted surface inside the container in order to avoid trapping grain and to facilitate cleaning. The accumulation of dust and moisture is minimised and the contents are kept clean and wholesome. The interior is unpainted, and robust construction and the durable materials used ensure low maintenance costs.

The vehicle shown in Fig. 2, which is used for the road transport of malt, has a light-alloy body mounted on a trailer chassis and is filled as well as discharged in the tipped position. The malt is stored in silos and fed into the vehicle from chutes 14 ft. 6 in. above road level. The top leading edge of the container is bevelled at an angle of 45 deg., and a 2-ft. square opening in the centre forms the loading hatch and is provided with a sliding cover. The rear of the container is arranged as a chute with a similar opening placed so as to be horizontal when the container is tipped to 45 deg. For loading, the trailer is towed beneath the silo with the container tipped up; discharging is accomplished in the same position, the receptacle being below road level. The lorry has been built by J. H. Sparshatt and Sons (Portsmouth), Limited, Portsmouth, for Samuel Thompson and Sons, Limited, maltsters, who have found that handling and transporting malt and barley in bulk are much more convenient and less expensive than using bags carried in drop-side vehicles. Not only is the cost of the bags saved, but loading and unloading are much more rapid. Mounting the container on a trailer makes it possible to meet the requirement that the maximum overall height shall not exceed 14 ft. 6 in.; an integral engine and chassis arrangement would not have permitted this. Moreover, a chassis of sufficient size to take the container would have required a larger engine, and a substantial saving in fuel is thus achieved by the tractor that is employed.

With the collaboration in design of the Northern Aluminium Company, the body has been built entirely in Noral alloys. For the framework Noral 51S sections were used. The longitudinal runners and cross-bearers are 4-in. by 2-in. channel sections, and the side pillars are "top-hat" sections $1\frac{3}{4}$ in. deep. To join the sides to the floor and roof, 2-in. by 2-in. by $\frac{1}{4}$-in. internal closing angles are used, with a $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. 135-deg. angle along the top front edge. Panelling is of Noral M57S alloy, $\frac{1}{4}$-in. plate being used for the chute end to withstand the hammering during loading and the high load intensity when the container is full in the tipped position. The rest of the panelling is 10-s.w.g. sheet. The weight of the container is only 16 cwt.; constructed with other materials the weight might have been as much as 30 cwt. In addition to keeping down the tare weight, lightness enables smaller tipping gear to be used; it should be noted that since the body is fully laden in the tipping position, the tipping gear and body have to withstand severe racking. In addition to minimising weight, construction of the container in aluminium has the advantage that the interior surfaces will remain smooth and clean, and risk of infection by moulds or bacteria is practically eliminated.

The main vehicle is a Dodge tractor, type 123, with a Perkins P6 Diesel engine and 35-in. by $7\frac{1}{2}$-in. tyres. It has a five-speed gearbox and an Eaton two-speed back axle, giving ten gear ratios. The drop-frame trailer was built by J. H. Sparshatt and Sons. The 10-in. by 3-in. steel main channels are carried on semi-elliptical springs, of the slip-end type at the trailing end. The tandem axles, supplied by the Dunlop Rubber Company, Limited, have twin wheels with 29-in. by 7-in. low-loading tyres, giving the lowest possible loading height without wheel arches. The overall length of the trailer, with a semi-permanent Tasker coupling, is 19 ft. The brakes, operated by servo mechanism from the tractor, are of the Girling type, and there is a ratchet brake for parking. Jockey wheels are not provided because the trailer is seldom detached from the tractor. The tipping gear is of the "Edbro" twin-ram type, supplied by Edwards Brothers, Limited, Bolton. The tare weight of the complete vehicle, including tractor, is 5 tons 13 cwt.

INSTITUTE OF WELDING AWARD.—Mr. A. D. Barker, foreman of the welding and fitting shops at John Fowler & Co. (Leeds), Ltd., Leeds, 10, has been informed by the Educational Committee of the Institute of Welding that his entry has been awarded the 1952 C. W. Hill competition prize. The presentation will be at Sheffield on May 7, when Mr. Barker will receive a case of drawing instruments and a certificate from the Master Cutler, who will be guest of honour. The competition consisted of re-designing a two-ton cast-iron drilling-machine table for welded fabrication.

THE DESIGN OF BRITISH POWER STATIONS.*

By S. D. WHETMAN, B.Sc., and A. E. POWELL, B.Sc. (Eng.).

(*Concluded from page* 448.)

THE unit system has been adopted for the auxiliary switchgear at all stations, the voltages and other main data of which are given in Table V. The exceptional voltage of 6 kV at Littlebrook "B" is to line up with the "A" station, where that voltage was originally chosen with an extensive development in view. The auxiliary switchgear is installed in chambers outside the turbine houses and at the rear of the boiler houses, with control panels on the operating floor. The switchgear itself, where possible, is placed at operating-floor level for easy access.

TABLE V.—ELECTRICAL EQUIPMENT.

Description.	Blackwall Point.	Earley.	Cliff Quay.	Poole.	Littlebrook "B."
Alternators—					
Rating, MW	30	40	45	50	60
Generation voltage, kV	11·0	33	11·8	11·8	11·8
Cooling	Air	Air	Air	Air	Hydrogen
Ventilating fans	One	Two—80 per cent.	Two—80 per cent.	Two—80 per cent.	Nil
Reactance: sub-transient, per cent.	12·5	16	12·5	12·5	13
Exciters: type of drive	Direct	Direct	Motor	Gear	Motor
Main switchgear—					
Type	Metalclad	Metalclad	Air-blast	Air-blast	Low oil-content impulse
Voltage, kV	33	33	132	132	132
Rating, MVA	1,000	750	2,500	2,500	2,000
Main auxiliary gear—					
Type	Air-break	Air-break	Air-break	Air-break	Oil-break
Voltage, kV	3	3·3	3	3	6
Rating, MVA	150	100	150	150	250 and 150
Low-tension auxiliary switchgear—					
Type	Air-break	Air-break	Air-break	Air-break	Air-break
Voltage, kV	0·415	0·4	0·415	0·415	0·415
Rating, MVA	15	25 and 15	15	15	25
Generator transformers—					
Type (see Note)	OFW	One—OFB	OFW	OFW	OFB
Rating, MVA	34	45	54	58	75
Station transformers—					
Type (see Note)	ON	ON	ON	ON	ON
Rating, MVA	Two 5	Two 5	Two 7·5	Two 7·5	One 10*
Unit transformers—					
Type (see Note)	ON	ON	ON	ON	ON
Rating, MVA	3	3	4	6	6

* Interconnection with "A" station.

Note: OFW Oil-immersed forced oil circulation with water cooling.
OFB Oil-immersed forced oil circulation with air-blast cooling.
ON Oil-immersed natural cooling.

TABLE VI.—OPERATING RESULTS FOR PERIOD JANUARY TO JUNE, 1952

Data.	Blackwall Point.	Earley.	Cliff Quay.	Poole.	Littlebrook "B."
Energy generated, kWh	136,324,120	259,279,700	716,610,000	424,834,000	472,178,000
Energy sent out, kWh	128,231,000	243,913,000	675,413,000	399,161,000	444,430,000
Percentage of energy generated used on works	5·94	5·92	5·75	6·04	5·88
Station capacity, MW	90*	120	225†	150‡	120
Maximum load sent out, MW	58·2	118·7	220·2	149·5	116
Plant load-factor, per cent.	81·4	83·5	89·3	91·2	92·9
Running load-factor, per cent.	67·61	57·9	70·2	61·4	88·4
Total fuel consumed, tons	65,751	124,589·3	347,500	175,658	208,132·5
Pounds of fuel per kilowatt-hour sent out	1·149	1·143	1·152	0·986	1·049
Average calorific value, B.Th.U. per lb.	11,273	11,727	10,963	12,296	10,826
British thermal units per kWh sent out	12,948	13,417	12,634	12,121	11,357
Thermal efficiency (energy sent out), per cent.	26·35	25·43	27·01	28·15	30·04
Boiler efficiency, per cent.	86·48	84·02	82·83	84·9	86·5
Turbine efficiency, per cent.	34·12	32·25	34·62	36·55	37·89
Make-up, per cent.	2·86	1·65	1·19	1·9	1·7
Steam pressure at turbine stop valve, lb. per sq. in.	589§	615·8	606	898	1,257
Steam temperature at turbine stop valve, deg. F.	843	838·2	826	922	842
Back pressure, in. Hg	0·97	1·41	1·01	0·94	1·1
Cooling-water inlet temperature, deg. F.	56	51·7	53	51	55
Cooling-water outlet temperature, deg. F.	70	70·7	64	65	69
Final flue-gas temperature, deg. F.	255	294·5	309	300	312
Station availability, per cent.	80·9	80·55	79·71	71·78	92·55

* Third turbine commissioned April 29. Third boiler commissioned March 17.
† Five turbines and eight boilers in commission.
‡ Three turbines: fifth boiler commissioned March 28.
§ Fine steam strainers in use.

OPERATING ROOMS.

