1,000-KW GAS-TURBINE ALTERNATOR SET FOR THE ROYAL NAVY.

The advent in recent years of the gas turbine as a practical prime-mover, with its potential advantages of compactness, light weight, and low maintenance requirements, in addition to those of self-contained operation and quick starting already associated with the Diesel engine, led the Admiralty to consider the development of a gas turbine-driven alternator suitable for naval requirements. A development contract was therefore placed by the Admiralty at the beginning of 1948 with Messrs. W. H. Allen, Sons and Company, Limited, Bedford, who have had long experience with steam turbo-generators for naval service.

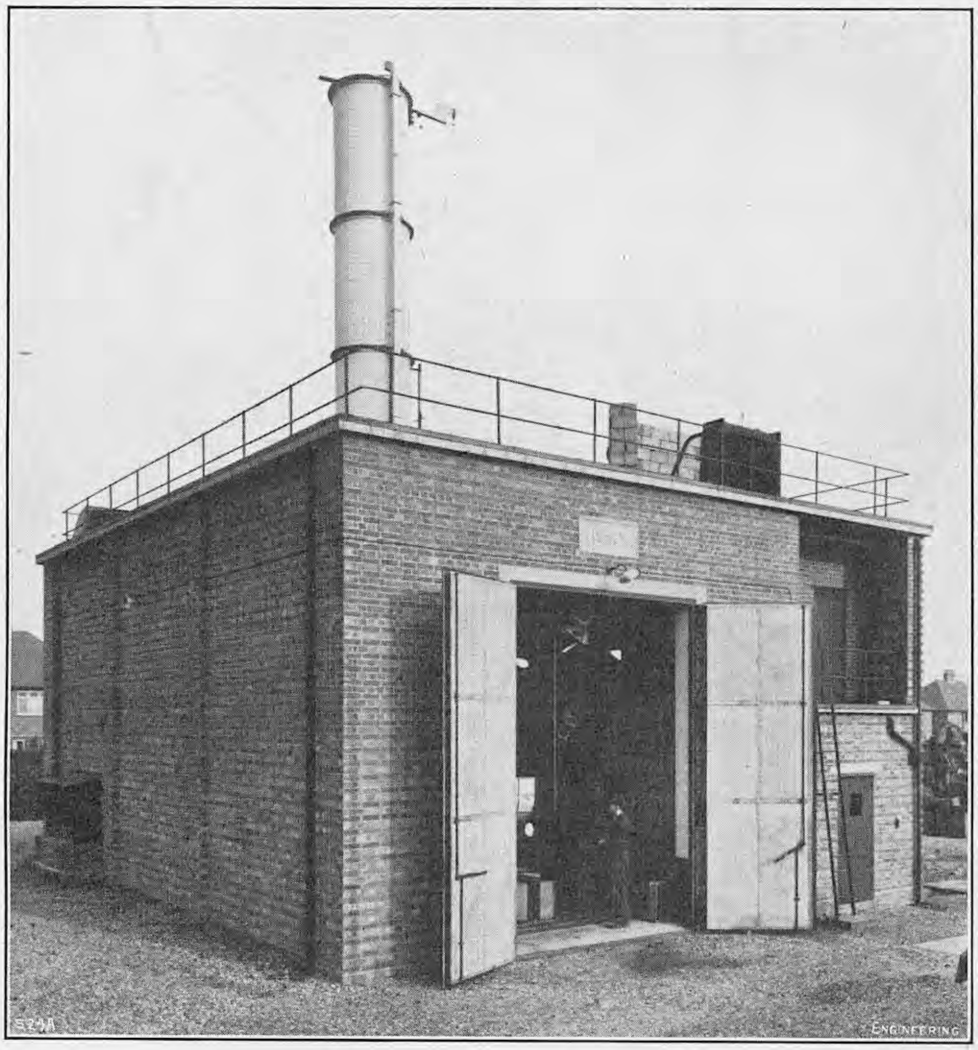

Fig. 1. Gas-Turbine Test House.

It was appreciated that the fuel consumption of a gas turbine in the present stage of development, especially when designed for maximum reliability and long life, is high compared with the Diesel engine, although of the same order as a steam turbo-generator. It was therefore decided that a gas turbine-driven alternator should be built to a clearly-defined naval specification for base-load operation. Messrs. Allen commenced the design at the beginning of 1948, and the unit was successfully run at full speed and full power early this year. The results already achieved in such a short space of time have been brought about by concentrating a new gas-turbine team on the problems, and by the extension of existing facilities. The firm have set aside a section of their Biddenham Works for the assembly of gas turbines and for the installation of special machine tools required for blade manufacture. In addition, they have built on behalf of the Admiralty a fully-equipped and instrumented test house, which is shown in Fig. 1, herewith. The work has been greatly facilitated by a consultancy agreement between the Bristol Aeroplane Company, Limited, and Messrs. Allen, which entitles them to design data, advice on production methods, and the use of certain testing facilities.

After carefully balancing the conflicting requirements of low weight and space with reasonably good efficiency, a comparatively simple open-cycle set was chosen, having an axial-flow compressor with a compression ratio of $4\frac{1}{4}$: 1, driven by a two-stage turbine; an annular two-pass cross-flow heat exchanger; a multi-chamber combustion system disposed symmetrically round the engine; and a separate single-stage power turbine driving the Allen alternator through Allen-Stoeckicht epicyclic gearing. The drawings reproduced in Figs. 2 (on page 610), 3 (page 611), and 11 (on Plate XXXVIII), show the general arrangement of the set, and Figs. 9 and 10, on Plate XXXVII, show it erected for testing. The set is within the required height of 7 ft., and has a length of 16 ft. and a width of 8 ft. 6 in. The total weight of the gas turbine, including heat exchanger but excluding alternator, is $8\frac{1}{2}$ tons. The unit is without a baseplate, a three-point mounting being effected by mounting the compressor independently. The supports on either side of the heat exchanger are flexible and take care of thermal expansion. The set is carried on resilient rubber mountings to minimise the effect of shock loading due to under-water explosions.

The Admiralty specification called for a set of 1,000-kW maximum continuous rating, with a 20 per cent. overload for 10 minutes, to be suitable for operation at all loads up to overload under temperate (60 deg. F.) or tropical (100 deg. F.) conditions, and capable of running satisfactorily in parallel with steam turbo-alternators. The governing requirements were a $2\frac{1}{2}$ per cent. speed change for 50 per cent. load change, and the ability to accept or shed 100 per cent. load without the emergency gear operating. The fuel was to be Diesel oil (Admiralty reference fuel B 310), and a maximum fuel consumption of 1·27 lb. per kilowatt per hour under tropical conditions, in the range 60 to 100 per cent. power, was specified. Total head pressures of 14·1 lb. per square inch (absolute) at the compressor intake and 15·1 lb. per square inch at the power-turbine outlet were called for, thus allowing for very high inlet and exhaust trunking losses. The engine was to be entirely self-contained and to be as small as is consistent with reasonable accessibility, the maximum height available being 7 ft., and every reasonable opportunity was to be taken to reduce weight without sacrificing reliability. Shock loadings of $40g$ upwards, $25g$ downwards and $15g$ athwartships were specified. Finally, a life of 100,000 hours was to be aimed at, this period being made up of 65,000 hours at 80 per cent. power under temperate conditions, 33,000 hours at 80 per cent. power under tropical conditions, and 2,000 hours at full power under tropical conditions. The principal dimensions, etc., are shown in Table I, herewith.

Table I.—*Basic Design Particulars.*

Continuous maximum rating at power-turbine coupling, including fouling margin, b.h.p. ..	1,512
Estimated specific fuel consumption at C.M.R., lb. per b.h.p. per hr.	0·745
Estimated thermal efficiency at power-turbine coupling at C.M.R., per cent.	19·75
Mass flow at C.M.R., lb. per sec.	37
Max. gas temperature under tropical conditions, deg. C.	700
Max. gas temperature under temperate conditions, deg. C.	650
Compressor speed, r.p.m. approx.	8,000
No. of compressor stages	13
No. of compressor-turbine stages	2
Estimated compressor adiabatic efficiency, per cent.	84
Estimated compressor-turbine adiabatic efficiency, per cent.	85
Power-turbine speed, r.p.m., approx.	6,750
No. of power-turbine stages	1
Estimated power-turbine adiabatic efficiency, per cent.	84
Alternator speed, r.p.m., approx.	1,500
Type of combustion chambers	Straight-through
No. of combustion chambers	8
Type of burner	"Simplex"
No. of heat exchanger passes, hot gas	1
cold air	2
Heat-exchanger thermal ratio, per cent.	70

Note.—The output stated is that obtained with the high inlet and exhaust losses specified. Without these abnormal losses, the C.M.R. electrical output would be 1,250 kW (temperate conditions), the thermal efficiency would be 24 per cent., and the specific fuel consumption 0·625 lb. per brake horse-power per hour.

The mechanical design is based on the component-assembly principle, i.e., each assembly is removable from the machine independently of the others. The compressor casing is split on the horizontal centre-line, as shown in Figs. 12 and 13, Plate XXXVIII, and the top half is easily removable for inspection purposes without breaking any pipe joints. The centre bearing can be inspected by dismantling the air pipes connected to the top half of the casing and removing the top half casing, which is also split on the horizontal centre-line. The two turbines can be readily inspected after removal of the compressor air-delivery pipes and the combustion chambers, by splitting the casing vertically between the compressor turbine and power turbine and moving the compressor, with its associated turbine, away bodily, while supporting its weight by an overhead crane. If necessary, either the power-turbine or the compressor-turbine assembly can be removed end-wise as a unit for further dismantling. The gear case is split horizontally and the epicyclic-gear assembly can be removed vertically for inspection or dismantling.

The compressor is of the axial-flow multi-stage type. The rotor, shown in Fig. 14, Plate XXXVIII, is of a special built-up design to reduce its moment of inertia to as small a value as possible in order to assist the speed governor during sudden large load changes. The inlet end of the shaft is manufactured from 1 per cent.-chromium molybdenum steel, and the outlet end of Nitralloy steel hardened at the bearing journals. The rotor wheels are of 1 per cent.-chromium molybdenum steel to British Standard Specification En. 19, the discs being secured to each other on the faces of the bosses by means of dowel pins, through which the torque is transmitted. The complete rotor-disc assembly and the shaft ends are clamped together by a steel bolt passing through the centrally-bored discs. Due allowance is made in the design of this bolt to withstand any load due to thermal expansion, etc., during running. Concentricity is maintained between the compressor-disc assembly and the two stub shafts under all conditions of speed and

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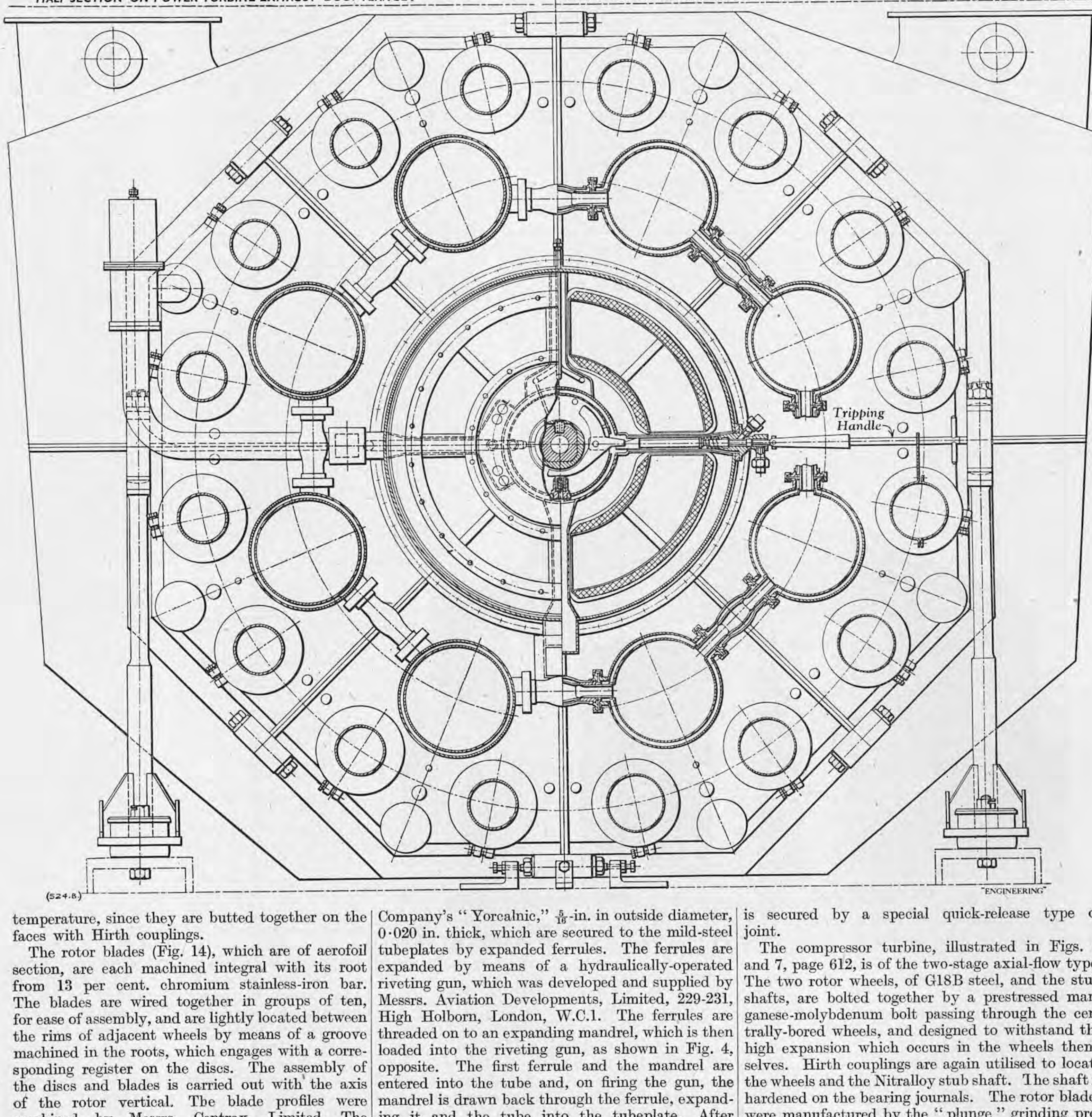
Fig. 2. LOOKING FROM COMPRESSOR END.

HALF SECTION ON POWER-TURBINE EXHAUST DUCT FLANGE. | HALF SECTION ON C.L. OF INTERCONNECTORS AND POWER-TURBINE EMERGENCY TRIP.



temperature, since they are butted together on the faces with Hirth couplings.

The rotor blades (Fig. 14), which are of aerofoil section, are each machined integral with its root from 13 per cent. chromium stainless-iron bar. The blades are wired together in groups of ten, for ease of assembly, and are lightly located between the rims of adjacent wheels by means of a groove machined in the roots, which engages with a corresponding register on the discs. The assembly of the discs and blades is carried out with the axis of the rotor vertical. The blade profiles were machined by Messrs. Centrax, Limited. The stator blades are of Monel-metal rolled strip, also of aerofoil section, cast into combined roots, and spacers and secured in grooves in the casing. The casing is of cast-steel construction, split on the horizontal centre-line. Double-skin construction of the stator casing is adopted to ensure sufficient space for an adequate amount of air blow-off, but it has since been found that this is not necessary.

The heat exchanger, illustrated in Fig. 15 on Plate XXXVIII, is of the tubular cross-flow recuperative type, arranged with a single pass on the hot exhaust-gas side and two passes on the cold inlet-air side. It is built of eight similar segments, each containing just over 2,000 tubes, the total number being 16,500. The shell is of fabricated aluminised mild steel, fitted with tubes of the Yorkshire Copper Company's "Yorcalnic," $\frac{5}{16}$-in. in outside diameter, 0·020 in. thick, which are secured to the mild-steel tubeplates by expanded ferrules. The ferrules are expanded by means of a hydraulically-operated riveting gun, which was developed and supplied by Messrs. Aviation Developments, Limited, 229-231, High Holborn, London, W.C.1. The ferrules are threaded on to an expanding mandrel, which is then loaded into the riveting gun, as shown in Fig. 4, opposite. The first ferrule and the mandrel are entered into the tube and, on firing the gun, the mandrel is drawn back through the ferrule, expanding it and the tube into the tubeplate. After expanding, the inside diameter of the ferrule is the same as that of the tube bore, as shown in Fig. 5. This method of tube assembly has been found to be satisfactory and extremely rapid.

The machine is provided with a multi-chamber combustion system consisting of eight chambers, which are disposed symmetrically about the axial centre-line of the turbine shaft. The combustion chambers were designed and made by Messrs. Joseph Lucas, Limited. The inner flame tubes are of Nimonic 75 nickel-chromium alloy, cooled by the secondary air. The outer air casing is of mild-steel sheet, aluminised and fitted with two bellows expansion pieces to take up the differential expansion between the turbine casing and the heat exchanger. Each end of the combustion chambers is secured by a special quick-release type of joint.

The compressor turbine, illustrated in Figs. 6 and 7, page 612, is of the two-stage axial-flow type. The two rotor wheels, of G18B steel, and the stub shafts, are bolted together by a prestressed manganese-molybdenum bolt passing through the centrally-bored wheels, and designed to withstand the high expansion which occurs in the wheels themselves. Hirth couplings are again utilised to locate the wheels and the Nitralloy stub shaft. The shaft is hardened on the bearing journals. The rotor blades were manufactured by the "plunge" grinding process patented by the Bristol Aeroplane Company, and are of Nimonic 80A, secured in axial fir-tree serrations in the periphery of the wheels, each blade being fixed by a locking key. All stator blades are of Nimonic 80 material, produced by the lost-wax process of precision casting. The first-stage blades are riveted in groups to segmented strips to form assemblies easy to handle. Each second-stage blade is secured in a groove in the intermediate casing ring and located circumferentially by means of two pegs. The inner end of the blades has a cylindrical projection which fits into a radial hole in the diaphragm. This engagement is such that the stator blade is free to expand radially towards the centre of the diaphragm, and the diaphragm to expand radially outwards. The diaphragm is

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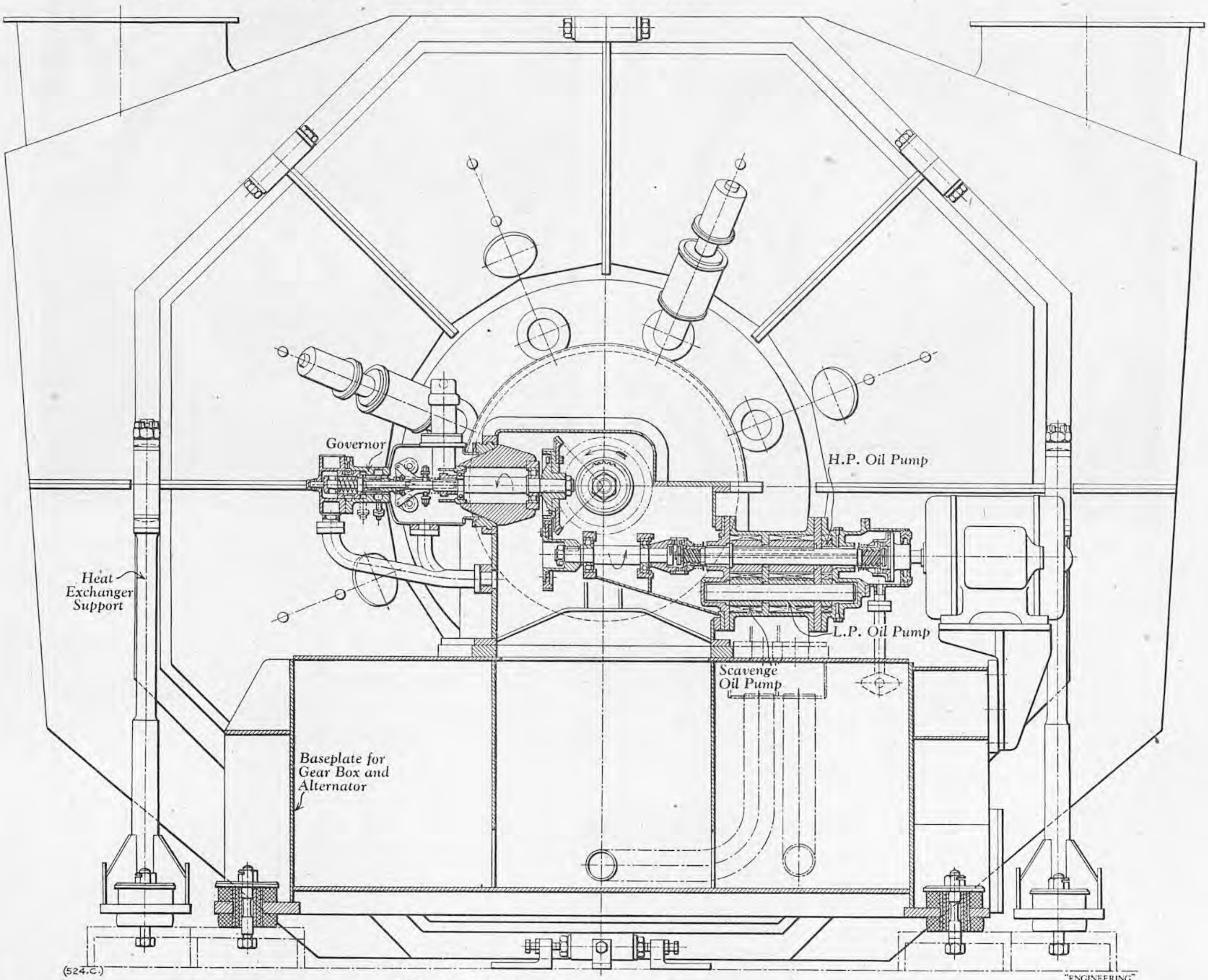
Fig. 3 SECTION ON GOVERNOR AND OIL PUMP, LOOKING FROM ALTERNATOR END.



protected by heat shields designed to prevent distortion due to the temperature gradient.

The compressor-turbine casing consists of an inner and outer member designed to minimise thermal stresses due to expansion and to allow all parts to expand freely and yet remain concentric. A centre casing ring of heat-resisting material is located in the main casing by means of radial keys, in such a manner that it is free to expand in a radial direction at all points on its circumference. Inner segmented shroud rings of H.R. Crown Max steel are arranged to expand circumferentially in grooves in this casing ring. This arrangement maintains the blade-tip clearances at all loads, thus improving the efficiency and also making it quite safe to shut down and start up quickly. Cooling air from the compressor passes around the inner casing and through passages in the centre casing ring before joining the main gas stream. The coupled compressor and driving turbine shafts are supported in three bearings. Allowance for any mal-alignment of the shafts is made by connecting them by means of a quill shaft forming an extension of the turbine shaft, which is located in the bore of the compressor shaft. The driving torque is, however, transmitted through a normal gear-tooth muff coupling.

The power turbine is of the axial-flow type, consisting of a single-stage unit, mechanically independent of the compressor turbine. The materials and

Fig. 4. SECTION BEFORE EXPANDING

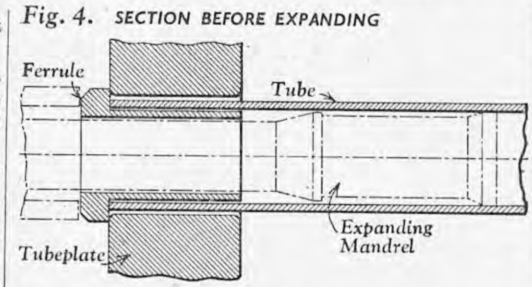
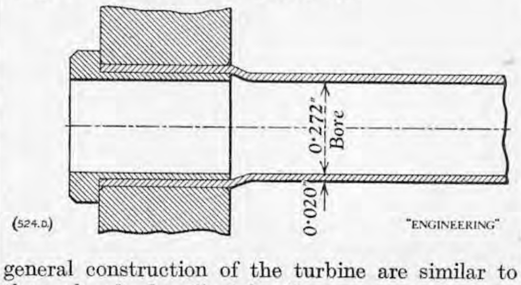


Fig. 5. SECTION AFTER EXPANDING



general construction of the turbine are similar to those already described for the compressor turbine, with the exception that the rotor wheel is of Jessop's H 40 ferritic steel. The bearing is connected radially to the outer main turbine casing by four radial fabricated struts passing through streamline aerofoils, which are themselves integral with the mild-steel power-turbine exhaust-diffuser ducting assembly.

Great attention has been paid to the efficient cooling of the rotors and casing. There are several cooling systems so arranged that air from the compressor delivery passes through passages in the turbine casings and up both sides of the turbine rotor discs, finally joining the main gas stream.

All main compressor and turbine bearings are of the sleeve type, the design generally following well-established steam-turbine practice. The bearings are of steel, lined with white-metal, with the exception of those which may be subjected to higher temperatures, which are of mild steel, lined with lead bronze. They are lubricated and cooled by oil at a pressure of approximately 10 lb. per square inch. Ball and roller bearings are incorporated in the auxiliary drives. The thrust bearings are of the Michell type. Journal bearings are fitted with thermocouples and thrust bearings with hydraulic wear gauges. The casing glands of the compressor and turbine, as well as the inter-stage glands, are of the labyrinth type, consisting of stationary stainless-iron fins working in conjunction with stepped shaft journals. The turbines and their driving shafts are coupled by means of continuously-

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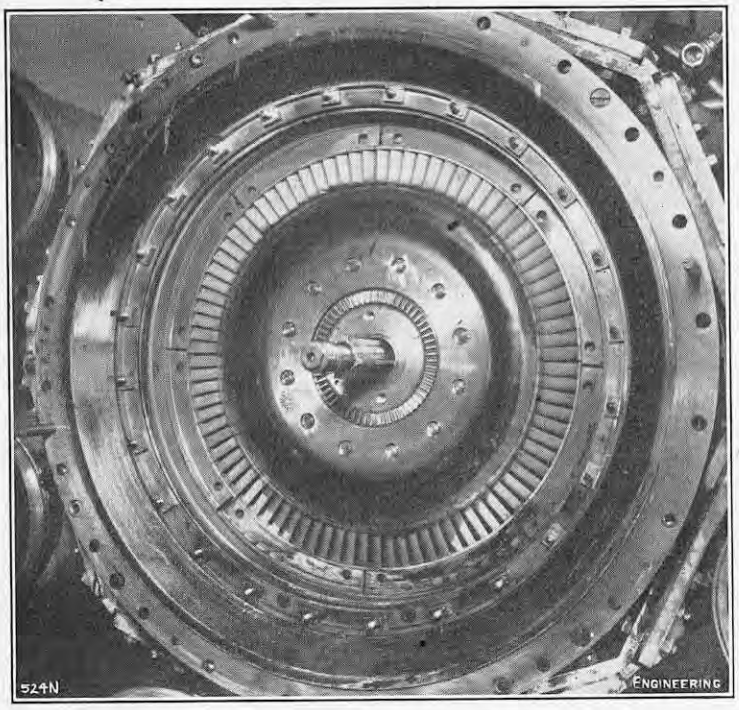


Fig. 6. First Stage of Compressor-Turbine Stator.

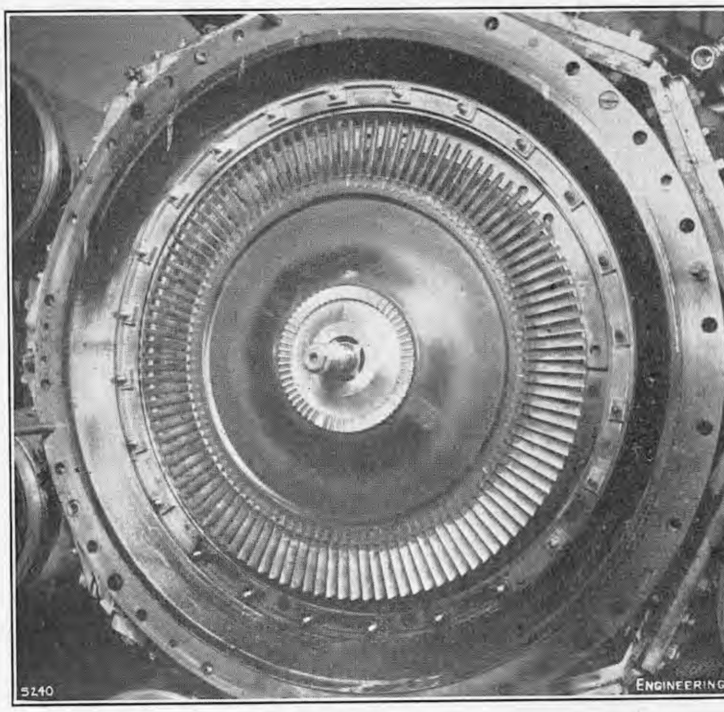


Fig. 7. Second-Stage Rotor of Compressor Turbine.

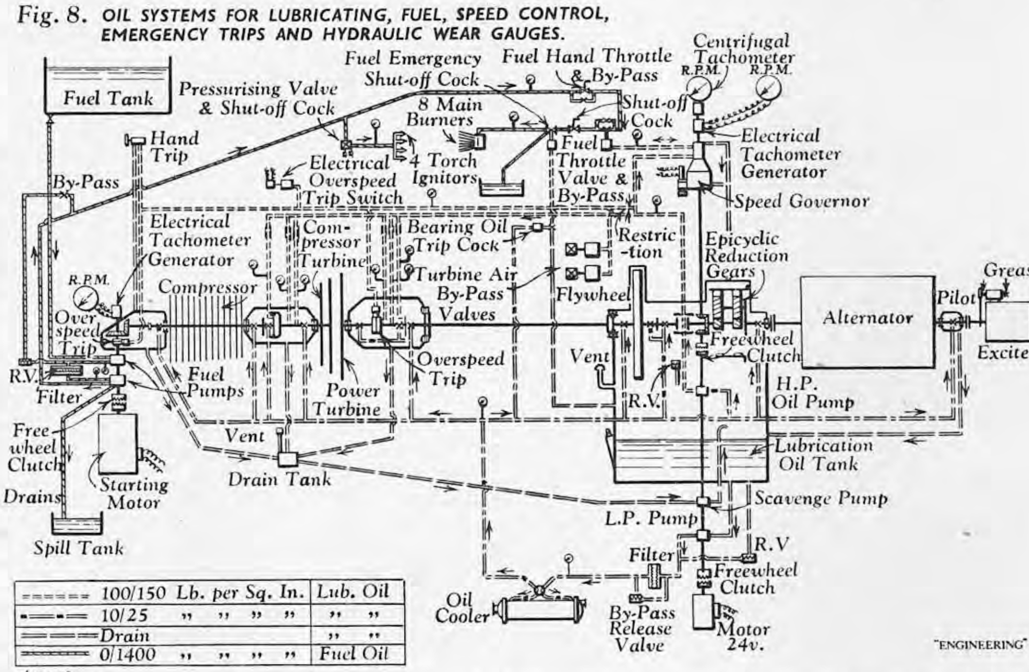
lubricated couplings of the internal-tooth type. Oil is fed by centrifugal force through internal passages to each tooth engagement.