The operating rooms are equipped with those controls which are essential to the running of the power station and are not intended to be used as system-control centres. The only controls provided are therefore those which are essential for operating the generators and dispatching the load. For this reason, the buildings are placed geographically between the station and the 'bus-bar switchgear to provide the shortest length of cabling and for access to the switchgear itself for isolation. The indicators, instruments and control equipment are mounted on the front panels of cubicles (or on a small desk) with the protective relays and voltage regulators on the rear panels. Each generator has a separate cubicle, but feeders and other circuits with less control and protective equipment can be conveniently mounted in pairs. The instruments, switches, terminal boards and relays are of normal switchgear construction; and light current telephone type apparatus is only used for alarm and communication purposes. The generator desk contains the generator speed and excitation controls, and, where appropriate, the transformer tap-change controllers. To meet the demand for more accurate operation to a specified load the generator wattmeters and reactive volt-ampere meters have been in most cases duplicated on the desk. Switching cannot be carried out at the desk, the circuit-breaker control switches and synchronising plug being on the control panel. At some stations, a steam-pressure indicator has been provided in the operating room, although the authors feel that the control of steam pressure is best left to the boiler operator and that the presence of this instrument in the operating room may lead to conflicting action. The turbine gauge boards and boiler-control panels have generally been arranged individually and located conveniently with respect to the associated turbine or boiler. At Littlebrook, however, two boilers are operated as one unit and the instrument panels are arranged side by side in front of the pair of boilers, so that the boiler and turbine operators can see each other without difficulty. Wherever possible, the instruments and controls have been mounted on the vertical face of the panel, but the greater number of instruments required for the reheat turbines at Littlebrook has led to the use of a desk-fronted cubicle designed so as to reduce space. These cubicles are mounted back to back with common instruments, such as tank water-level indicators and circulating-water pump indicators, on the ends.

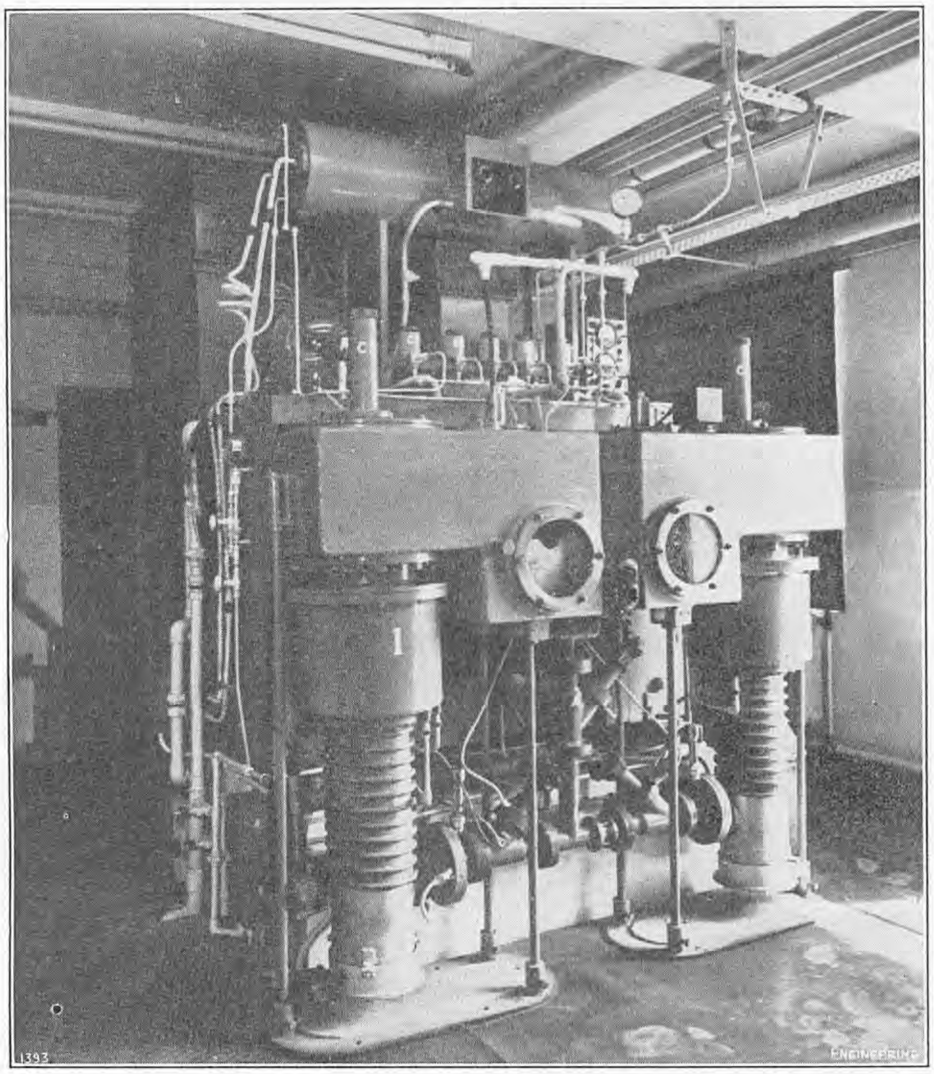
The demand by the staff for increasing numbers of instruments makes it difficult to prevent these panels becoming of unwieldy dimensions, with the result that the operator's task may become more arduous rather than simpler. Overcrowding of instruments to reduce the overall dimensions also leads to congestion behind the panel and reduces reliability. Some simplification can be achieved by omitting signal lamps where ammeters are provided, by using differential and dual-purpose draught

TABLE VII.—*Causes of Reduced Output, January to June,* 1952.

—	Number of Outages.	Total Duration, Hours.	Maximum Load Dropped.	Output Lost.
BLACKWALL POINT.				
Boilers—			MW.	MWh.
Economiser caps	10	218	19	4,150
General	1	24	19	456
Steam and feed ranges	4	137	30	4,846
Turbines and feed heaters—				
Governors	2	63	30	1,890
General	3	52	30	
Construction and manufacturer's maintenance	6	521	30	15,630
EARLEY.				
Boilers—			MW.	MWh.
Overhauls	4	3,600	20	72,000
Milling plant	3	8	10	69
Turbines and feed heaters—				
Overhauls	2	1,672	40	74,880
General	11	335	40	13,400
Alternators and exciters	1	11	40	440
Miscellaneous electrical	1	5	16	80
CLIFF QUAY.				
Boilers—			MW.	MWh.
Limitation of steam range	2	1,279	17	21,690
Steam ranges	2	11	45	495
Turbines and feed heaters—				
Overhaul	1	1,355	45	60,975
General	10	203	45	9,135
Condenser and cooler cleaning	10	261	45	8,785
Condenser leakages and maintenance	11	16	45	2,900
Alternators and exciters	7	136	45	6,120
132-kV switchgear	1	512	45	23,040
Miscellaneous electrical	1	9	45	405
POOLE.				
Boilers—			MW.	MWh.
General	6	43	54	933
Milling plant	3	7	34	222
Turbines and feed heaters—				
General	8	43	50	1,750
High eccentricty	2	27	50	720
Condenser cleaning	1	55	50	2,750
Condenser leakages	9	81	50	3,850
Alternators and exciters	1	47	50	2,350
132-kV switchgear	1	11	95	1,045
Miscellaneous electrical	3	2	50	47
LITTLEBROOK B.				
Boilers—			MW.	MWh.
General	8	362	34	11,488
Milling plant	25	210	34	3,220
Damaged control panels	1	8	105	475
Steam and feed ranges	1	4	35	140
Turbines and feed heaters—				
General	5	94	60	4,955
High eccentricity	5	466	60	10,535
Alternators and exciters	1	10	60	600
132-kV switchgear	1	8	60	480
Miscellaneous electrical	1	87	18	1,566
Chimney inspection	2	44	120	5,280

* Paper read before a joint meeting of the Institutions of Mechanical and Electrical Engineers on Thursday, March 5, 1953. Abridged.

ELECTROMAGNETIC SEPARATION OF ISOTOPES.



gauges, by omitting draught gauges which are of more value to the boiler-maintenance than to the operating staffs and by omitting all recorders and integrators. The last two items can be mounted at convenient positions away from the control panel. Present-day practice is to install all these panels in pairs, in order to facilitate control of two boilers by one operator.

OPERATING EXPERIENCES.

Table VI, opposite, gives the operating results at the five stations during the first six months of 1952, and Table VII gives an analysis of every occasion during the same period when the output was affected by breakdown to plant. In 1951, the boilers at Littlebrook were taken out of commission to add heating surface above the superheaters by cutting and looping the generator tube risers across the top of the boiler. This alteration was made to decrease the primary and reheat steam temperature, which in the initial design could only just be maintained with the superheat attemperator at maximum de-superheat and the reheater by-pass fully open. This difficulty was accentuated by the over-allowance made for temperature drop in the steam pipework to and from the boiler and reheater, which resulted in a corresponding increase in the temperature of the reheated steam supplied to the intermediate-pressure turbine. At the same time, four rows of tubes were added to the economiser in the space left available.

The machines at Earley were the first of their kind in this country to be fitted with radial contact strip in addition to the usual end-tightened shrouding in the high-pressure turbines. Trouble was experienced in the early days with this radial strip, which, on making contact with the blade shrouding resulted, in overheating and damage to the shrouds and blades. The strip was V-shaped and was changed to a single strip set at right angles to the cylinder. This has proved successful in remedying the trouble. In the third machine some trouble was experienced with the stainless-steel blades in the last row of the low-pressure turbine, which resulted in modifications to the erosion shields and the methods of brazing the shields and lacing wires. Blade failures on two turbine spindles were experienced at Cliff Quay and similar failures on one of the Blackwall Point spindles necessitated the return of the shafts to the works. These failures were attributed to pieces of material left in the system at commissioning, even though fine-mesh strainers were provided at the stop valves during the initial steaming. Some broken blade-tip rivets were found in one expansion of the intermediate-pressure turbines of the Littlebrook machines. This was attributed to vibration and the two similar wheels were rebladed with the addition of a lacing wire.

At Littlebrook the high-pressure shaft of the first machine became eccentric during the run-up after a prolonged shut down and could not be rectified on site. The eccentricity was found to be 0·025 in. and the shaft was thermally unstable. It was stabilised by low-temperature heat treatment and returned to service after re-machining. One high-pressure shaft from Cliff Quay and one from Poole have also been returned to the works for suspected distortion, but only the Poole shaft was found to be eccentric—to the extent of about 0·005 in. A spindle from Blackwall Point was found to be bent to the extent of 0·003 in. when it was returned to the works for blade repairs and had been rubbing at the glands. All these shafts were returned for heat stabilising tests and trued up before going back into use. Since excess reheated steam temperature was experienced at Littlebrook during the first year's operation, the intermediate-pressure turbine diaphragms were examined, but no distortion was found and they are considered satisfactory for operation at 850 deg. F.

Serious tube corrosion occurred in the condensers at Cliff Quay, where aluminium-brass tubes were fitted to two of the first four machines and cupro-nickel tubes to the remainder. The aluminium-brass gave such poor results that the first machine was re-tubed within a year. Cupro-nickel is the best of the commercial alloys that have been used in experimental batches at this station, although it is not entirely free from attack. The tube materials were chosen, as at other stations, from the outcome of water analyses; and the disappointing results were attributed to a reduction in the dissolved oxygen content of the river and sulphide-forming bacteria. Split tubes and leaky expansions on the high-pressure feed heaters were the cause of two breakdowns at Poole and two at Littlebrook in the first half of 1952. There were several examples of split tubes at Littlebrook during the first year of service and three instances of tube expansion leaks, which may have been due to striations on the tube surface. The tube material is cupro-nickel at Littlebrook and mild steel at Poole.

The alternator rotor of one of the Littlebrook machines was found to contain a number of short-circuited turns, which were attributed to an excess of solvent in the insulating varnish. As these short-circuits showed a tendency to increase the rotor was rebuilt. One of the Cliff Quay alternator rotors was also rebuilt.

THE ELECTROMAGNETIC SEPARATION OF ISOTOPES.

THE accompanying illustration shows one of the electromagnetic separators which has been installed at Harwell and is being used to separate some 20 elements, including most of the common metals, into their constituent isotopes. The operation of the separator is controlled electronically and is largely automatic, and the elements so far dealt with are boron, lithium, carbon, magnesium, silicon, calcium, titanium, vanadium, chromium, iron, nickel, copper, zinc, germanium, krypton, strontium, cadmium, indium, tin and antimony. These have been separated on the gram scale, the actual amounts depending on the initial availability. Sulphur, selenium, potassium, rubidium, zirconium, molybdenum, silver, barium, tungsten and certain rare earths are to be added.

It may be recalled that separated isotopes are essential for the study of certain nuclear reactions, work which involves the bombardment of elements with various high-speed particles and examinations of the scattered radiation. The fundamental nuclear and physical properties of isotopes can be much more simply and accurately determined when these are separated, and the information thus obtained is vital for the study of atomic energy and for the development of theories of nuclear structure. Stable isotopes also aid the application of pile-produced radioactive tracer isotopes. For instance, enriched iron 59, which is required for medical research, can be freed from the undesirable iron 55 isotope by irradiating separated iron 58 instead of natural iron. Similarly, calcium 45, made from enriched calcium 44, provides a more efficient tracer than that produced from the natural element. Spectroscopic studies, too, can be greatly simplified by using single isotopes; it is feasible to set up more accurate wavelength standards in the spectral line by employing separated isotopes of certain elements such as cadmium. Super-conductivity can also be studied and small traces of impurities chemically analysed.

These materials are much in demand by scientists, and about 200 consignments have been used at Harwell or sent to universities and research institutions in this country and abroad.

MOTOR ROAD TRANSPORT IN TURKEY.—Statistics published by the International Road Federation, 18, South-street, London, W.1, show that, during the period 1945 to 1951, the number of motor vehicles (private and commercial combined) in Turkey nearly quadrupled, from 8,900 to 33,500. In the same period the length of good roadways doubled, from 13,000 km. to 25,000 km. The rate of growth of both the vehicle fleet and the road mileage is continuing to show an upward trend, with an increase of about two vehicles for each mile of road constructed or improved.

THE METROPOLITAN WATER BOARD, 1903-53.

On page 435, *ante*, we reported the special meeting of the Metropolitan Water Board on March 27, at which the following memorandum (which we have abridged slightly) was put to the meeting by Mr. W. H. Girling, O.B.E., and duly adopted.

The Metropolitan Water Board, 1903-1953.

The 50th anniversary of the first meeting of the Metropolitan Water Board falls on Thursday, April 2, 1953. During the latter part of the Nineteenth Century, the water supply to London and its environs was in the hands of eight statutory water companies, which had come into being over a period of nearly 300 years. Important questions concerning the adequacy and purity of the water supplied, and the management of the companies' undertakings, pressed themselves with increasing insistence upon the public and Parliament, and a number of remedial measures were taken. Three Royal Commissions examined the water question in great detail. The first, in 1869, recommended that the undertakings should be transferred to a public body; the second, in 1893, after examining the whole question of the adequacy of the existing sources to meet actual and anticipated requirements in the London area, came to the conclusion that these were likely to be sufficient for a period of 40 years, provided adequate storage reservoirs were constructed; the third, in 1899, dealt specifically with the question of control and also of intercommunication. This last Commission came to the conclusion that, having regard to the magnitude of London's future water requirements, the concentration of the undertakings into the hands of one authority was desirable, and recommended the establishment of a Water Board for that purpose. The London Water Bill, introduced into the 1902 session of Parliament as a Government measure, gave effect to the Commission's recommendation. After some amendment, it reached the statute book on December 18, as the Metropolis Water Act, 1902.

The new Board met for the first time on April 2, 1903. The "appointed day" for the transfer of the undertakings was June 24, 1904, except in the case of the New River Company, which followed on July 25 of that year. The Act of 1902 provided for 66 members appointed by authorities, generally referred to as constituent authorities, consisting of (i) single bodies and (ii) grouped councils acting through joint committees in the appointment of a single member of the Water Board to represent each group of councils. The term of office of the chairman, vice-chairman and members of the Board is three years. By section 28 of the Act, the Board are required to submit an annual report of their proceedings to the Minister of Housing and Local Government, who lays it before Parliament. The first meeting of the Board was held in the Council Chamber of the Privy Council, Downing-street, London. Adjourned meetings were held on April 23, 1903, at Caxton Hall, Westminster, and on April 30, at the offices of the Metropolitan Asylums Board. The latter office continued to be used until May 10, 1918. Subsequent meetings were held at No. 2, South-place, Finsbury, until the present head offices at New River Head were opened in May, 1920.

The newly-created Board were at once confronted with what was probably the biggest arbitration on record at that time, and this task overshadowed all others during the first year of office. The claims of the water companies amounted in all to 50,939,989*l*. The Court of Arbitration awarded 30,662,323*l*. in cash in respect of the transfer of the undertakings, to which sum a number of other items had to be added, bringing the total cost of acquisition to 46,939,258*l*. The provision which has to be made for extinguishing the "acquisition debt" by the year 2003 is one of the principal items of the Board's annual expenditure. From the "appointed day" until March 31, 1952, the Board have spent some 28,600,000*l*. on extending and improving the undertaking. Works at present in hand are estimated to cost some 8½*l*. million.

The Act of 1902 placed upon the Board the obligation to promote within three years from the "appointed day" a Bill providing for uniform scales of charges applicable throughout the limits of supply. This was a matter of some complexity. Varying scales of charges for domestic supplies operated in the companies' areas and numerous other differences and anomalies were prevalent. The Board's charges scheme, as submitted to Parliament, provided for the assessment of water charges on the basis of the rateable (now net annual) value of the premises supplied, and was designed to produce equilibrium between the income inherited from the companies and that to be derived from the new uniform charges. During the passage of the Bill, which became the Metropolitan Water Board (Charges) Act, 1907, changes were imposed, however, which caused a loss of income to the Board of something like 29,000*l*. per annum. The succeeding years to 1921-22 were years of financial deficiency, and frequently the Board were called upon to consider complaints regarding the method provided in the Charges Act of 1907, for the liquidation of deficiencies in the Water Fund.