Speed reduction between the power turbine and alternator is achieved by a double-helical Allen-Stoeckicht epicyclic gear,* illustrated in Figs. 16 and 17, Plate XXXIX, which offers the maximum saving in weight and space. The gear is designed on the well-known Stoeckicht principle (which ensures equal load sharing, not only between the planet wheels, but also between the helices), and is capable of transmitting 1,800 h.p. continuously with a turbine speed of 6,750 r.p.m. and an alternator speed of 1,500 r.p.m. There are no high-speed shaft bearings in the gear unit, the sun wheel, which is supported between the three planet wheels, being connected to the power turbine by means of a flexible coupling of the double-helical-tooth type.

The Allen alternator is of the open self-ventilated rotating-field salient-pole type, continuously maximum rated to develop 1,000 kW at 0·8 power factor, 50 cycles, three phase, at a pressure of 400/430 volts when driven at 1,500 r.p.m. The machine is capable of developing 20 per cent. overload for a period of 10 minutes. The stator windings, which are of high-conductivity copper, insulated with moulded micanite, are held in position by synthetic-resin-bonded fabric wedges. The rotating-field windings are of robust strip-on-edge construction. The rotor poles are secured to a steel shaft which is carried in a single split-sleeve pedestal-type bearing and arranged for rigid coupling to the gearwheel shaft. The bearing is arranged for pressure lubrication, oil being provided from the turbine lubrication system. A carbon-pile voltage regulator is connected in the exciter-field circuit, and to obtain quick voltage response a permanent-magnet pilot exciter is employed, belt-driven from the main exciter. The use of a permanent-magnet pilot exciter avoids the necessity for a small commutator and brush gear. It comprises a four-pole permanent-magnet rotor in a normal stator frame, the output from which supplies the field of the main exciter via a metal-oxide rectifier located in the air stream of the main exciter at the bottom of the commutator end bracket. The exciter is of the two-bearing type, flexibly coupled to the rotor shaft, and is provided with a shunt-field regulator.

* Epicyclic gear units of this type were described in Engineering, vol. 171, page 117 (1951).

Fig. 8. Oil Systems for Lubricating, Fuel, Speed Control, Emergency Trips and Hydraulic Wear Gauges.



(524.P)

The set has no baseplate, a three-point mounting being effected by mounting the compressor independently. The supports on either side of the inlet to the heat-exchanger are flexible and take care of thermal expansion.

The lubricating-oil system closely follows usual steam-turbine practice, embodying two separate valveless gear-type oil pumps (Fig. 3). One pump delivers oil at about 120 lb. per square inch (gauge) to the governor oil system, while the other delivers oil at approximately 45 lb. per square inch for bearing and gear-teeth lubrication. The pumps are arranged for driving in tandem, either by an electric motor when starting up, or by the turbine shaft through gearing during normal running. A clutch arrangement enables the drive to be automatically transferred from the motor to the turbine when the latter has reached a speed sufficient to maintain the pressure in the oil system. The oil for the governor pump is taken from the lubricating system so that the oil for both systems passes through a filter and cooler. The oil systems are shown in Fig. 8, herewith.

The turbine is provided with a simple fuel-oil system employing Lucas Simplex-type burners. The quantity of fuel delivered to the combustion chambers is varied by the opening of a throttle valve fitted in the fuel-supply pipe to the burners and controlled by the speed governor through an oil relay. A hand-controlled throttle valve is used when starting up. The fuel pump is a Lucas type B, driven through gearing from the compressor shaft. An emergency shut-off valve is incorporated in the fuel system, which operates automatically in the event of the turbine over-speeding or on failure of the lubricating-oil pressure. This valve is also arranged to close on manual operation of trip cocks situated both on the turbine and on the control panel. Four of the eight inter-connectors fitted between the combustion chambers are fitted with a torch igniter assembly, each assembly consisting of a thermocouple, a plug and the torch itself.

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(*For Description, see Page* 609.)

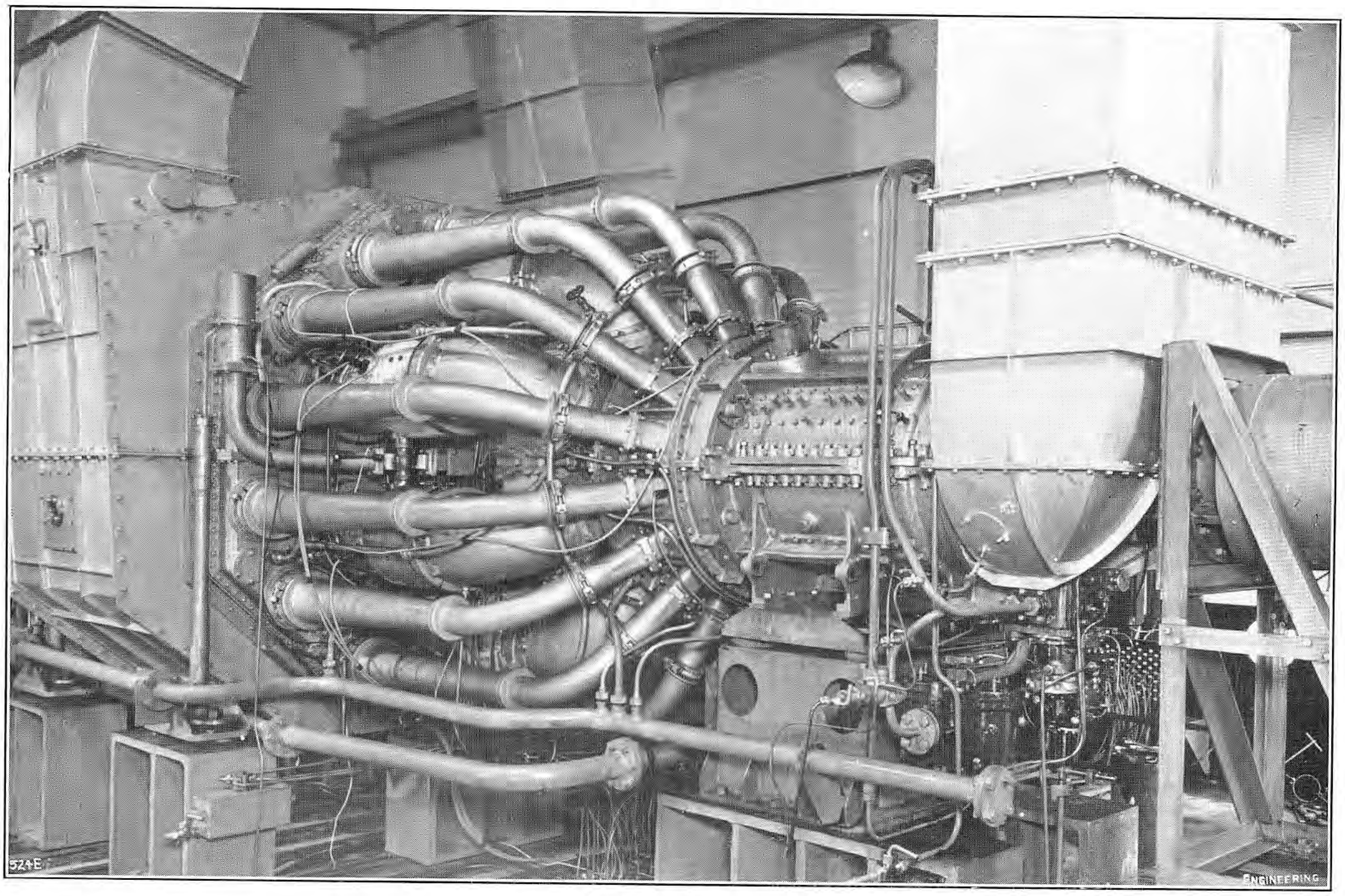

Fig. 9.

Fig. 10.

Figs. 9 and 10. Views of the Set, from Opposite Sides, Erected for Testing.

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1,000-KW GAS-TURBINE ALTERNA

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Fig. 11. SECTIONAL ARRANGEMENT OF TURBINE FOR 1,000 KW. ALTERNATOR.

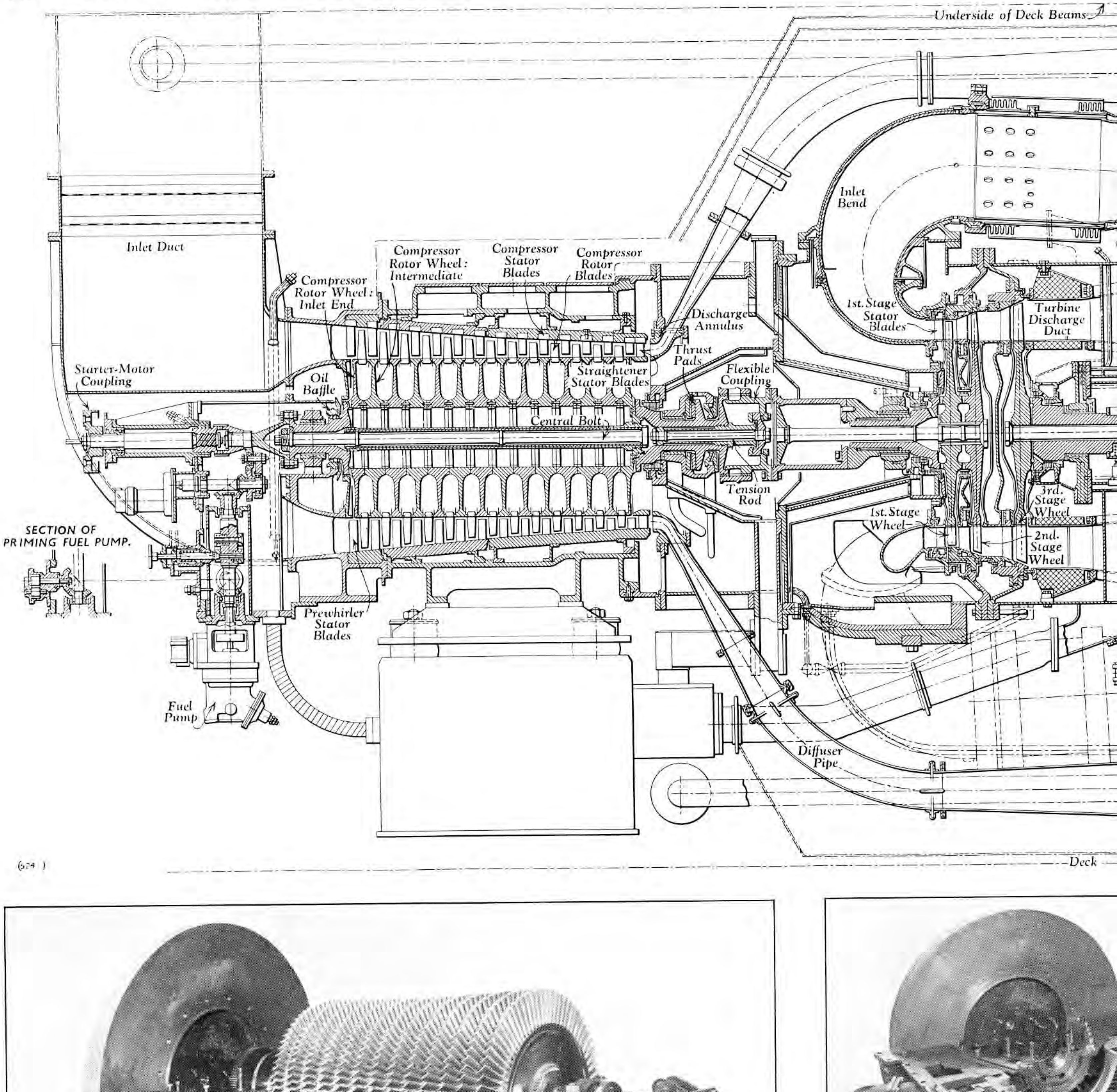

Fig. 12. Bottom Half of Compressor Casing, Rotor in Position.

Fig. 13. Bottom Half of Com

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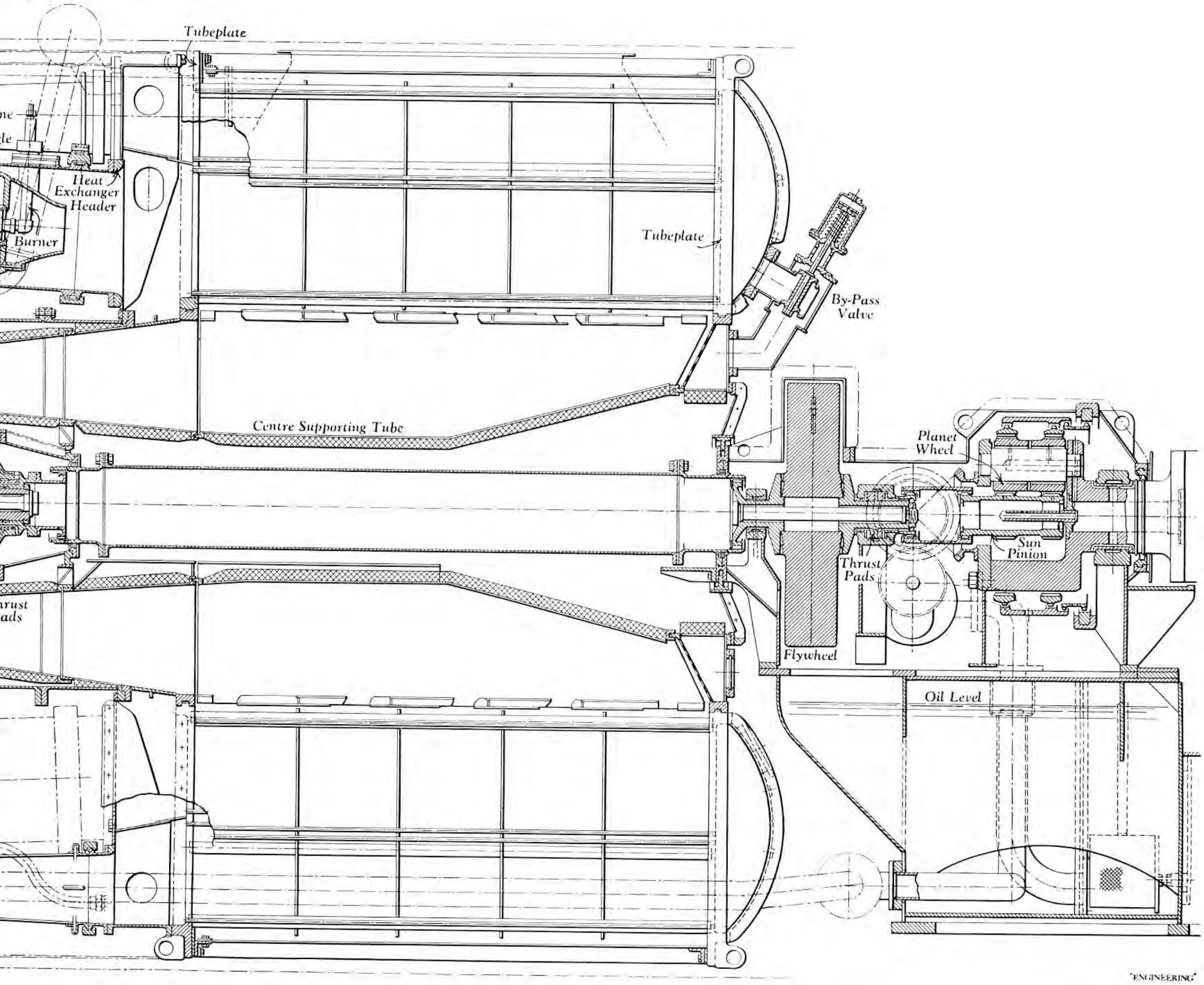

G, WITHOUT ROTOR.