In 1919, at the request of the Board, a Committee of Inquiry was appointed by the Minister of Health to investigate the working of the Board in the light of the provisions of the Metropolis Water Act of 1902. The Committee, which was presided over by Sir Horace Munro, K.C.B., vindicated the Board's methods of management, and the Metropolitan Water Board (Charges) Act of 1921, largely based upon the Committee's proposals, enabled the Board to improve their financial position and so to carry out effectively their statutory obligations. By 1939, the water rate had been reduced by successive stages to 5¾ per cent. of the net annual value of the premises supplied. The disruptive conditions created by the war placed the Board in a somewhat difficult position, and it was soon evident that the existing rate would be insufficient to meet the Board's requirements. The rate was raised to 7 per cent. for 1940-41 and to 8½ per cent. for 1941-42, at which figure it remained until March, 1947. By that time, however, rising costs and the greater consumption of water considerably increased expenditure, both in the revenue working expenses and in the debt charges borne by Revenue Account. Furthermore, the Board were faced with a large programme of repair and reconstruction of existing works, much of which had fallen into arrear during the war, but required to be undertaken. It was accordingly necessary to raise the rate to 9 per cent. for the year 1947-48 and, the year following, to 10 per cent., at which level it has since stood except for the two years 1950-51 and 1951-52. The current rate of 10 per cent. is the maximum which the Board are empowered to charge, but the Charges Act of 1921 stipulates that the rate shall not exceed 8½ per cent. unless and until the Ministry of Health (now the Ministry of Housing and Local Government), on the application of the Board, otherwise direct.

With the transfer of the several undertakings of the companies, the Board inherited a large number of engineering works of great diversity, and also a variety of schemes, some of which were in course of construction and some only on paper. In addition, consideration had to be given to the question of re-organising the engineering department, and this process culminated in the setting up of the present functional system, based upon the nature of the duties to be performed. The maintenance of the existing supply was, of course, the primary task, but the Board soon addressed themselves to their next duty, namely, that of providing for the future needs of their consumers. In 1907, the Board endorsed the conclusions of the Commissions of 1893 and 1899 regarding the adequacy of the rivers Thames and Lee. Since then the provision of storage accommodation in the valleys of these rivers has been pursued with vigour. The King George's reservoir at Chingford was completed in 1913, the Queen Mary reservoir at Littleton in 1925, the King George VI reservoir at Staines in 1947, and the William Girling reservoir at Chingford in 1951. These reservoirs, which together cover an area more than five times the size of Hyde Park, have increased the Board's storage accommodation by 17,000 million gallons. Work on a new reservoir at Walton, which began in 1939, is still in abeyance, as is also the construction of two further reservoirs at Datchet and Wraysbury, for which powers were obtained in the Board's Act of 1946. Even when these are in use, however, more reservoirs will doubtless be required. Investigations as to possible sites for this purpose are proceeding.

Many of the works have been remodelled and others substantially altered by the installation of new machinery. The most noticeable example of a reconstructed works is at Hampton, where, at the turn of the century, three of the water companies had engineering works of one kind or another. At these works, one engine-house has been constructed, into which has been concentrated the work previously performed in eight pumping stations. In addition, much of the filtration plant has been reconstructed, and primary or rapid filters have been installed. New filtration works have been constructed and others are in hand. They include an entirely new filtration and pumping station in the Thames valley, capable of producing 90 million gallons of filtered water a day. The slow sand filter beds at this station, and certain other parts of the work, have been completed. Good progress is being made on the remainder. Primary filters have been installed at a number of works since 1922. Their installation has enabled the supply to be increased and has effected considerable economies without impairing the quality.

The distribution system throughout the 540 square miles of the Board's area of supply has been strengthened and extended. Over 2,500 of the present total of 8,500 miles of mains have been laid since 1903, and the distribution networks of the former companies have been integrated. At the present time, the construction of a 60-in. main, which will convey water from the Thames Valley to the Western area is nearing completion. The supply from underground sources has been augmented by the construction of 20 wells or boreholes, with their attendant pumping stations.

The changes which have taken place in the work of examination and purification of the water since the Board's early days have been of a far-reaching character. The Board were anxious to place the examinations on a uniform basis and accordingly, in 1905, a laboratory for the analysis of samples and research was established at 20, Nottingham-place, London, W.1. In 1916, pre-chlorination on a large scale was introduced at Staines. In 1921, terminal chlorination was first used by the Board. In 1936, all water passing into supply was treated by ammonia and chlorine. In 1948, this process was superseded by "superchlorination," which not only prevents the formation of chlorine-derived tastes, but also removes algal and many of the other tastes natural to the raw water. The water is virtually free from colour, formerly a frequent cause of complaint. Superchlorination has had a more profound influence upon the physical quality of the water and its bacterial purity than any other measure since the introduction of sand filtration. Not the least of its virtues is that it has effected a marked saving in the cost of chemicals alone. Samples of water from all points of the system are analysed, many of them daily, at the present laboratories at New River Head, which were opened in 1938. During 1952, the number of samples collected was over 93,000; in the early days of the Board, it was approximately 10,000 per annum. Such, in broad outline, has been the work of the Board during the past 50 years. There have been critical times, such as the severe droughts of 1921, 1934, 1944 and 1949; the flooding of the Lee Bridge works in 1947; and, above all, the second World War.

Institute of Marine Engineers.—Two new local branches have recently been formed by the Institute of Marine Engineers. These are the North East Coast Section, with headquarters in Newcastle-upon-Tyne, which was inaugurated on March 26, and the Clydeside and Southern Scotland Section, with headquarters in Glasgow, which was inaugurated on March 27. Mr. A. W. Jones, B. Sc., A.M.I.Mar.E., Mechanical and Marine Engineering Department, University of Durham, King's College, Newcastle-upon-Tyne 1, was appointed honorary secretary of the first-mentioned section and Mr. J. D. B. Mundie, M.I.Mar.E., Stow College School of Engineering, 43, Shamrock-street, Glasgow, C.4, honorary secretary of the Clydeside Section.

FILTER AND REDUCING VALVE FOR AIR LINES.

HYMATIC ENGINEERING CO., LTD., REDDITCH.

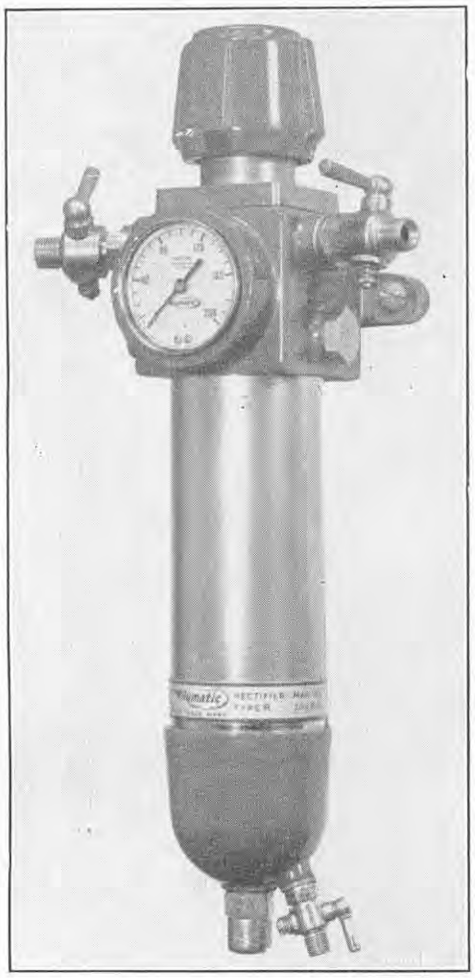
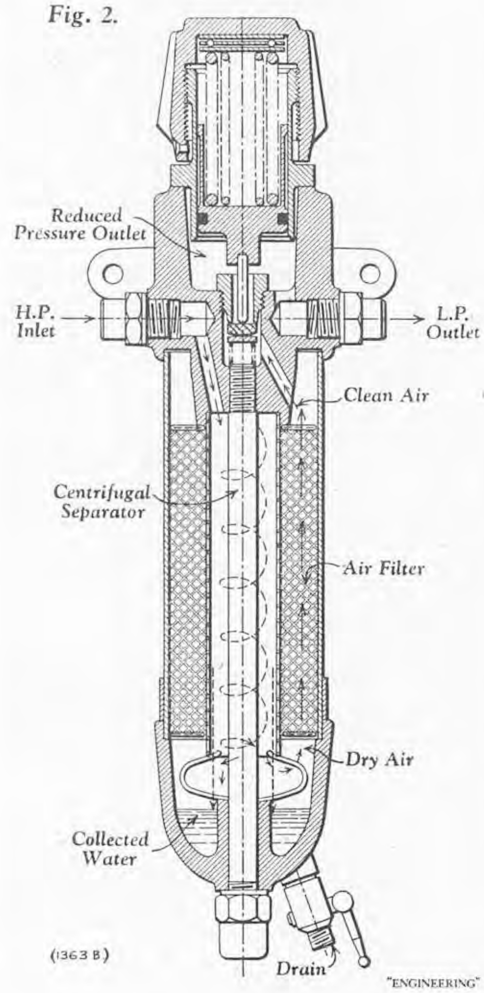


FIG. 1.

Fig. 2.



FILTER AND REDUCING VALVE FOR COMPRESSED-AIR LINES.

THE combined air-cleaning and pressure-reducing unit for a maximum inlet pressure of 200 lb. per square inch illustrated on this page is made by the Hymatic Engineering Company, Limited, Redditch, Worcestershire, and replaces four earlier models. It is known as the type R50, and is suitable for use on compressed-air lines supplying paint spray guns and pneumatic tools where the delivery required does not exceed 25 cub. ft. per minute, which is sufficient for three spray guns of normal design.

The air entering the unit is directed downwards into a central cylinder, as shown in Fig. 2, at an angle sufficient to produce vortex flow which, it is claimed, separates particles of oil, water, and other impurities by centrifugal action. The air then passes upwards round the outside of the cylinder, through a filter which removes the remaining moisture and dirt, to a pressure-reducing valve, and thence to the outlet; or it may leave through the plugged hole shown on the right in Fig. 1. The moisture removed from the air collects in a sump to which a drain cock is fitted. The pressure-reducing valve can be set by hand to give any desired delivery pressure between 20 lb. and 180 lb. per square inch by turning the knob shown above the dial gauge in Fig. 1. To reduce the effort required for turning the knob a ball thrust race is fitted between the inner face of the knob and the springs, as shown in Fig. 2.

The main casting, housing the reducing valve, has a $\frac{1}{4}$-in. B.S.P. thread inlet and outlet, both of which are fitted with male-ended stop cocks, a $\frac{3}{8}$-in. B.S.P. threaded outlet for use when the flow is required to by-pass the valve, and a built-in pressure gauge which shows the outlet pressure. At the back of the casting are two mounting lugs for $\frac{1}{4}$-in. bolts on 4-in. centres. The filter is contained in an anodised light-alloy cylinder and can be removed for cleaning by unscrewing the nut beneath the cast sump. The sump is mounted on a rod that passes through the central cylinder and is screwed into the base of the main casting. The complete unit is $14\frac{1}{2}$ in. high, $4\frac{5}{8}$ in. deep, 8 in. wide and weighs $7\frac{1}{4}$ lb.

LAUNCHES AND TRIAL TRIPS.

M.S. "RAPHAEL."—Single-screw cargo vessel, with accommodation for six passengers, built by Bartram and Sons, Ltd., Sunderland, for the Lamport and Holt Line, Ltd., Liverpool. Main dimensions: 440 ft. between perpendiculars by 61 ft. $9\frac{1}{2}$ in. by 39 ft. to shelter deck; deadweight capacity, 10,050 tons on a draught of 28 ft. $4\frac{1}{2}$ in. N.E.M.-Doxford six-cylinder two-stroke opposed-piston oil engine, developing 7,500 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Launch, March 16.

M.S. "PEARLSTONE."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the Alva Steamship Co., Ltd., London, E.C.3. Main dimensions: 438 ft. between perpendiculars by 59 ft. 9 in. by 37 ft. 7 in. to shelter deck; deadweight capacity, about 10,000 tons on a mean summer draught of 25 ft. $9\frac{1}{2}$ in. N.E.M.-Harland and Wolff-Burmeister and Wain six-cylinder opposed-piston single-acting two-stroke oil engine, developing 4,400 b.h.p. at 115 r.p.m., installed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 13 knots. Launch, March 17.

M.S. "LA HACIENDA."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for Buries Markes, Ltd., London, E.C.3. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; gross tonnage, about 6,000; deadweight capacity, 10,000 tons on a draught of 26 ft. 5 in. Swan Hunter-Doxford four-cylinder heavy-oil engine, developing 4,400 b.h.p. at 115 r.p.m. Speed on service, $13\frac{3}{4}$ knots. Trial trip, March 23.

THE SAFETY FACTOR IN CONSTRUCTION.—II.*

(*Concluded from page 446.*)

ANOTHER, and very much more controversial, question arises with regard to the phosphorus content to be permitted. That the yield point and tensile strength of a mild medium-carbon steel in the unhardened state increase with the phosphorus is well known; see Table II, herewith, due to Stead.

TABLE II.—*Effect of Phosphorus on the Tensile Properties of a 0·3 Per cent. Carbon Steel, as Rolled.*

Phosphorus, Per cent.	Yield Point, Tons per sq. in.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reducton of Area, Per cent.
0·04	20	33	23	52
0·3	25	40	23	45
0·5	32	44	20	45

That the ductility falls, but at no particularly alarming rate, has been shown by Stead so far as straightforward tensile properties are concerned. There is, however, the belief, for which a considerable body of evidence exists, that steels of high phosphorus content may fail by brittle fracture when subject to shock, and that such steels are inherently "wicked." A good deal of work has been done on the effect of phosphorus, particularly on low-carbon material. Micrographically, it results in the grain size becoming coarser for a given heat-treatment, and along with this is an increased tendency for brittle cleavage fracture. There are, however, other elements—aluminium for instance—the effect of which on the structure of the steel is in the opposite direction, resulting in a finer grain size; and investigation regarding the possibility of obtaining adequate ductility and toughness in steels of distinctly higher phosphorus content than those now employed, which also contain small amounts of other elements, would appear to be among the most promising of empirical investifations. H. W. Gillett,† as far back as 1935, and many others have already discussed the problem, and J. H. Andrew and D. Swarup‡ have particularly indicated the beneficial effect resulting from the addition of 0·2 per cent. aluminium to structural alloy steels of high phosphorus content. As examples of the tensile properties which can be obtained from high-phosphorus steels, a few typical results given by J. A. Jones§ are recorded in Table III, on page 478. It must be emphasised, however, that this discussion is restricted to ordinary structural steels statically loaded. Where fluctuating or shock stresses may be imposed, any marked increase in the phosphorus content, on the evidence at present available, would be highly dangerous, as would be the presence of high phosphorus in steels of higher carbon content.

The effect of sulphur is, in the main, economic. Provided that the manganese content of the steel is sufficiently high, sulphur exists almost entirely as a complex iron-manganese sulphide, out of solution. As a result of the forging operations, this sulphide is drawn out into threads, and then exerts an influence neither greater nor less than that of any other inclusions, such as silicates. It seems difficult to understand why the sulphur content should be so strictly controlled when other non-metallic inclusions are taken more or less for granted. So long as the stressing is longitudinal, the effect of the sulphur is almost non-existent, though the transverse ductility and toughness may be considerably reduced. Brinell, many years ago, showed that even $\frac{1}{2}$ per cent. of sulphur, in the presence of 1 per cent. of manganese, gave a material with adequate tensile properties, which presented no special difficulty in production. More recently, confirmation has been obtained, again on a steel containing 0·5 per cent. of sulphur, the mech-

* The second of two Cantor Lectures, delivered to the Royal Society of Arts, London, on March 2, 1953. Abridged. The first lecture, delivered on February 3, 1953, was reprinted on page 343, *ante*.

† *Iron Age*, vol. 137, page 42 (1936).

‡ *1st Report of Alloy Steels Research Committee.* Section XII, page 227 (1936). Iron and Steel Institute.

§ *Jl. I. and S. Inst.*, vol. 135, page 113 (1937).

anical properties of which, taken from the centre of the ingot and after a forging reduction of 16 : 1, were as shown in Table IV, herewith. The properties in the longitudinal direction seem entirely adequate, while the poor tensile properties in the transverse direction afford a most valuable warning, which is of general application, against over-working a steel when it is subsequently to be stressed transversely. There is some evidence to suggest that the corrosion resistance of high-sulphur steel is rather lower than that of normal material.

Although the major portion of the carbon content of a soft steel exists in the pearlite as iron carbide, since ferrite at room temperatures has a negligible solubility for this element, this solubility may reach a figure of the order of perhaps 0·025 per cent. just below the carbon change point. Further, it has been suggested by C. Benedicks* that the iron phase of the pearlite may contain carbon in solid solution in concentrations much greater than that which is present in the normal ferrite. When the pearlite becomes sorbitic and then troostitic, the corresponding increase in the electrical resistivity suggests that the iron matrix is holding a still higher concentration of carbon in solution. This conclusion is in complete accord with the well-known physical-chemical fact that the solubility of a material increases as the particle size diminishes. It would appear at any rate not impossible, that the increased strength of a steel in the sorbitic and then in the troostitic states is due not so much to the increasing fineness of the state of dispersion of the carbide, as to the fact that this carbide is immersed in a matrix which itself is of a progressively higher carbon content. Not only does the solid solution of carbon in α-iron increase the hardness, but it may also lead to age-hardening phenomena which raise the strength still further.

Another element which causes age-hardening effects in steel is copper, and Table V, herewith, shows the increased strength which can be obtained in an 0·3 per cent. carbon steel (as cast) due to the presence of 1·2 per cent. copper. In order to get such hardening, the minimum content of copper or other alloying element must be above the limit of solid solubility, and in this case about 1 per cent. is required to provide an appreciable hardening effect. By the simultaneous addition of other metals in solid solution, however, the solubility of the age-hardening element may be reduced, and corresponding effects, therefore, obtained at lower concentrations. Since, at any rate in certain circumstances, copper also reduces corrosion, it would appear that investigation from the age-hardening point of view of copper steels containing small amounts of several other elements might be a profitable field for investigation.

Nitrogen, even in the amounts normally present in steels, is known to exert a considerable effect in enhancing strain-ageing. It may, however, result in serious embrittlement, and a field of fundamental research which calls for urgent examination is the full story behind the brittleness of materials which are normally ductile. The main difficulty in increasing the strength of engineering materials lies, indeed, in the fact that, though this hardening can be effected without difficulty, it is so often associated with embrittlement. A complete understanding of the reason for the brittleness should enable increased hardness and strength to be obtained without the drawback of inadequate ductility. Surface decarburisation may exert serious effects on the mechanical properties, especially under conditions which may lead to fatigue. Mild carburisation of hot-worked or heat-treated material, by eliminating the weak ferritic surface, should produce material the mechanical strength of which is substantially higher.