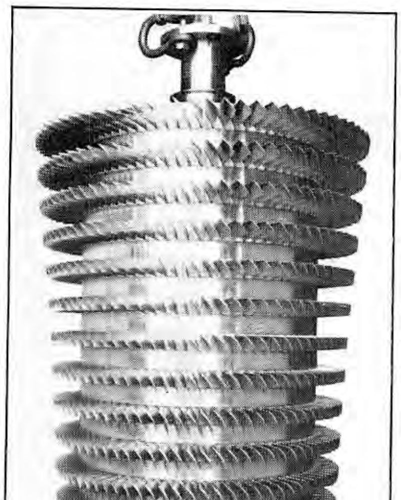

FIG. 14. AXIAL-FLOW COMPRESSOR ROTOR.

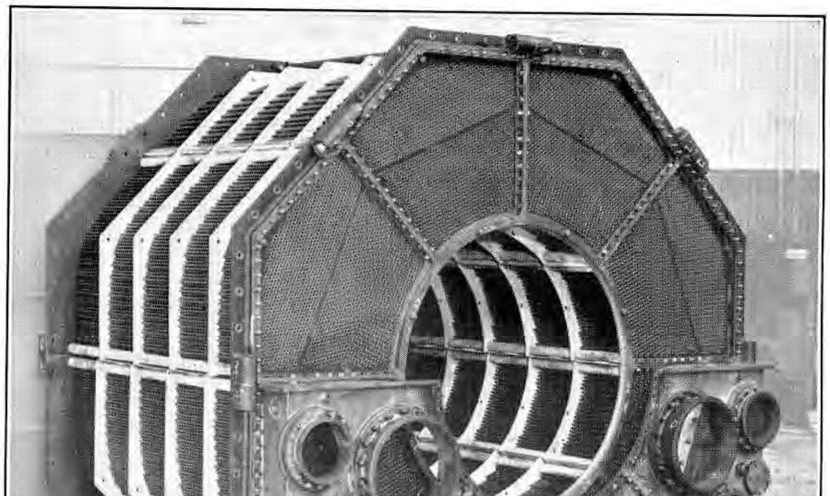

FIG. 15. HEAT EXCHANGER; TOP FOUR AIR HEADERS REMOVED.

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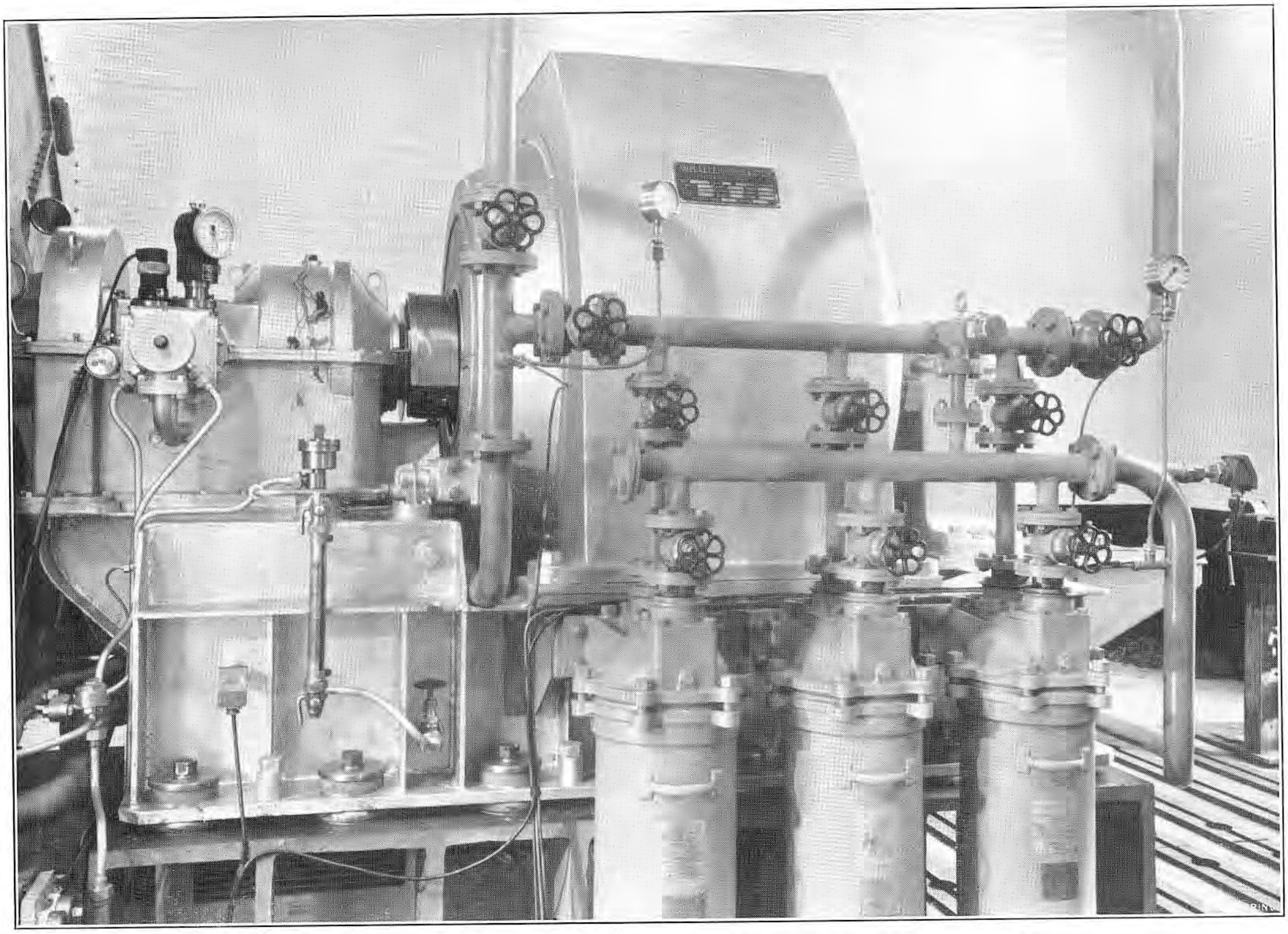


FIG. 16. ALLEN-STOECKICHT EPICYCLIC-GEAR UNIT BETWEEN POWER TURBINE AND ALTERNATOR.

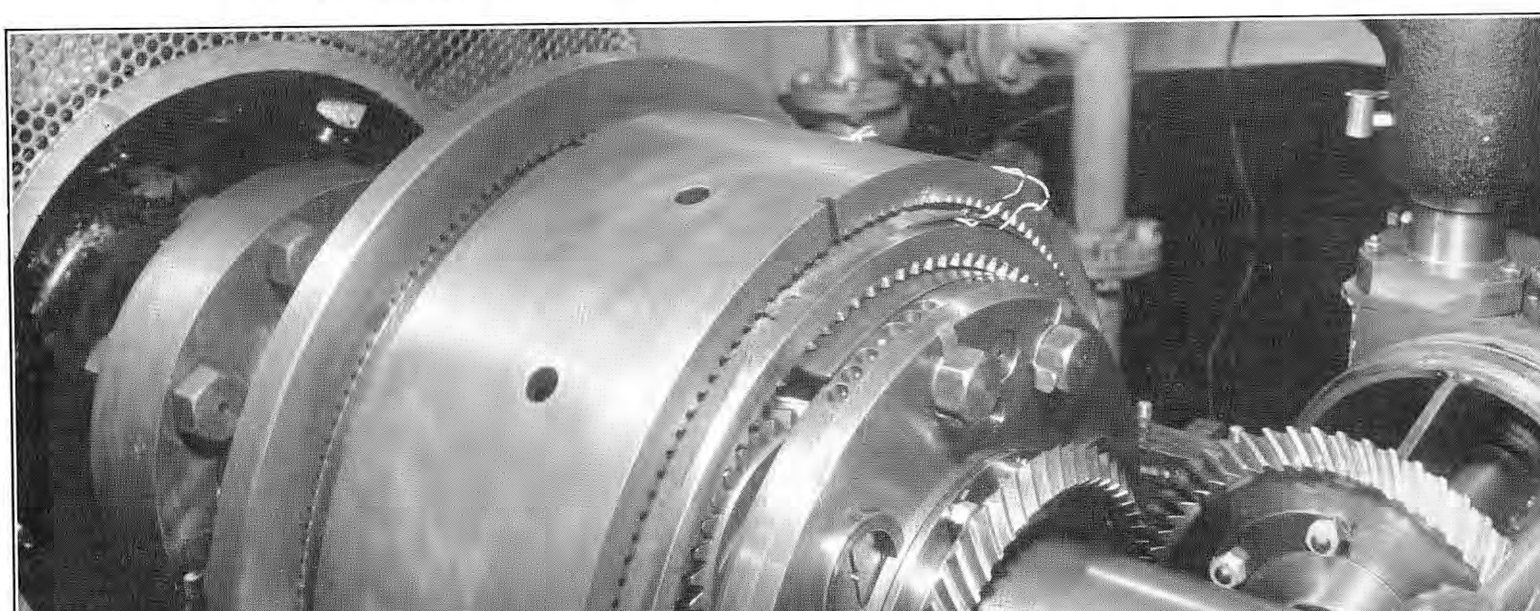


FIG. 17. EPICYCLIC-GEAR UNIT WITH TOP COVER REMOVED.

Complete reliability at starting is ensured with this arrangement, as each chamber is ignited directly from a torch. As a double safeguard in the event of one or more of the torches failing to ignite, the inter-connectors ensure satisfactory ignition in all the chambers.

The speed-control governor is of the centrifugal type, driven from the power-turbine shaft, and operates the fuel throttle valve through an oil relay. The oil relay is supplied with high-pressure oil and is arranged so that in the event of a failure of the lubricating-oil supply the machine is automatically shut down. To assist the speed governor during sudden load changes, a small flywheel is fitted on the high-speed shaft and housed in the reduction-gear casing, while the compressor rotating assembly is specially designed to have a low moment of inertia. The speed governor is provided with a manual speed-regulating handwheel on the governor itself, capable of adjusting the speed of the power turbine at no-load within 5 per cent. above or below the rated speed. A small electric motor is also embodied in the governor gear, enabling this speed adjustment to be effected from both the switchboard and the control panel.

Overspeed trip governors of the shock-proof unbalanced-ring type are fitted to both the compressor and the power-turbine shafts, arranged to operate an emergency shut-off valve in the fuel system by destroying the pressure in the oil relay when the speed exceeds the rated speed by a predetermined amount. Hand trip-cocks are fitted both on the machine and on the control panel.

The starting procedure is briefly as follows. The compressor is run up by an electric motor to approximately 1,500 r.p.m. (taking approximately 16 h.p.). The torch igniters are then lighted by means of an ordinary sparking plug, and when the thermocouples indicate that they are operating satisfactorily, the main fuel supply is switched on to the burners. Further thermocouples indicate when each combustion chamber is alight, and upon verification that all chambers are functioning satisfactorily, the turbine is accelerated on the hand throttle valve. The starter motor continues to assist the turbine up to a speed of approximately 2,500 r.p.m., when the turbine becomes self-sustaining and its speed overtakes the starter motor, which disengages by means of a free-wheel clutch. As the turbine speed approaches no-load speed, the automatic speed-control governor takes over control of the fuel supply through the oil-operated throttle valve. The time required to reach the no-load condition is approximately one minute. Normally, the turbine is run for five minutes at this condition for warming up before proceeding to higher loads, but if necessary it is capable of accepting full load straight away, giving a time for obtaining full load of approximately 1½ minutes. No "barring-over" of the machine is necessary after shutting down, but oil circulation to the bearings is continued for a few minutes.

The Bristol Aeroplane Company have carried out tests on the compressor and compressor turbine as separate independent units. These tests proved the adiabatic compressor efficiency to be 86 per cent. compared with the design figure of 84 per cent., and that the compressor turbine exactly achieved the design efficiency of 85 per cent. at the designed point, and exceeded this figure by 1 per cent. at lower duties. Pressure combustion tests carried out on the combustion chambers at the normal working pressure by Messrs. Joseph Lucas, Limited, proved the combustion efficiency to be slightly in excess of 98 per cent. Aerodynamic tests were undertaken by Messrs. Allen at their Bedford Works on scale models of the compressor inlet and outlet ducting, the heat-exchanger return header and the power-turbine exhaust diffuser, to reduce the flow-path losses to a minimum. Methods of securing the heat-exchanger tubes were the subject of a number of experiments at Bedford, resulting in the use of expanded ferrules as already described.

The unit, without the heat exchanger, has been on test since early this year. Full speed, full load and overload were achieved in the first series of tests with the minimum of mechanical "teething" troubles. A comprehensive series of performance, governing and endurance tests are now in hand.

LITERATURE.

Cornish Engineers.

By Bernard Hollowood. Holman Brothers, Limited, Camborne. [Published for private circulation.]

When the author of this commemorative volume undertook to prepare a survey of the history of the well-known engineering firm of Holman Brothers, to mark the completion of 150 years since the foundation of the business by Nicholas Holman in 1801, he encountered at once a difficulty that is regrettably frequent in such circumstances; namely, that the records of their early years either had not been systematically kept at all, or that they had been destroyed as soon as they ceased to have any practical utility. In the present instance, however, Mr. Hollowood was more fortunate than many similar researchers, in that the contacts of the founder and his immediate successors with other engineering pioneers were so extensive that it proved possible, after all, to piece together a fairly connected narrative from references such as those in surviving documents relating to Watt, Trevithick and others, and to provide an authentic background from the recorded history of Cornwall and the main Cornish industries. Moreover, the fact that the business has been continuously in the hands of the one family, and that Cornish newspapers have taken an interest above the ordinary in the achievements of local firms, afforded additional sources of information which, if rather disjointed in detail, amount in the aggregate to something really useful.

By dint, therefore, of patient research, which those who have pursued similar studies will be able to appreciate in spite of the author's modest reticence regarding it, Mr. Hollowood has managed to produce a volume not unworthy of the accomplishments that he chronicles. Five generations of Holman's have contributed to the development of the business, now known all over the world as makers of rock drills and other mining equipment, but originally general engineers of the type who were prepared to undertake any kind of work that might come their way. Nicholas Holman (1777-1862), a blacksmith, was followed by his two sons, John (1819-90) and James (1825-92), and they, in turn, were succeeded by John's two sons, John Henry (1853-1908) and James Miners (1857-1933), to whom, in conjunction with a Scotsman, James McCulloch, was due the establishment of the rock-drill side of the business. Their joint patent for "Machines for Drilling Rocks, etc." was No. 4567 of 1881, and the machine that they produced was first demonstrated at Dolcoath in December of that year. Of John Henry's two sons, Mr. Treve Holman is now chairman, and joint managing director with his brother, Mr. Kenneth Holman and his cousin, Mr. Percy Holman, whose brother, Leonard, was also a director until his death two years ago; and there are four more, of the fifth generation, also active members of the board of directors.

A wide variety of work in addition to boilers and steam engines, rock drills and air compressors has been undertaken from time to time, especially during the two world wars, and this will be found duly recorded in Mr. Hollowood's book, accompanied by numerous illustrations from photographs and documents, and from paintings and drawings by Mr. Terence Cuneo; not to mention the reproduction of John Norden's map of Cornwall, dating from 1728, which forms the front end-paper. The firm have, indeed, gone "a long way since the pack mules carried Nicholas Holman's boilers across the Andes to Cerro de Pasco," to the silver mines which cost Trevithick so dearly; and the story of their 150 strenuous years has a wider interest as explaining and justifying the intense pride of the Cornishman in Cornish achievements, especially those of the Cornish engineers, in face of the problems inherent in their environment.

Diamond Tools.—A lecture on "Diamonds in Physical Instruments," will be delivered by Mr. P. Grodzinski, A.M.I.Mech.E., at the South-East London Technical College, Lewisham-way, London, S.E.4, on Monday, November 19, commencing at 7 p.m.

SCIENTIFIC RESEARCH IN AUSTRALIA.

(Concluded from page 566.)

The Division of Electrotechnology, besides maintaining standards, has done some interesting work on the properties of dielectrics and developed a bridge method of measuring permittivity and loss factor at frequencies as low as 0·4 cycle per second. A simple approximate expression has been found for deducing loss factor at still lower frequencies from the current that flows after sudden application of a direct voltage. This anomalous effect, known as charge soaking, can be produced in paraffin wax by prolonged heating, or by adding small quantities of liquid alcohols to the wax. The investigation is being pursued farther with pure hydrocarbon docosane instead of paraffin wax, since the latter is a mixture of hydrocarbons of different chain lengths. It will make a valuable contribution to a comprehensive study of the dielectric properties of materials, with particular emphasis on the mechanism of dielectric loss. Long-chain hydrocarbons and their derivatives have been selected for this research mainly because of their fairly simple molecular and crystal structure. An unexpectedly high dielectric absorption, observed in solid secondary alcohols, has been further investigated in pure alcohols and mixtures of alcohols with pure hydrocarbons and with paraffin wax. The absorption has been found to depend on the method of solidification of the compound, on the chain length of the alcohol, and on the time interval between preparing the sample and measuring its dielectric properties. The high absorption is attributed to the presence of long chains of hydroxyl groups linked by short-range hydrogen bonds.

As industry and technology develop in Australia, it will be found necessary, no doubt, to extend the range of physical standards, more particularly in the direction of acoustics, in which branch of science the Division of Physics has already started research. For the time being, however, attention is being directed to the more urgent needs of industry; to such good purpose, indeed, that most of the demands for the calibration of precision equipment can now be met. Standard scales of a yard and a metre have been purchased from abroad, together with a Société Génévoise universal comparator, whereby length measurements can be determined henceforward in terms of Commonwealth standards. A geodetic base is also being set up, for calibrating surveying tapes. It embodies 47 concrete pillars, of which one set of surfaces must be aligned to within $\pm$ 0·04 in. of a common vertical plane extending over the 50-metre length of the base, while the alignment of another set of surfaces must be within $\pm$ 0·02 in. of a common horizontal plane. Changes in base length will be observed by means of Invar sag-wires fixed between pairs of pillars, and temperature will be controlled by electronic equipment. Tests of the latter have proved so satisfactory that similar temperature-control systems are to be used in the corridor where surveying tapes are calibrated, and in the cases housing the comparators used for end standards.

New methods are under development for interferometric standardisations of length and angle, among the equipment being a multiple-beam interferometer, and apparatus for producing highly reflective films on glass surfaces by evaporation and sputtering techniques. By the use of these instruments, standards of surface finish on glass have been absolutely calibrated to such precision that irregularities of the order of 10 Angstroms, i.e., 4×10^{-8} in., in depth were measurable. A liquid surface has been used as a natural reference for calibrating the flatness of steel surfaces and of optical flats up to 6 in. in diameter. The problem of producing, on hardened steel, lapped surfaces of sufficiently high quality for interferometric studies is the motive for research into the grading of fine abrasives, for which a Grayson settling apparatus and a supercentrifuge are used. By the polishing technique recently developed, hard-steel optical flats are now being made on which the maximum scratch depth is only about one millionth of an inch. Lapped finishes of excellent quality are also being produced on copper and stainless steel.

The common practice of wringing gauges together has been found to cause surface damage of molecular dimensions. This is being investigated, for glass and metal surfaces, by experiments on the magnitude of the tangential and normal forces existing between surfaces in wringing contact. For general research into minute changes or differences of length, a highly sensitive capacitance displacement meter has been evolved which depends for its action on the measurement of frequency-change in an inherently stable electronic oscillator. In this apparatus stabilisation is a serious problem. It has been achieved as regards variations in mains voltage, but to minimise the effects of temperature, the major frequency-determining components have to be housed in a chamber maintained at a constant temperature of 50 deg. C. The technology of length micrometry has permitted a gear 12 ft. in diameter, hobbed at the Bendigo Ordnance Factory, to be examined for evidence of machining inaccuracies. Undulations on the tooth flanks, due to periodic errors in the hobbing machine, have been recorded and analysed by a method not hitherto used for undulation records. Another new method of test has served to determine the combined effect, in precision lathes, of axial float of the spindle and squareness of the surfacing slides.

The Australian secondary standards of mass, used in the Metrological Laboratory, were re-verified during 1950 by comparison with the primary standard. The latter, a platinum-iridium kilogram, was imported and determined in terms of the International kilogram, as well as included in the decennial intercomparison of British National Standards, before being shipped to Australia. Continued observations on five sets of rhodium-plated brass screw-knob weights have revealed mass changes in most of them. Among quantities often associated with mass, with which the Standards Laboratory is concerned, are volume and density. For this class of work a hydrostatic balance, a liquid bath and an electronic temperature controller for it have been set up recently, and experiments have been carried out to examine techniques appropriate for the use of transfer pipettes. Refrigeration is available for measuring liquid densities at low temperatures, though the accuracy in such cases is not so high as it is for temperatures around 20 deg. C., where liquid densities can be measured with a precision of one part in 100,000.

Also associated with mass standards is the calibration of materials-testing machines, and increasing attention is being paid to the needs of industry for precise determinations of force, pressure, stress, strain, hardness and angular speed. Developments in these directions include the supply and installation in Australia of a 50-ton deadweight loading machine in which portable force-measuring devices, such as proving rings, can be accurately calibrated. Concurrently, experiments are in hand to study the long-term stability of wire resistance strain gauges, for which work a four-channel electrical measuring bridge has been specially designed. In the case of direct measurements of hydrostatic pressure, it is remarked that the accuracy at present attainable by use of the conventional plunger-in-cylinder type of deadweight tester is governed by the accuracy with which the effective diameter of the plunger-cylinder combination can be measured. Accordingly, a modified form of pressure-gauge tester has been designed in which the plunger-cylinder combination for a particular range of pressure can be completely removed from the apparatus, thus permitting the cylinder to be placed in a measuring machine in which its internal diameter can be determined to a higher order of accuracy than has been possible hitherto. For the verification of industrial hardness-testing machines, a deadweight penetrator machine of the type designed by the National Physical Laboratory, and recently described in ENGINEERING,* is shortly to be constructed. The relations between the Laboratory and industry in this class of work are exemplified by a recent case where light-load indentations were made and demonstrated at high magnification to a manufacturer of hardness-tester indenters, in order to exhibit the special requirements of diamond-pyramid indenters for use in micro-hardness testing.

Assistance to various industrial bodies has also been given to solve vibration problems arising, for example, from road traffic or heavy machinery adjacent to buildings, precision workshops or instrument rooms. For explorations of this sort prior to vibration isolation, two methods of measurement are being investigated. One employs optical interferences in combination with a stroboscopic light source, and the other depends on change of electrical capacitance. Preliminary tests indicate that both methods are very promising, and a single vibrometer is accordingly being constructed to incorporate both principles. The optical interference elements will enable the pick-up to be calibrated directly in terms of light wavelength, while the capacitance device will permit the vibrational wave forms to be observed by means of compact and easily portable apparatus.

Vibrations on a different scale, albeit not without important industrial applications, are the preoccupation of the Organization's Division of Radiophysics and Radio Research Board. They are exploiting the peculiar advantages offered by radar in meteorology and in aids to navigation, in which latter sphere of application a new project of great promise is a system whereby the radar display seen on a high-power ground installation can be relayed to an aircraft in flight. With such a device, the pilot is able to "see" his own aircraft in relation to the ground radar, including other aircraft, hills and all such navigational hazards within range. Experimental microwave radio transmitters, serving as navigational beacons, have also been extensively tested in the vicinity of Sydney to appraise their use to aircraft for such purposes as homing, route flying, collision prevention, and the conduct of "holding" and "approach" procedures. Similar tests of these beacons as aids to marine navigation in coastal waters are also in prospect.

The application of radio technologies to the study of extra-terrestrial physics continues actively in Australia, where the year's observations of galactic noise have led to the discovery of about 20 new radio stars. The distribution of radio energy among wavelengths of 1½ to 5 m. differs for different stars, suggesting that there are probably at least two types, one of which has the same thermal emission spectrum as a very rarefied gas at a temperature of some million degrees. Fluctuations in radiation intensity for individual radio stars are not the same at points on the earth only a few tens of miles apart. The inference that the sources of fluctuations originate relatively locally—probably by scattering at irregularities of the earth's ionosphere—is supported by the observation that the fluctuations from a single source exhibit an annual variation. However, the mechanism which generates galactic noise is not yet established, and measurements over a wide range of wavelengths have demonstrated that the known facts cannot be adequately explained by the theory that galactic noise originates in thermal radiation from ionised rarefied gas in interstellar space. Indeed, the distribution of radiation intensity conforms closely with what is known of the distribution of matter within the galaxy, and a "cause and effect" relation between the two is therefore a reasonable assumption. An outstanding discovery is that, in addition to a marked concentration towards the centre of the galaxy of which the solar system is a part, an important maximum occurs at right angles to that direction, suggesting that this galaxy is a spiral (like the nebula visible in Andromeda) rotating with the spiral arm leading. This conception entails a revision of astronomers' present ideas on the sense of rotation of galaxies.

Systematic studies, on wavelengths ranging from 1 cm. to 500 cm., of radio emission from the sun have suggested the existence of a "base level" of radiation due to thermal emission from the outer solar atmosphere. Increases above this base level of intensity have been analysed into various separate source components, attributable, for example, to exceptionally hot regions in the sun's atmosphere, or to the same source as sunspots. During such so-called noise storms, the apparent source travels across the sun's disc faster than the associated sunspot, indicating that the source is very high up in the solar atmosphere. Other components, termed outbursts, are sporadic short-lived phenomena, attributed to eruptions of gas from the sun outwards into its atmosphere at speeds in the region of 1,000 km. per second. A fourth type of disturbance, called an isolated burst, is not yet associated with any visible phenomena and is, at present, the sole evidence for a remarkable type of solar explosion lasting for no more than a few seconds.

The Organization is co-operating with the Physics Department of the University of Melbourne in a programme of research in nuclear physics and cosmic rays, the ultimate aim being to further the understanding of the constitution of the atomic nucleus and of the forces which hold it together. The equipment available for the nuclear physics investigations includes a million-volt electrostatic generator, already in use, and a 600-kV generator, in course of construction, to provide high intensity sources of neutrons and γ-rays. In the cosmic-ray studies, the disintegration produced in the earth's upper atmosphere by high-speed particles from outer space is being analysed by means of ionisation chambers, a cosmic-ray spectrometer, and apparatus for measuring meson decay. The practical applications of nuclear physics are receiving increasing attention for chemical, metallurgical, and biological and medical research. Pile-produced radio-isotopes, from Harwell and from the United States Atomic Energy Commission, are regularly obtained and many different "isotopically labelled" compounds have been made to meet local demands, especially for radioactive assay procedures.

In the foregoing survey of the Organization's activities, attention has been especially directed to the material physical sciences. It will have been remarked, no doubt, that many fairly obvious subjects for research, having applications in industrial engineering and aeronautics, lie outside the scope of the Organization. They are, of course, undertaken by other Government departments as well as by some of the universities. It is important to appreciate, however, that more than half of the Organization's reported investigations are concerned with biological, agricultural and related subjects which figure very prominently in the economy of the Australian Commonwealth. In the broad sense, it may be said that all the principal animal and vegetable industries of Australia are under continuous examination, with consequences that are profitable to the well-being of science as well as of the industries concerned. In certain directions, such as irrigation and meteorology, the physical sciences exert important influences on agricultural prosperity and are correspondingly recognised as proper fields for research by the Organization. The Section of Meteorological Physics, in particular, has been doing really fundamental work on atmospheric processes, concurrently with more immediately applicable experiments on such matters as the use of motor-driven fans for preventing low-level frost damage in fruit-growing districts, and the artificial precipitation of rain by "seeding" appropriate cloud formations with crystals of solid carbon dioxide, sown by aircraft. The opinion has now been clearly formed that this method has a high probability of success when the upper levels of suitable clouds are at least 7 deg. C. below freezing point. Similar trials are in prospect with silver iodide and water spray as means of promoting droplet formation.

The examples of research selected for mention in this review are typical of the Organization's work as a whole, in that they convey the impression of a very high standard among the scientists of the Commonwealth, and of an admirable balance between the needs of industry for applied work and the prosecution of fundamental research as a worthwhile contribution to the general advancement of science. The support afforded to an Australian Research Association by the Organization, and the Commonwealth Treasury support of the Organization itself—now in the region of 2,000,000*l*. per annum—are substantial additional evidence that scientific and industrial research may confidently expect to grow in concert with the future prosperity of the Commonwealth, which they are doing so much to promote.

* See page 57, *ante*.

THE ELECTRICAL RESEARCH ASSOCIATION.

Fig. 4. High-Speed Cathode-Ray Oscillograph.