It has been estimated that, in Great Britain alone, the total annual cost due to corrosion is now of the order of 200*l*. million. The British Iron and Steel Research Association has recently published a brochure† outlining some of the practical conclusions reached by its Corrosion Committee. Rusting may be prevented, or at any rate retarded, by the addition of inhibiting reagents in the corrosive medium; by modification of the design to reduce the danger of moisture lodging in the structure; by changes in the composition of the steel; and by efficient protective measures, including painting, the use of metallic coats or cathodic protection. Relatively inexpensive low-alloy steels containing small percentages of chromium and copper may be three times as resistant as ordinary mild steel under atmospheric conditions, and it is justifiable to inquire whether sufficient use is made of such material in this country. Zinc is probably still the best metallic coating for steel, though sprayed aluminium coats, about 0·004 in. thick, under normal conditions, give almost as good results.

Improvement by Heat-Treatment.

The importance of the crystal boundaries in determining the strength and ductility of a metal is generally appreciated, though certain researches which suggest variations in the strength of the boundary may be due to simultaneous changes which have been effected in the crystals themselves, as a result of the heat-treatment required to produce modifications of the crystal size. Much recent theoretical work is based on assumptions which, at the moment, are pure speculation. The idea of certain theorists that the crystalline structure extends more or less unchanged up to the very edge of the grain, and is almost immediately replaced by that of the new crystal, is pure assumption, unsupported by a vestige of evidence. It is equally true that J. C. W. Humfrey's hypothesis* that, at the boundary, there is a gradual swinging over from the orientation of one crystal to that of its neighbour, is similarly unsupported. What, then, is the "thickness" of the boundary? An answer to this question cannot be given. In the same way, we know nothing about the effects, if any, of heat treatment on these boundaries, and there is here a field of fundamental research of extreme importance.

Although, in general, the mechanical properties of an alloy improve as the grain size becomes smaller, there are exceptions. The small grain-size steels obtained by controlled deoxidation with aluminium may give much higher Izod values than do coarser-grained materials, but, not infrequently, a lower yield stress. A 1⅛-in. bar of 0·35 per cent. carbon steel with 1·4 per cent. manganese and 0·2 per cent. molybdenum, for instance, when oil quenched from 840 deg. C. and tempered at 550 deg. C., had a yield point of 65 tons per square inch in the coarse-grained condition, against only 54 tons in the fine-grained state. Interrupted quenching is no new process, but the application of some such process to ordinary structural steels during their cooling from the hot rolls offers an interesting field of study.

Rapid cooling results in the retention of some of the ferrite—the weakest constituent in the whole structure. Another aspect is that, in steels of very low carbon content, no quenching, however rapid, is sufficient to retain a fully-martensitic structure, a not inconsiderable amount of ferrite always being precipitated. The martensite, in such cases, due to its low carbon content, is relatively ductile, and exerts a strengthening effect which is not associated with any serious embrittlement. Where such low-carbon steels are employed, would it be improper to suggest deliberate quenching, even in water, of the sections as they cool down from the rolls? (Table VI).

If, from the hot rolls, the section be taken to the shears and then allowed to cool until a temperature of around 900 deg. C. is reached, they could then be "quenched" by dropping into a pit in which the temperature is allowed to fall fairly rapidly to, say, 400 deg. C. On attaining this temperature, the lengths could be transferred to an isothermal furnace at a similar or a slightly higher temperature, and kept there for a period depending on the composition of the steel, but which even with a manganese content as high as 1·8 per cent. need not exceed, say, 15 minutes. The lengths could then be cooled in air and the steel would possess a structure with less ferrite than that normally present, and a much finer, sorbitic, type of pearlite.

In the fully hardened martensitic state, the limit of proportionality of steel is very low; on tempering, this value rises to about 400 deg. C., in the case of plain carbon steels, when the structure has become troostitic, and then falls again. It is this troostitic structure which possesses the highest ratio of elastic limit to tensile strength. In most cases, however, a sorbitic structure, obtained at a higher tempering temperature, is preferred, presumably on account of its much higher impact value. A steel of the composition: 0·26 per cent. carbon, 0·30 per cent. silicon and 0·75 per cent. manganese, in the form of bars 1⅛ in. in diameter, water-quenched from 900 deg. C. and tempered at 400 deg. C. gave the following mechanical results: yield point, 38 tons per square inch; maximum stress, 54 tons per square inch; elongation on 2 in.,

TABLE III.—Mechanical Properties of Some High-Phosphorus Low-Alloy Steels.

Composition, Per cent.				Normalising Treatment, Deg. C.	Yield Point, Tons per sq. in.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.	Izod Value, Ft.-lb.
C	Mn	P	Alloy Elements.						
0·10	0·30	0·19	—	920	24	32	36	68	79
0·17	0·30	0·18	—	900	28·6	35·4	33	59	26
0·25	0·30	0·11	Cu 0·4	880	28	37	31	57	40
0·08	0·30	0·21	Cu 0·96	—	29	34·5	33	66	52

TABLE IV.—Properties of Steel with 0·5 Per Cent. Sulphur.

—	Yield Point, Tons per sq. in.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.	Izod Value, Ft.-lb.
Longitudinal	17	24	38	58	51
Transverse	12·4	13·2	3	11	18

TABLE V.—*Age-Hardening Effects of Copper on a Cast 0·3 Per Cent. Carbon Steel.*

Cu, per cent.	Normalised at 900 deg. C. and Precipitation Hardened 3 hours at 500 deg. C.				
	Yield Point, Tons per sq. in.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.	Brinell Hardness No.
0	26	42	14	22	175
1·2	39	53	10	15	230

TABLE VI.—Mechanical Properties of 0·17 Per Cent. C., 0·72 Per Cent. Mn, Steel Bars, 1⅛ In. Diameter.

Treatment.	Yield Point, Tons per sq. in.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.	Izod Value, Ft.-lb.
Water-quenched at 920 deg. C.	32	46	22	51	24
Water-quenched at 920 deg. C. and then water-quenched at 760 deg. C.	24	40	32	64	43
Oil-quenched at 920 deg. C.	23	36	31	65	92

* Doctorate thesis to the University of Upsala, 1904.

† *The Fight Against Rust.* Brit. Iron and Steel Res. Assn. (1952).

* *Carnegie Scholarship Memoirs*, vol. 5, page 86 (1913), Iron and Steel Institute.

15 per cent. ; and reduction of area, 44 per cent. ; with an Izod value of 26 ft.-lb. Surely, such a steel has both adequate ductility and toughness for many purposes, despite its troostitic structure, and the high yield stress (for a 0·26 per cent. carbon steel) should be undeniably attractive.

MECHANICAL IMPROVEMENT.

The essential constancy of Young's modulus for steels of widely differing composition and treatment is well known. An increase of at least 10 per cent. in this modulus may, however, be obtained by cold-work followed by "blueing," i.e., reheating to a temperature of the order of perhaps 300 deg. C. This seems to be the only possibility available for increasing the modulus of elasticity, since alloying steel has normally little effect, and, where it does exert an influence, this is frequently detrimental.

With regard to fatigue, all that can be said is to draw a clear distinction between the initial crack, due to the fatigue itself, and the "creeping" crack which is then propagated due to stress concentration. The fatigue limit is a function of the tensile strength, and fatigue proper is, therefore, diminished by the employment of a stronger steel. The creeping crack is connected with the notched-bar toughness of the material, which tends to decrease as the hardness is raised.

The increase of strength and, when properly heattreated, of the elastic limit, resulting from cold-work, is well known. Whether, however, full advantage is taken of this fact by the structural engineer may be doubted. Particularly in the case of built-up structures, and if a lower ductility than is at present demanded can be accepted, there would appear to be advantages in the use of cold-rolled sheets, provided that the material is not annealed during fabrication, for instance, by welding. The importance of the ageing treatment, if such material is to be employed, is outstanding, and the following figures, due to Aitchison,* illustrate the order of the elastic limit which might be expected (Table VII).

TABLE VII.—*Effect of "Blueing" on the Properties of Cold-Worked Steel.*

Blueing Temperature.	Limit of Proportionality.	Maximum Stress, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.
Room temperature ..	27	70	5	18
400 deg. C.	51	73	9	37

The limit of proportionality immediately after working a steel, if there be such a thing at all, is quite low. As the reheating temperature rises, so does the elastic limit, up to a temperature in the region of 400 deg. C. The tensile strength remains little affected, and the proportion, therefore, of the elastic limit to the maximum stress rises considerably; but, when the elastic ratio is a maximum, the ductility is often comparatively low, and the time must come for the engineer to review the whole position regarding the essential degree of ductility required in statically stressed structures.

The two outstanding points seem to revolve round the degree of ductility and toughness really required. If the engineer could satisfy himself that he is asking for too much in both of these properties, the metallurgist would have no difficulty in providing material, still very far from brittle, and with greatly increased yield strength. To many of the questions which have been asked an answer can clearly only be given after research, both technological and scientific, which will require years, to each completion. The issues involved are, however, so big that there ought to be no delay in beginning to think about them and in planning the work on which most important decisions will rest. The suggestions which have been made both for control of composition and of heat-treatment would inevitably lay extra burdens on the producers, and hence increase the cost of the material. It would be a matter for the economist to determine whether this increased cost was justified in view of the enhanced strength of the material.