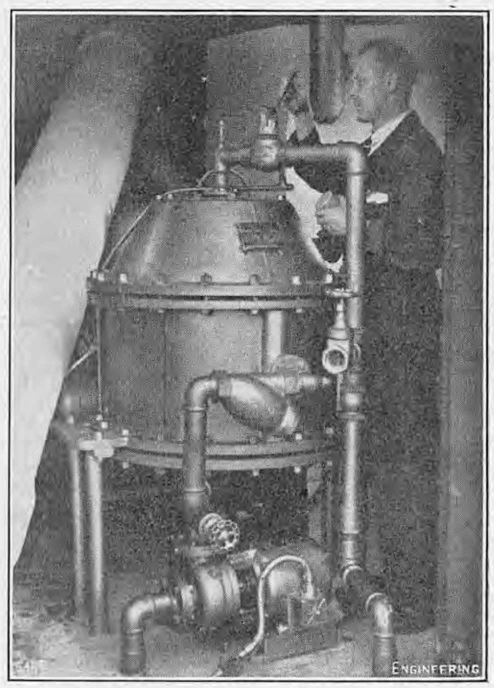


Fig. 5. Heat Pump at Shinfield.

THE ELECTRICAL RESEARCH ASSOCIATION.

(*Concluded from page* 586.)

The investigation of surge phenomena, directed mainly to the solution of problems relating to lightning and its effects on various items of equipment, as well as to the performance of devices intended to reduce the damage it may cause, forms an important part of the work of the Association for which purpose full use is made of the facilities available at the National Physical Laboratory. The effect of surges on transformers is also studied, as well as other matters which concern the design and construction of transformers, such, for instance, as the calculation of stresses due to short circuits, temperature gradients and the production of noise. For the calculation of short-circuit stresses in transformers several assumptions have to be made to render the subject amenable to mathematical treatment, and a special experimental transformer has been made to check the validity of the assumptions. In this, the two disc windings are arranged so that the degree of asymmetry can be controlled; the method of measurement was demonstrated. Another transformer in use at the Laboratories is designed for the study of temperature gradients and oil flow. An interesting piece of equipment designed and constructed by the Association is illustrated in Fig. 4, on this page. It is a high-speed single-sweep cathode-ray oscillograph for use in conjunction with the surge generator, which is visible in the background. The oscillograph is shown in the lower part of the illustration near the centre, and of the three units on the left the upper one is the generator-tripping unit and the other two are power units; that on the extreme right is a surge counter. The cathode-ray tube is of the sealed-off type. An accelerating voltage of 10 kV is employed and the time taken for the spot to traverse the screen can be varied from $0 \cdot 2$ μ sec. to 300 μ sec. The camera used to record the phenomena depicted on the screen is fitted with a Wray lens of $f1 \cdot 0$ aperture.

Although at first sight it is not quite obvious why rural electrification and wind power should be combined as they are in the E.R.A., the reason is that small wind-driven electric generators may be used to supply electrical energy in isolated farms and other premises situated in districts a considerable distance from any public supply area. As previously mentioned, the E.R.A. has a field station for the study of rural electrification problems at Shinfield, Berkshire. Only the preliminary stages are handled at Shinfield, subsequent studies being conducted on farms and horticultural holdings. Early investigations on wind power are made at Shinfield, but the later work is necessarily carried out at specially selected sites in various parts of the country. Most of the exhibits staged to illustrate this part of the Association's work took the form of photographs and models, although several easily portable instruments, such as anemometers, were shown. The aim in connection with the application of electricity to agriculture and horticulture is to produce barn and field machinery, crop-drying equipment, soil-warming apparatus, etc., which will be effective, economical in use and acceptable to the supply authorities from the point of view of load factor. In the study of potentialities of wind power for the generation of electricity researches are being made on the wind régimes on various selected sites, the behaviour of wind flowing over hills of different formation, on the design of wind-driven plants, and on the performance of pilot plants of up to 100 kW capacity. One such plant is now being built at Costa Hill, on the Orkney mainland, by the North of Scotland Hydro-Electric Board and Messrs. John Brown and Company, Limited. The plant will be connected to the supply network of the island, and tests carried out during the coming winter will provide performance and operational data.

Another section of the Association's work relates to space and water heating. In connection with space heating investigations have been carried out on the heat-pump since 1947, particular attention having been paid to sources of low-temperature heat suitable for heat pumps of small capacity. Comparatively recently, a 10-h.p. heat pump has been installed at the Shinfield field station for warming the laboratories there; a photograph of this installation is reproduced in Fig. 5, on this page. One of the exhibits relating to space heating was a scale model of a domestic sitting room, the walls of which were lined with metallised paper. It has been shown, both by means of scale models and in full-scale trials, that, using metallised paper having a surface reflectivity of the order of 80 per cent., the time required for the transient heating of a room is only about one-third of that needed with ordinary wallpaper on uninsulated walls. The reduction, it is interesting to note, is about the same as would be effected by lining the walls with high-quality insulating boards.

A few years ago, the Association initiated research on the electro-physics of the welding arc, in collaboration with the British Welding Research Association, and the work, which covers the investigation of direct- and alternating-current arcs in ferrous-welding practice, involves the use of electromagnetic and cathode-ray oscillographs, high-speed ciné and slit photography, as well as of stroboscopic methods. This class of equipment was shown in use in several of the exhibits during the open days. Of particular interest among the exhibits were the demonstrations illustrating the work that has been done, and is being continued, to improve the argon-arc welding process now being used in industry to a considerable extent for welding aluminium metal and various light alloys. A characteristic of the alternating-current argon-arc is that, normally, the arc is extinguished when the plate becomes negative in the course of a complete cycle, unless open-circuit voltages of the order of 100 volts r.m.s. are maintained. To enable a lower voltage to be employed and still maintain the arc, high-frequency spark injection, a large capacitance in series with the arc and special circuits have been successfully applied in industry, but the sparks have caused severe radio interference. A new method, however, has been developed at Greenford, and was demonstrated in use during the open days, by which the argon-arc can be maintained for welding aluminium with an open-circuit voltage of less than 50 volts r.m.s. This is achieved by injecting into the welding circuit an electronically-timed short-duration impulse of some 200 to 300 volts to simulate a much higher open-circuit voltage. The impulse, which is effectively shock-free, is a capacitative discharge across the arc gap through a cold-cathode stroboscopic-type valve which is triggered at the welding-current zero. Injection of the impulse into a step-up transformer produces a spark for initiating the arc from cold without the need for bringing the electrode into contact with the work; once initiated, the arc is maintained by the lower-voltage impulse. Among the advantages claimed for the method, which is being patented, are the low open-circuit welding voltage, and the comparative freedom from radio interference, the latter being demonstrated on a television receiver. The demonstration also included a stroboscopic picture of the arc in slow motion, together with a cathode-ray oscillographic display of the arc current and voltage.

We must mention, in conclusion, that as the above is merely a brief survey of some of the exhibits, the whole of which only represented a cross-section of the work of the Association, the article can give but a faint impression of its magnitude. It may, however, serve to give some idea of the nature of the work, but it would be easier to do so, and possibly more effective, if the open days could be held more frequently.

HEAVY FORGE SHOP AT HADFIELDS LIMITED, SHEFFIELD.

With the object of improving their heavy special-steel forging facilities, Hadfields Limited, have erected a new forge shop equipped with two modern air-hydraulic forging presses, one of 2,700 tons and the other of 1,500 tons capacity, together with the necessary re-heating and heat-treatment furnaces, at their East Hecla Works, Tinsley, Sheffield, 9. The shop was recently completed and the opening ceremony was performed by H.R.H. The Duke of Gloucester, K.G., on Thursday, November 8. A general view of the two presses and of the forge bay of the new shop is reproduced in Fig. 1, on this page, and a closer view of the 1,500-ton press, seen in the background in Fig. 1, is given in Fig. 4, on page 617. The new shop has been designed to handle ingots up to 45 tons in weight and to produce forgings measuring up to 40 in. in diameter or up to 40 ft. in length, rings having a maximum diameter of 12 ft., and sleeves measuring up to 6 ft. in diameter and 10 ft. in length. The forge shop, the arrangement of which is shown in elevation in Fig. 2, and in plan in Fig. 3, is near the steelmaking plant and is also conveniently placed in relation to the machine shops. As will be seen in Fig. 2, the building consists of four bays, namely, the heat-treatment bay, the furnace bay, the forge bay and the stock bay. The total floor area is 122,000 sq. ft. The three main bays have a crane span of 80 ft., a height from floor level to crane-rail level of 52 ft., and a total length of 386 ft. The stock bay is of the same length, but has a crane span of 51 ft. 9 in. and a height from floor level to crane-rail of 39 ft. 6 in.

The foundations of the new forge shop, as may be seen in Fig. 2, comprise a number of foundation blocks and, to minimise the heavy timbering of individual excavations, it was decided to excavate the entire site to a depth of 3 ft. The depth of this bulk excavation was further increased to 10 ft. in the area occupied by the furnace and the press foundations. Owing to the nature of the ground, as revealed by test borings, it was decided to drive in pre-cast concrete piles, ranging in length from 25 to 30 ft., for the majority of the column foundations, the remainder being formed of the usual rectangular concrete blocks. The furnace foundations were constructed of concrete, suitably reinforced, and the press foundations, which were also of reinforced concrete, were taken down to a depth of approximately 40 ft. Two vertical watertight cylindrical pits were required in the heat-treatment bay to house two tanks to be used for the quenching of long forgings. These tanks, the position of which is shown in the lower right-hand corner in Fig. 3, are each 8 ft. in diameter and 54 ft. deep. The upper edges of the tanks are just below floor level. The tanks, one of which is to contain oil and the other water, are formed of cast-iron segment rings bolted together, caulked and pressure grouted; each has a capacity of 17,000 gallons. After completion of the foundations the site was backfilled with furnace slag, and a 6-in. concrete floor was laid in the stock, furnace and heat-treatment bays. The floor in the forge bay consists of 2-in. and 4-in. thick steel plates laid on sand. The excavation, piling and concreting work and the making of the rail tracks, roadways and building work was carried out by Sir Robert McAlpine and Sons (Midlands), Limited. The consultants for the design of the buildings and the foundations were Messrs. Bylander and Waddell, London.

The forge building is of the usual steel-frame construction and is fitted with continuous ridge ventilators. The steelwork was supplied and erected by Banister, Walton and Company, Limited, Manchester, in association with the Cargo Fleet Iron Company, Limited, Middlesbrough. The walls are of brickwork 7 ft. high and, above this, the building is completely covered with corrugated sheeting, with the exception of two runs of vertical glazing in the side wall of the heat-treatment bay. The total area glazed, namely, that in the side wall and that on the roof, is 45,000 sq. ft., and the approximate area covered by corrugated sheets is 194,300 sq. ft. The sheeting of the building was

HADFIELDS HEAVY FORGE SHOP.

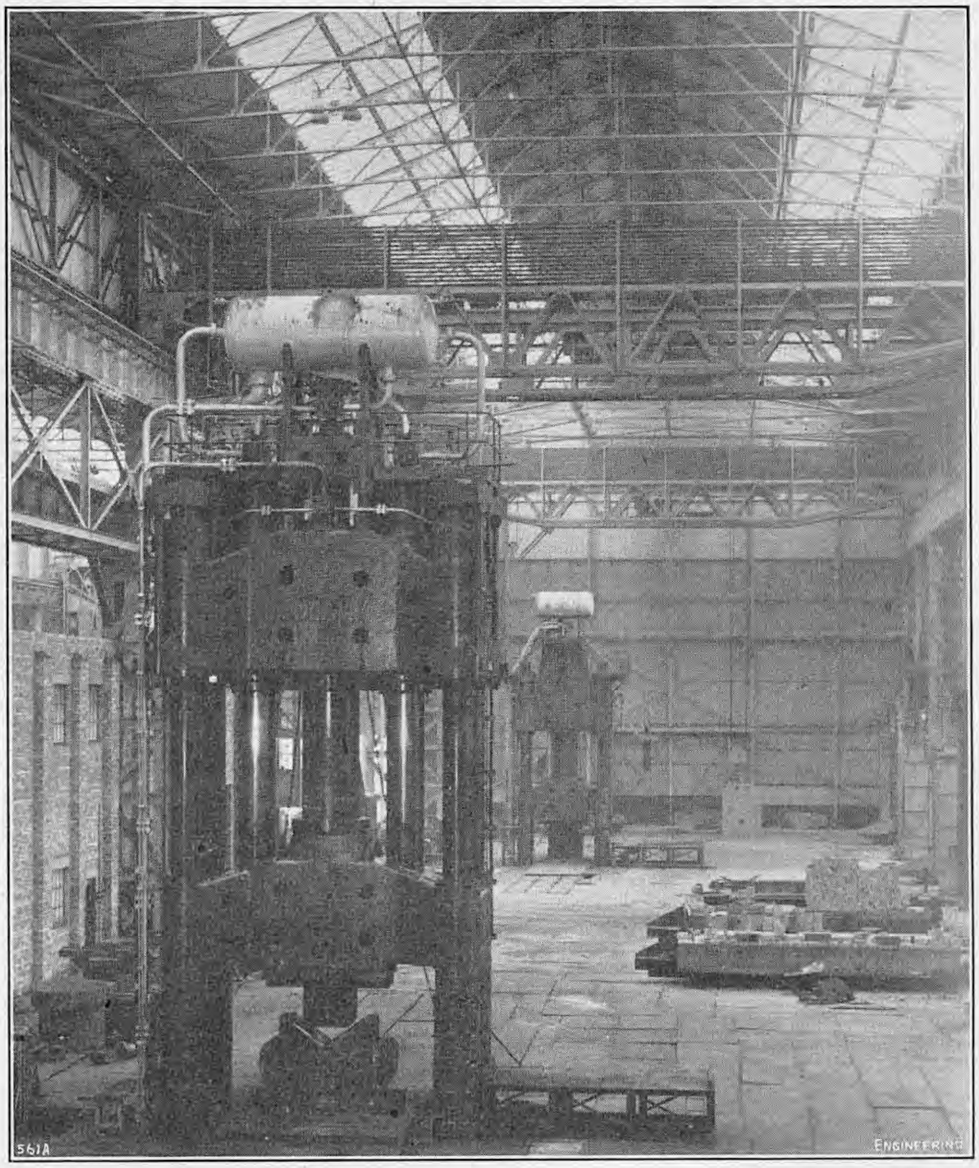


Fig. 1. General View of Forge Bay.

carried out by Carter-Horseley (Engineers), Limited, and the sub-contractors for the glazing were Messrs. Mellowes and Company, Limited, Sheffield.

The two forging presses, which are operated by a common pressure water station, have been designed and supplied by the Loewy Engineering Company, Limited, London and Bournemouth, and manufactured by F.B. Engineers, Limited, Sheffield, and Light Machines, Limited, Yeovil. One of the main features of the press plant is its high working speed and ease of operation over a wide range of forging work. To make this possible, and also to allow for the greatest flexibility, it was decided to install an air-hydraulic accumulator station in preference to direct pump drive. Trials so far made have shown that penetration speeds of 6 in. per second and upwards can be achieved on both presses at full power, and, for planishing and finishing operations, well over 100 strokes per minute have been maintained. This flexibility and high speed are of particular importance in the forging of highly-alloyed steels, where the maximum amount of work must be accomplished per heating cycle.

The suspension of the upper entablature on the presses is a special feature by which it is possible to dispense with nuts or collars on the main columns. The design embodies a small crosshead resting on the head of the column. From this crosshead are suspended forged-steel tie bolts which hold the entablature securely against the upper column nuts. Both presses are provided with three-point guiding of the moving crossheads to take up the effects of eccentric loading or other forces occurring during forging operations. The 2,700-ton press has three cylinders and the 1,500-ton press one cylinder. The application of the three-point guiding in a three-cylinder press is believed to be novel and is achieved by having the central cylinder rooted into the moving crosshead, the upper end of the cylinder sliding in a sleeve fitted into the upper entablature.

Each press has a moving table which is divided into three parts, a centre portion and two outer portions. The table sections can either be connected together to form one table, or the two outer sections can be operated independently by special double-acting hydraulic cylinders, a draw-bar being provided for coupling the tables to the hydraulic movement. This gives great flexibility of operation when dealing with a wide variety of forging work. Further, each press has a multi-station ejector to facilitate handling during high-speed piercing and die-forging work. Hydraulic table locks are also provided for the accurate centring of the tables when such work is carried out. The table and ejector controls are interlocked electrically so that movement of the ejector can only take place when the tables are in the ejecting position, and also to ensure that the tables cannot be moved until the ejectors are in the retracted position. Lubrication of all moving parts has been adequately provided for by means of mechanical lubricators and grouped nipple assemblies. Shock absorbers ensure smooth operation of the presses.

The main control valves for the presses are operated by servo valves which give sensitive control and enable a high working speed to be maintained without effort on the part of the operator. Low-pressure water pre-filling devices are provided for the idle movements of the presses so that the high pressure is used only during the

HEAVY FORGE SHOP, HADFIELDS LTD., SHEFFIELD.

Fig. 2.

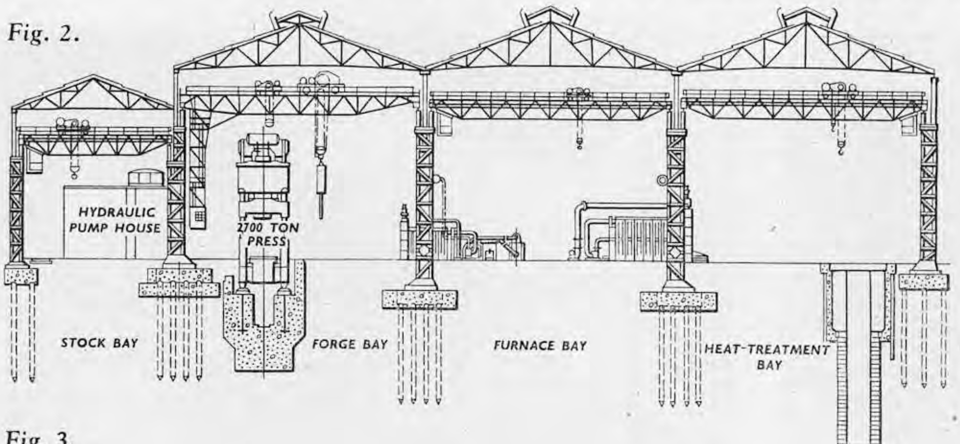
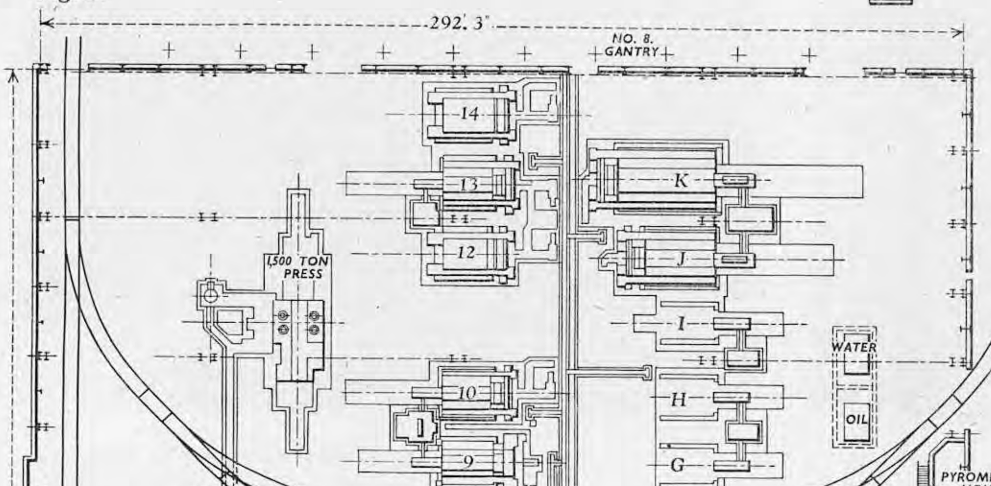


Fig. 3.



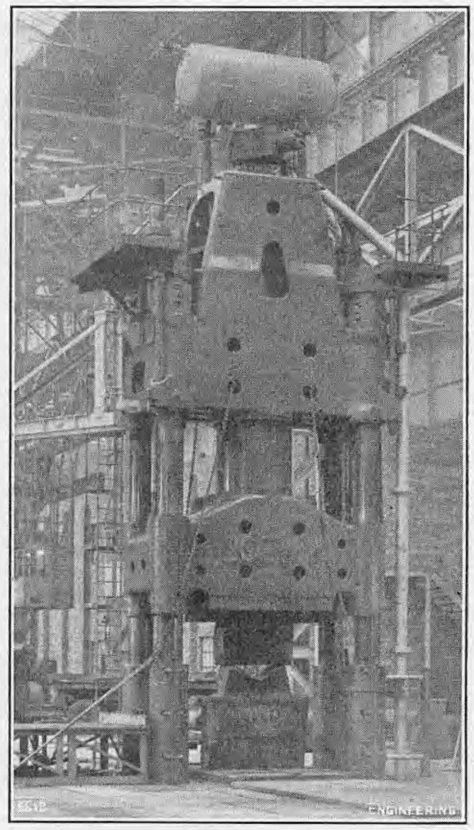


Fig. 4. 1,500-Ton Press.

actual pressing strokes. The air-hydraulic pressure water station consists of an accumulator with air and water bottles and five high-pressure hydraulic-pump units. This station, which is housed in a two-storey brick building erected in the stock bay between the two presses, as can be seen on the lower left-hand side in Fig. 3, also contains an electrical substation for the supply of electricity to the pumps and to the forge building itself. For reasons of space, the hydraulic pump units are mounted on separate floors, three being on the ground floor and two on the upper floor. Four pumping units are normally in operation, the fifth unit acting as a standby. Electrically-controlled and hydraulically-operated valves control the delivery from the pumps through by-pass apparatus and the entire system is designed to ensure maximum economy of working under all operating conditions.

The forge bay is served by three forging cranes built by Sir William Arrol and Company, Limited. Two have a capacity of 75 tons and are fitted with separate 20-ton auxiliary crabs, and the third is of 40 tons capacity with a separate 10-ton crab. The driver's cab on all these cranes is at a height of some 12 ft. above the floor level.

All the furnaces in the forge shop are situated in the furnace bay, the re-heating furnaces discharging into the forge bay, while those of the heat-treatment type discharge into the heat-treatment bay. Eleven coke producer-gas fired re-heating furnaces serve the two forging presses and all have been provided by Priest Furnaces, Limited, Middlesbrough. Six of the furnaces, namely, Nos. 3, 7, 8, 9, 10 and 13, in Fig. 3, are of the bogie-hearth type. Three have effective dimensions of 14 ft. in length, 7 ft. in width and 7 ft. in height; the other three are 15 ft. long, 7 ft. 3 in. wide and 7 ft. high. The remaining five reheating furnaces, namely, Nos. 1, 2, 6, 12 and 14, in Fig. 3, are of the fixed-hearth type, three having dimensions 14 ft. by 7 ft. by 7 ft., and two 12 ft. by 6 ft. by 6 ft. Fig. 5, on Plate XL shows, from right to left, reheating furnaces 1, 2 and 3. All are of the reversing regenerative type, both air and gas being preheated. The air passes through regenerators and the gas through a tubular metallic needle-type recuperator. The reversing equipment has several features of interest. The air-waste gas valve, which is of the rotary type, has a water-cooled paddle and drum, enabling it to deal with high-temperature exhaust gases with a minimum of leakage. Gas reversal is effected by means of water-sealed dipper-type valves. The functioning of the reversing equipment is entirely automatic and electrically controlled. From the reversing unit, gas is led to the furnace through lagged mains terminating at the combustion ports, to which air is distributed through underground flues These combustion ports are arranged alternately to direct the products of combustion over and under the stock.

The furnaces are of robust construction, the side and back walls being enclosed in mild-steel casing; the fronts and doors are constructed of hæmatite-iron castings. The bogies and ancillary equipment are similar to those of the bogie heat-treatment furnaces described below. All re-heating furnaces have a maximum working temperature of 1,350 deg. C., this being controlled within the limits of ± 10 deg. C., from 550 deg. C. upwards. The removal of ingots from the furnaces, for forging, is conducted, in the case of the fixed-hearth type, by using a porter bar and a balance weight, and, in the case of the bogie type, by means of lifting tongs. The ingots are normally manipulated under the presses by means of Arrol turning gear and burden chain controlled from the crane cage.

The nine gas-fired furnaces serving the heat-treatment bay are all of the bogie-hearth type. Two are 40 ft. long, 14 ft. wide and 9 ft. high; two

HEAVY FORGE SHOP, HADFIELDS LTD., SHEFFIELD.

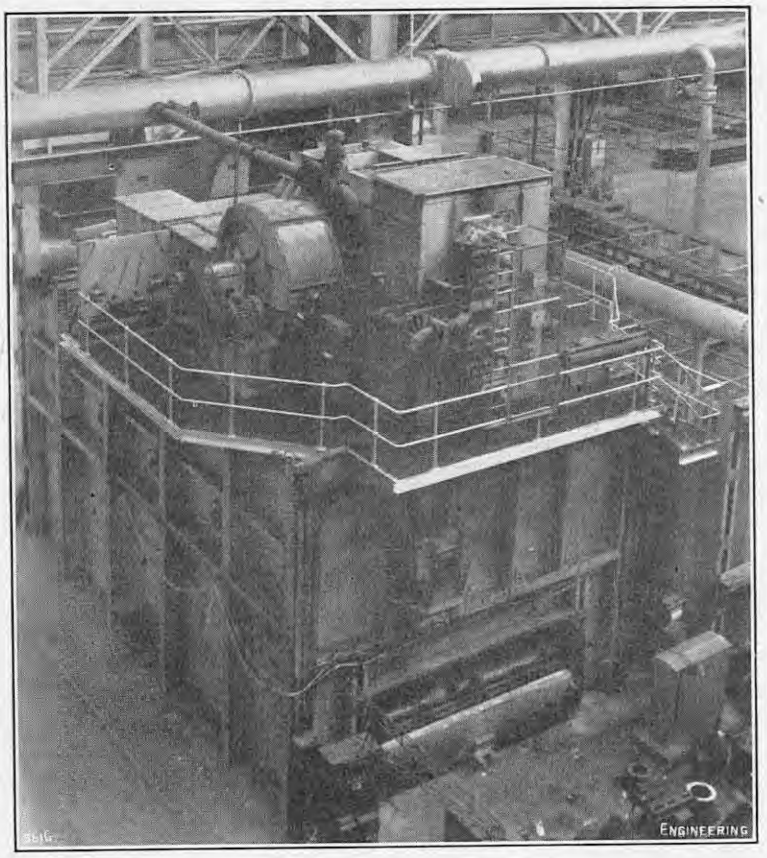


Fig. 8. Brayshaw Tempering Furnace.

Fig. 9. Quenching Tanks in Heat-Treatment Bay.

are 30 ft. long, 12 ft. wide and 9 ft. high; one is 30 ft. long, 12 ft. wide and 7 ft. 6 in. high; three are 15 ft. long, 9 ft. wide and 6 ft. 7 in. high, and one is 20 ft. long, 10 ft. wide and 9 ft. high. The situation of the five larger furnaces, A, B, E, J and K, is seen in Fig. 3, and one of the two largest A and B is illustrated in Fig. 7, on Plate XL. These five furnaces have been constructed by Priest Furnaces, Limited, and resemble in many respects the reheating furnaces; they are of the air-regenerative type, with similar combustion arrangements and reversing equipment. As, however, the maximum temperature requirements are lower, pre-heating of the gas is unnecessary. The bogies, which are constructed from rolled-steel sections, are carried on steel wheels with stub axles and have an insulated refractory hearth. Sand seals are arranged along each side and a special bridge construction is adopted in the furnace back wall to allow an extension of the bogie to pass beneath it and provide a means of sealing at this point. The maximum working temperature of the Priest heat-treatment furnaces is 1,250 deg. C.

Tempering furnaces F, G and H, in Fig. 3, are intended for precise temperature treatment within a range of 100 deg. to 750 deg. C. They are of the re-circulation type and have been designed and installed by Brayshaw Furnaces and Tools, Limited, Manchester. The tempering furnaces F, G and H are seen from left to right in Fig. 6, on Plate XL, the fourth, furnace I on the extreme right, being a Brayshaw hardening furnace which is described below. Furnace F, the largest of the three tempering furnaces is also shown in Fig. 8, on this page, and Figs. 10 and 11, on page 619. It has a bogie area measuring 30 ft. in length and 12 ft. in width and has a loading capacity of 45 tons.

The three tempering furnaces differ fundamentally from the usual type in that, instead of burners being used for heating the work chamber, the heat is generated in a combustion unit which is entirely separate from the furnace proper. This is seen in Figs. 10 and 11 and also in Fig. 8. The heating medium consists of large volumes of hot gases which are continuously circulated at high velocity by powerful fans through the furnace chamber, in a closed system of ducting. The control of the furnace temperature, to ± 3 deg. C., is relatively simple since it is only necessary to regulate the temperature of the circulating gases by adding to them small quantities of fresh gases burnt in the external combustion chamber. The direction of the flow of gases is automatically reversed at predetermined intervals in order to apply the heat to the load from each side in turn. The furnace combustion chamber has been designed for use with low-pressure air and either town gas having a calorific value of 500 B.Th.U. per cubic foot, or coke-producer gas which has a calorific value of 132 B.Th.U. per cubic foot. The furnace chamber works under a slight positive pressure and seals are provided on the doors and bogies to prevent the loss of circulating gases.

The two smaller recirculation-type heat-treatment furnaces, G and H, having a hearth area 9 ft. wide by 15 ft. long and a maximum loading capacity of 30 tons, use the same principle of recirculation and, in general, embody the same features of construction as the large 30-ft. furnace F. They are of a more simple downflow type, however, without reversing gear, the hot gases entering the furnace chamber through the furnace arch and returning for recirculation through ports at each side of the furnace. Operating in conjunction with, and of a size identical with the two 15-ft. tempering furnaces G and H, is a Brayshaw hardening furnace (I) designed to work at temperatures of from 550 deg. to 1,250 deg. C. It is directly-fired by two separate sets of burners, one set firing under the furnace arch and the other set arranged to fire through ports in the bogie hearth, with independent adjustment between the two sets of burners. Recuperation is arranged for both the air and the gas, the recuperators being of the metallic needle type. The waste flue-gases are exhausted to the atmosphere by a positive motor-driven exhaust fan.