* *Engineering Steels,* by L. Aitchison, page 268. Macdonald and Evans, Ltd., London (1921).

AUTOMATIC RADIO TRANSMITTER FOR LIFEBOATS.

A RADIO transmitter which is now being produced by Venner Electronics, Limited, Kingston By-Pass, New Malden, Surrey, should be a valuable contribution to the solution of the problem of still further increasing the safety of life at sea. It consists of a crystal-controlled oscillating valve, which is followed by a power-amplifier valve, the continuous wave produced being modulated by toning. The necessary power is generated by a manually-operated dynamo with both low-tension and high-tension windings, the shaft of which is extended so that it drives a signal-code disc. This disc is designed so that, when the transmitter is in operation, a continuous alarm interspersed with S O S signals is sent out. The sequence begins at any point in the cycle, depending upon when the transmitter cuts in, and continues so long as the handle operating the generator is being turned above a pre-selected minimum speed. A clutch is incorporated in the system to prevent damage due to over-voltage caused by the generator being turned at an excessive speed. The above equipment is housed in a watertight case, consisting of a light-alloy casting, which is provided with lugs so that it can be screwed under the thwarts of sailing and pulling lifeboats; and is provided with watertight panels for inserting the handle by which the dynamo is rotated. There are also two watertight caps, one of which seals the terminal to which the rod aerial is connected and the other covers a switch, which enables the transmitter to be tuned from outside.

As regards operation, once the lifeboat is clear of the ship, it is only necessary to remove a thin steel rod, which is secured by the beckets holding the oars, and use it to unscrew a small cover at the end of the box, which protrudes 3 in. from the side of the thwart. The rod is then inserted in the hole and the small handle underneath turned. Within a second or two, a light appears in one of the small windows at the end of the box to indicate that the handle is being turned at the correct speed, while 30 seconds later, a light appears in another window to assure the operator that the signal is being continuously transmitted. This continuous transmission, it is claimed, makes it easy for a searching vessel or listening post to pick up the signal and to ascertain the position of the lifeboat by direction finding. There being no batteries, maintenance is small, although it is advisable for the tuning, the valve filaments and the neon and filament indicators to be checked at intervals.

RECOVERING LAMINATED SPRING LEAVES OF COMMERCIAL VEHICLES.

LONDON TRANSPORT have introduced at their Chiswick 'bus and coach works, a system for recovering broken leaves in laminated suspension springs. Though it is in an early stage of development, it shows considerable promise. Briefly, the system consists of a simple routine for examining leaves magnetically for cracks, cutting out sound portions of fractured leaves in lengths suitable for shorter leaves, and re-manufacturing such lengths into new leaves for building into reconditioned springs. The specialised part of the process occupies only a small area in the works and requires only simple equipment; re-manufacture of cut-down lengths is carried out in the smiths' shop in the usual way.

Leaves from springs withdrawn from service (and not obviously scrap) are cleaned and sent to the recovery section for sorting into batches, according to width and thickness, and according to length in 6-in. steps. Each batch then passes to a magnetic crack detector, where the operator marks with red paint the extent of any crack that may be detected. The marked leaves are transferred to a bench which is provided with sets of sheet-aluminium templates of the various leaf-sizes used. Each template incorporates a stencil of the part number of the component it represents, and, at the centre, a circle for the locating dimple. The operator selects from the appropriate set the longest template which can be accommodated in the sound portion of a fractured leaf, and marks on the leaf, with blue paint, the length to which the sound portion is to be cut, the part number, and the place for the dimple. After marking, the leaves are sorted for cutting to the respective lengths and stored. The first part of the recovery routine is completed when notification is received of the quantities of various part numbers ready for re-manufacture. Actual re-manufacture is not carried out until orders for particular leaves are received, after which the process follows the normal method of spring manufacture. In the smiths' shop the appropriate leaves are cut to the marked lengths by oxy-acteylene flame, and the corners are cut off. The centre of each leaf is heated locally by the same means to enable the locating dimple to be formed. Finally, the leaves are heat-treated.

The question of the most appropriate heat treatment is at present under investigation by London Transport's central laboratory; meanwhile, a simple treatment is used, consisting of heating to a controlled temperature and quenching in oil. So far this method appears to have no disadvantages, but it is an aspect of the recovery process which will be watched carefully. Subject to any additional costs arising from a change in the method of heat treatment, the new practice should effect appreciable economies in the maintenance of London Transport's 'bus and coach fleet and materially ease the supply position. One immediate benefit has been that purchase of new spring leaves is now largely confined to the longer top leaves. It is of interest to note that the operations of crack-detecting and marking to template are of a light nature and are therefore particularly suitable for elderly or slightly-disabled workmen.

CONTRACTS.

HARLAND & WOLFF, LTD., Belfast, have received an order from the British Electricity Authority for five Diesel alternator sets for installation at Blackpool power station. Each set has an output of 1,280 kW at 333 r.p.m., and embodies an eight-cylinder four-stroke 840 S.B. trunk type of engine supercharged by means of a Napier exhaust-driven turbo-charger and direct-coupled to a three-phase alternator supplying current at 6,600 volts.

THE FAIREY AVIATION CO., LTD., Hayes, Middlesex have received a repeat order from Svensk Flygtjänst, Stockholm, Sweden, for a further series of Firefly target-towing aircraft. The present order brings the total of Firefly aircraft in Sweden up to 14.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have received an order from the British Broadcasting Corporation for the supply of three 5-kW vision transmitters and three 2-kW sound transmitters for stock, together with combining units, and monitoring and control equipment for each. Delivery will be in the spring of 1954.

GEO. SALTER & CO., LTD., West Bromwich, have received an order from the English Steel Corporation, Ltd., Sheffield, for a large-capacity portable suspended weighing machine of a type known as a crane weigher. The machine will have a weighing capacity of 200 tons.

COWANS, SHELDON & CO., LTD., Carlisle, have received a contract from the Auckland Harbour Board, New Zealand, for the supply of 18 five-ton jib cranes. The contract is valued at 425,000*l*., and delivery will begin in 18 months.

NEWTON, CHAMBERS & CO., LTD., Thorncliffe Ironworks, near Sheffield, have received an order from the Indian Tube Co., Ltd., Jamshedpur Tube Works, Tatanagar, for five large tube-mill needle recuperators.

A.C.V. SALES, LTD., have received orders for ten A.E.C. Regent double-deck omnibuses from the Sheffield Joint Omnibus Committee; for sixty 11·3-litre A.E.C. Diesel engines for omnibuses from the Canadian Car and Foundry Co., Ltd., Montreal; and for 150 of these 11·3-litre engines destined for incorporation in railcars to be produced in Holland for the Netherland State Railways

THE GRANGEMOUTH DOCKYARD CO., LTD., Grangemouth, have received a repeat contract from the Halal Shipping Co., Ltd., of London and Aden, for a single-screw motorship similar to the El Nabeel completed for these owners last year. As before, the propelling machinery will consist of a Kincaid-H. & W. B. & W. Diesel engine built by J. G. KINCAID & CO., LTD., Greenock.

TRADE PUBLICATIONS.

Conveyor Belting.—We have received from J. H. Fenner & Co., Ltd., Hull, an illustrated leaflet describing their "Fennaplast" fire-resistant conveyor belting, which has the approval of the National Coal Board for use on all underground conveyors.

Multi-Spindle Drills.—We have received a pamphlet from W. J. Meddings, Ltd., Kingsley Works, Ipswich-road, Slough, Buckinghamshire, giving details of their multiple-head drilling machines from ½ in. to 1 in. capacity.

Electro-Mechanical Integrator.—We have received from the Instron Engineering Corporation, 2, Hancock-street, Quincy 71, Mass., U.S.A., a bulletin describing the design and applications of their electro-mechanical integrator, based on standard computor techniques.

Stationary Batteries.—The Tudor Accumulator Co., Ltd., 137, Victoria-street, London, S.W.1, have sent us a catalogue giving details of the industrial and domestic applications for which their range of open and sealed type stationary cells are suited.

Drill for Brickwork.—We have received from Adam & Harvey (Rapid-Hammer), Ltd., Greenwich House, 10/13, Newgate-street, London, E.C.1, an illustrated broadsheet describing their "Rapid-Mate" electric hand-drilling machine and its attachments, suitable for drilling and cutting chases in brickwork, etc.

High-Tensile Wire for Prestressed Concrete.—Richard Johnson & Nephew, Ltd., Forge-lane, Manchester, 11, have published an illustrated brochure describing their indented high-tensile wire for prestressed-concrete. This wire is supplied in coils 8 ft. in diameter to save both the labour involved and the possible alteration of the mechanical properties incurred when straightening wire from small-diameter coils.

Saw Adaptor for Electric Drills.—An illustrated leaflet has been sent to us by Buck & Hickman, Ltd., 29-30, Whittal-street, Birmingham, describing their "Starsaw," an adaptor to be fitted to a ¼-in. electric drill that will convert the rotary motion into a reciprocating motion suitable for driving hacksaw blades.

Builder's Level.—An illustrated leaflet describing the "Cowley" automatic level (the optical sight is weighted so that it automatically takes up a horizontal line sufficiently accurate for setting-out by builders) and other accessories has been received from Buck & Hickman, Ltd., 29-30, Whittal-street, Birmingham.

Electric Motors.—A booklet of pocket size has been published by Higgs Motors, Ltd., Witton, Birmingham, 6, containing an abridged list of their range of electric motors.

33/38·5-kV Outdoor Circuit-Breaker.—A pamphlet received from the Brush Electrical Engineering Co., Ltd., Loughborough, deals with their 33/38·5-kV outdoor circuit-breaker, which is of the bulk-oil type and has been designed for use under arduous operating conditions.

15-kV Metal-Clad Switchgear.—The Brush Electrical Engineering Co., Ltd., Loughborough, have sent us a brochure dealing with their metal-clad switchgear. This is of the air-insulated vertical draw-out pattern and has ratings up to 1,200 amperes at 15 kV.

Industrial Matting.—A leaflet explaining the construction and showing typical uses of the firm's non-slip fibred rubber industrial matting has been sent to us by Nuway Manufacturing Co., Ltd., Coalport, Shropshire.

Electrical Measuring Instruments.—We have received an illustrated leaflet from Electronic Instruments, Ltd., Red Lion-street, Richmond, Surrey, which describes the company's full range of standard laboratory and industrial electrical-measuring instruments.

Electrical Instruments.—We have received an illustrated leaflet from the Croydon Precision Instrument Co., Windmill-road, Croydon, Surrey, which shows details of their variable-resistance boxes, volt-ratio box, and strain-measuring bridge.

Plastic Mouldings.—Two pamphlets have been issued by Precision Components (Barnet), Ltd., 13, Byng-road, Barnet, Hertfordshire. One illustrates their 2, 3, and 4-way connector blocks, and 12-way connector strip, and gives the sizes in which they are available, and the other gives details of bench assembly trays.

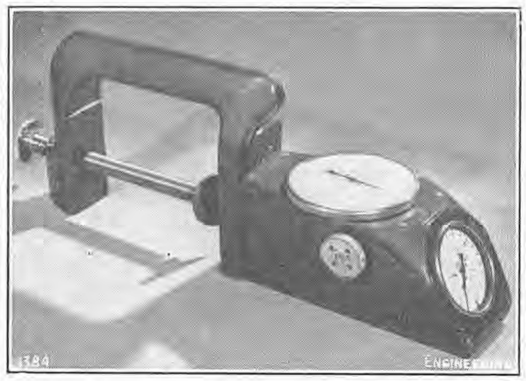
Infra-Red Plant Heating.—An illustrated pamphlet describing their "Stabilag" jackets, which can be made to fit any shape of vessel and provide controlled heating from 0-1,000 deg. C., has been sent to us by the Stabilag Co., Ltd., 1, Broad-street Buildings, Liverpool-street, London, E.C.2.

Combination Length Bars.—Complete details of their ⅞-in. dia. length bars for dimensions from ½ in. to 100 in. are shown in an illustrated booklet received from the Pitter Gauge and Precision Tool Co., Ltd., 32, Market-street, Woolwich, London, S.E.18. Also shown are accessories for converting the length bars to a gap, internal, or height gauge, and giving length adjustments of 0·0001 in. with the aid of standard slip gauges. The bars are made in three grades: workshop, inspection, and reference.

DIRECT-READING PORTABLE HARDNESS TESTER.

THE indentometer direct-reading portable hardness tester illustrated below, which is made by the Cabul Tool Company, Limited, 46-48, Battersea Bridge-road, London, S.W.11, was shown at the Factory Equipment Exhibition to which reference was made on page 404, *ante*. The tester can be used with a 120-deg. diamond cone indenter, a $\frac{1}{16}$-in. steel ball, or a ⅛-in. steel ball for readings on the Rockwell C and B, or F, G, E, K and A hardness scales. A "Supafine" model is also made which gives readings on Rockwell N and T hardness scales.

The body of the indentometer is an aluminium casting fitted with a brass pressure chamber in the form of a shallow cylinder, which is filled with fluid, and has a beryllium-copper diaphragm over one end. Attached to the diaphragm is a rod linking it with the indenter. The pressure in the chamber and hence the load on the indenter is varied by a small handwheel at the side of the instrument, which moves the chamber forwards or backwards. A pressure gauge mounted on the end face of the body shows the pressure in the chamber and on the top face is a rack and pinion-type gauge which records the movement of the indenter and gives readings on a dial graduated to show a movement of 0·002 mm., which corresponds to one point on the Rockwell scale. A cast-iron clamp



with a simple clamping screw holds the specimen being examined and it is stated that this type of clamp does not distort under the loads normally imposed. Various alternative clamping attachments are made which are interchangeable with the standard clamp. They include a chain clamp and also an electromagnetic base which can be used for attaching the indentometer to the surface of a large object upon which a number of readings must be made at different points.

To operate the instrument, after clamping the specimen in position, the handwheel must be rotated until the indicator of the pressure gauge is level with the position marked "minor load" which is equivalent to 3 kg. The dial of the hardness gauge is then set with the indicator at zero, and the load is again increased by the handwheel to the desired figure. Ten seconds is allowed for the indenter to settle and then the load is returned to the "minor load" setting, when the hardness value of the specimen will be shown by the indicator of the gauge on top of the instrument in points Rockwell. A maximum load of 150 kg. can be applied by the standard model, and of 45 kg. by the "Supafine" model. The latter is intended for laboratory work only and has a hardness dial graduated in 0·001 mm., corresponding to 0·5 on the Rockwell scale. It is said that the indentometer is also suitable for use with plastics because of the wide variety of loads that can be applied. The weight of the instrument alone is 17 lb., or 24 lb. complete with carrying case. The sole distributors are C. Tennant, Sons and Company, Limited, 4, Copthall-avenue, London, E.C.2.

BROADCAST RECEIVING APPARATUS FOR USE IN SCHOOLS.—The School Broadcasting Council for the United Kingdom, 55, Portland-place, London, W.1, have issued a fourth list of broadcast receiving apparatus approved as suitable for use in schools. All the apparatus mentioned has been tested by the Council.

BOOKS RECEIVED.

London's Water Supply. 1903-1953. A Review of the Work of the Metropolitan Water Board. Staples Press Limited, 14, Great Smith-street, London, S.W.1.

Ministry of Labour and National Service. Factory Department. Second Report of Proceedings of the Joint Standing Committee on Safety in the Use of Power Presses. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]

Department of Scientific and Industrial Research. Report for the Year 1951-52. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 8s. net.]

La Spectroscopie d'Émission et ses Applications. By PIERRE MICHEL. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). [Price 260 francs.]

Mechanics for Engineering Students. By G. W. BIRD and F. J. BATSON. Fourth edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 10s. 6d.]

Gestaltung und Berechnung von Ölkühlern. By DR. ANDREA F. FRITZSCHE. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 12.50 Swiss francs.]

Manual for the Design of Ferrous and Non-Ferrous Pressure Vessel and Tanks. By KARL SIEMON. Fourth edition. Edwards Brothers Incorporated, Ann Arbor, Michigan, U.S.A. [Price 3.85 dols.]

Engineering Manufacturing Methods. By PROFESSOR GILBERT S. SCHALLER. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 7 dols.]; and McGraw Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 59s. 6d.]

Canada. Department of Mines and Technical Surveys. Industrial Water Resources of Canada. Water Survey Report No. 2. *Ottawa River Drainage Basin*, 1947-48. By J. F. J. THOMAS. The Director, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada. [Price 75 cents.]

Modulators and Frequency-Changers. By DR. D. G. TUCKER. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 28s. net.]

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Adjustable Adaptors for Multiple-Spindle Drilling Heads.—A new specification, B.S. No. 1935, covering adjustable adaptors for multiple-spindle drilling heads, has been prepared in order that adaptors may be interchangeable not only between the various makes of spindle manufactured in this country, but also between British and American spindles. In the United States, the single adjusting nut has been found satisfactory, apparently, but in the present specification, although the general principle of the single nut has been adopted, it has been considered advantageous to include provisions for two nuts for use when precision adjustments may be required. The specification contains clauses relating to dimensions, material and various manufacturing matters. The adaptors specified, it is pointed out, are for Morse-taper shank tools and are not intended for use with tools having parallel shanks. [Price 2s. 6d., postage included.]

Free-Machining Brass Rods and Sections.—A second revision of B.S. No. 249, covering free-machining brass rods and sections, has now become available. In the present edition, the range of sizes covered has been extended to include material $\frac{1}{16}$ in. in diameter, the chemical composition has been altered slightly, and rolled material has been omitted as the type of material covered is now generally extruded or extruded and drawn. Tolerances have been amended to bring them into line with present-day practice. Throughout the specification, the term "rod" has replaced the word "bar" which was used in the 1940 edition. [Price 3s., postage included.]

Flat Dies for Thread Rolling.—The production of screw threads by the thread-rolling process has developed along two parallel lines, one using flat dies and the other circular dies, or thread rolls, as they are termed. Complementary specifications have been prepared, relating to each of the two methods. Specification B.S. No. 1946 presents dimensional and accuracy requirements for flat dies intended for the production of Unified, Whitworth or British Association threads. Two separate methods of production of the dies have been devised, one finishing the form by grinding and the other by milling. The limits of tolerance on the thread forms in the specification refer to the former only. The accuracies pertaining to the various die faces and planes have been extended to the duplex form which has been widely adopted. [Price 4s., postage included.]