The haulage of the bogies in the case of both the reheating and the heat-treatment furnaces is provided for by electrically-driven rack wheels engaging with pin-type tracks located centrally below the furnace bogies Where two bogie-type furnaces are in adjacent positions, a twin haulage unit is used in which a single electric drive with reduction gearing is situated between the furnaces to operate either of the bogies, a system of clutches ensuring that only one may be moved at a time. The haulage equipments, all of which were supplied by Priest Furnaces, Limited, are electrically interlocked with the door lifting gear, which is itself electrically operated, to ensure that the door is open prior to the withdrawal of the bogie. The heat-treatment bay is served by two 40-ton cranes having 10-ton auxiliary hoists. These have been supplied by the Butterley Company, Limited, Derby, as have also a 10-ton crane in the furnace bay and a 40-ton crane, having an auxiliary hoist of 10 tons capacity, in the stock bay. The 10-ton crane in the furnace bay has been installed chiefly for maintenance purposes, while the 40-ton crane in the stock bay is for the handling of ingots. As in the case of the three cranes in the forge bay, the above four cranes operate on a 230-volt direct-current supply.

As indicated above, clean gas of a calorific value of 130 B.Th.U. per cubic foot is distributed to the furnaces from a 30-in. diameter overhead ring main situated at a height of 28 ft. above the floor level. The main is supplied with fuel gas at a pressure of 2½ lb. per square inch, from the company's own coke producer plant. The pressure within the ring main is maintained at 30 in. w.g., by means of an oil-operated gas-pressure regulator supplied by Electroflo Meters, Limited, London. Shut-off valves and gas-pressure governors are fitted in all branch pipes and the gas is supplied to the furnaces at a pressure of from 6 in. to 8 in. w.g., except in the case of the four Brayshaw heat-treatment furnaces, which operate on a gas pressure of from 28 to 30 in. w.g.

The temperature of each of the 20 furnaces in the furnace bay is automatically controlled by an electronic potentiometer temperature recorder-controller. Two furnaces have been fitted with pressure-control devices, and gas and air-flow meters and pressure gauges have also been provided. In addition to those forming part of the automatic temperature-control equipments, thermocouples are inserted in the furnaces at various points to assist the operators to maintain equal temperature distribution throughout the hearth loads.

In addition to the two vertical quenching tanks, 54 ft. in depth, previously mentioned, two horizontal rectangular welded tanks, each of 30,000

HEAVY FORGE SHOP, HADFIELDS LIMITED, SHEFFIELD.

(*For Description, see Page* 616.)

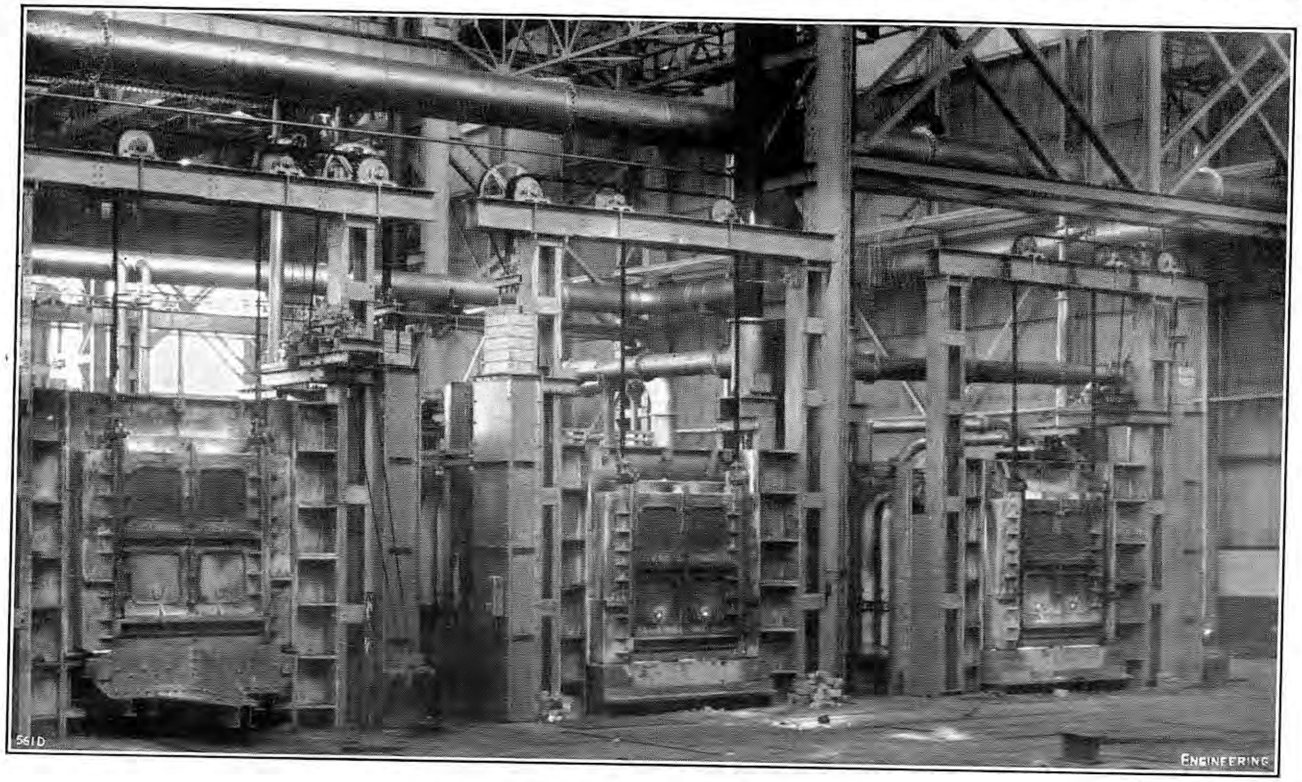


FIG. 5. PRIEST RE-HEATING FURNACES.

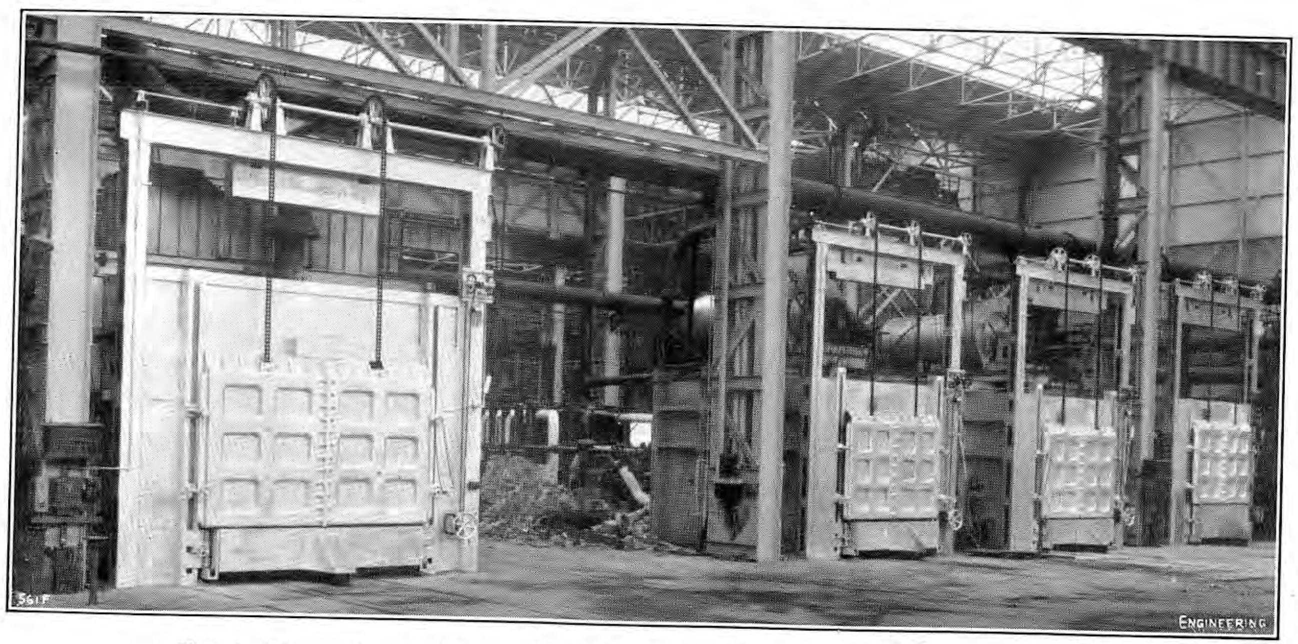


FIG. 6. THREE BRAYSHAW TEMPERING FURNACES AND, ON RIGHT, HARDENING FURNACE.

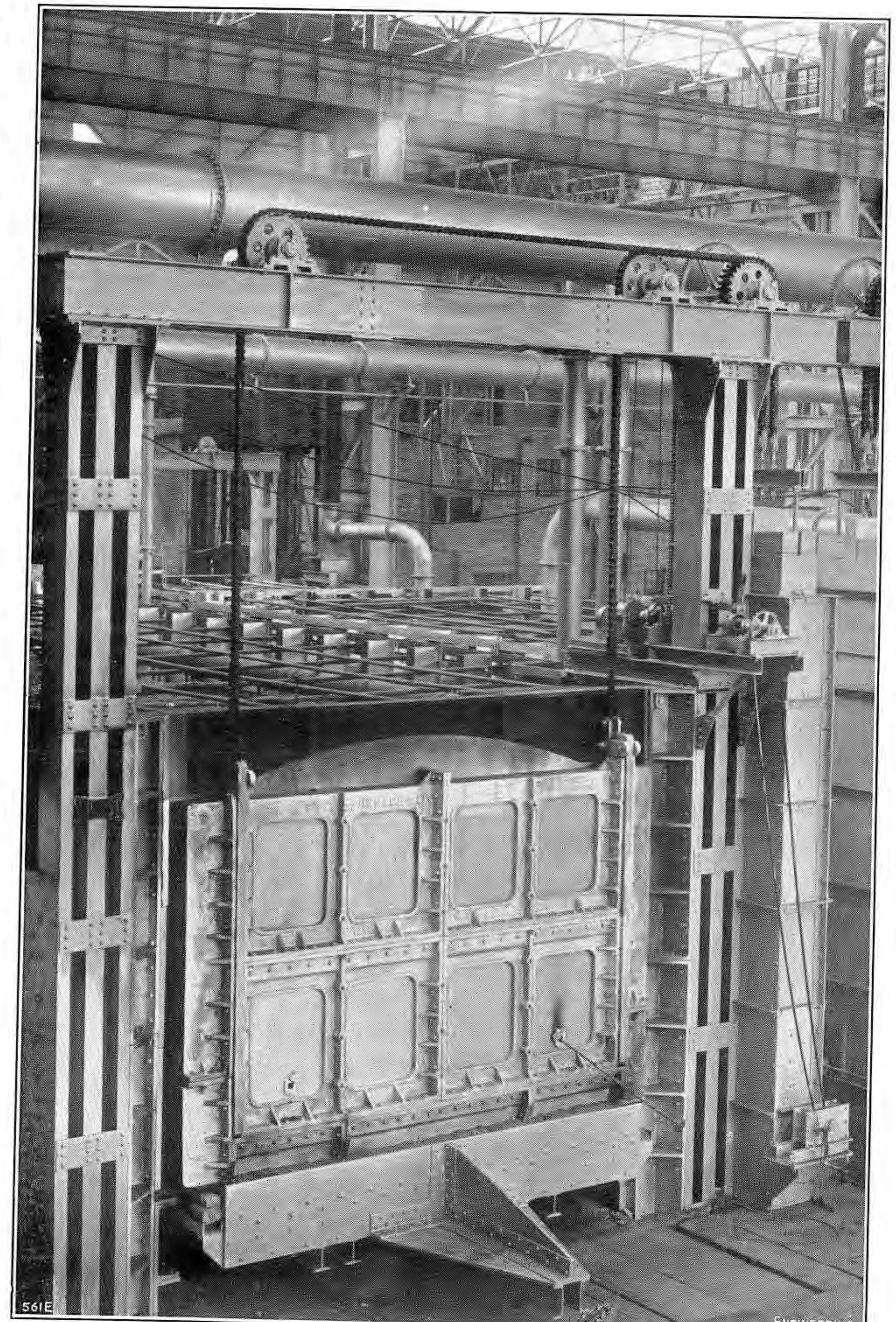


FIG. 7. PRIEST LARGE-BOGIE HEAT-TREATMENT FURNACE.

NEW HEAVY ENGINEERING WORKS AT WITTON, BIRMINGHAM.

THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

(*For Description, see Page* 620).

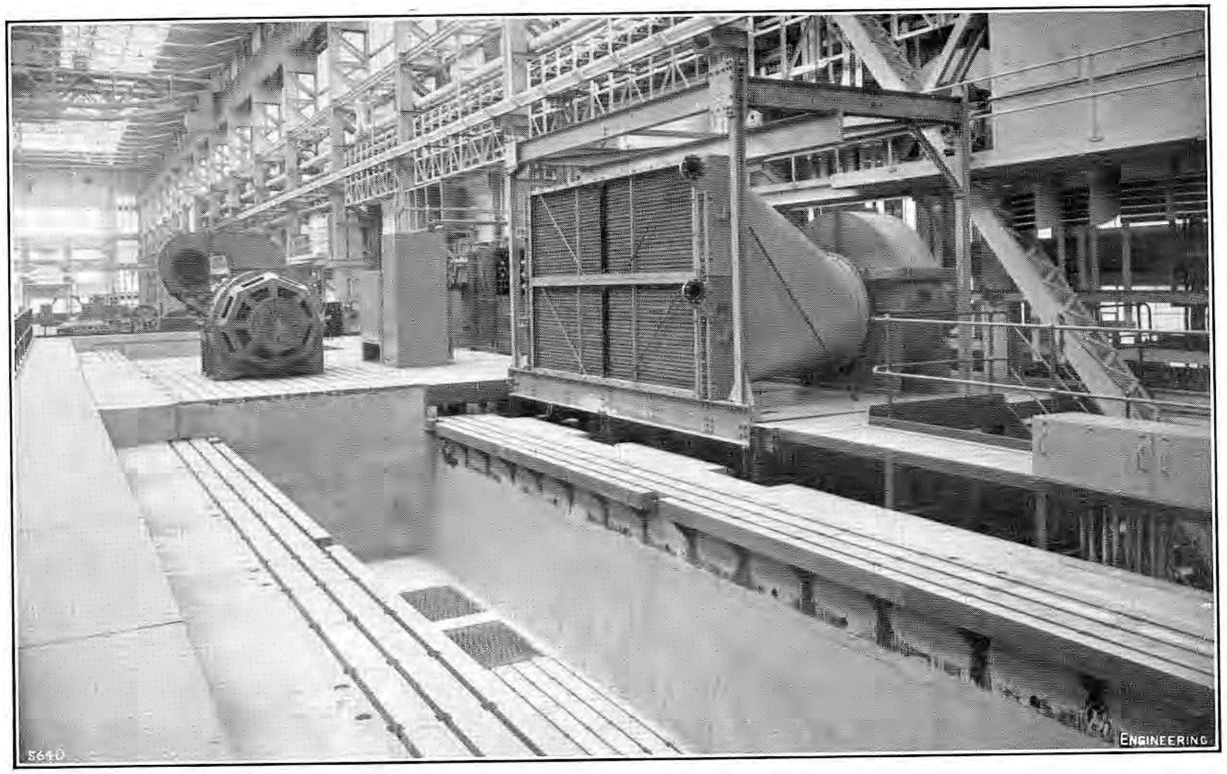


Fig 4. Turbo-Alternator Test-Bed.

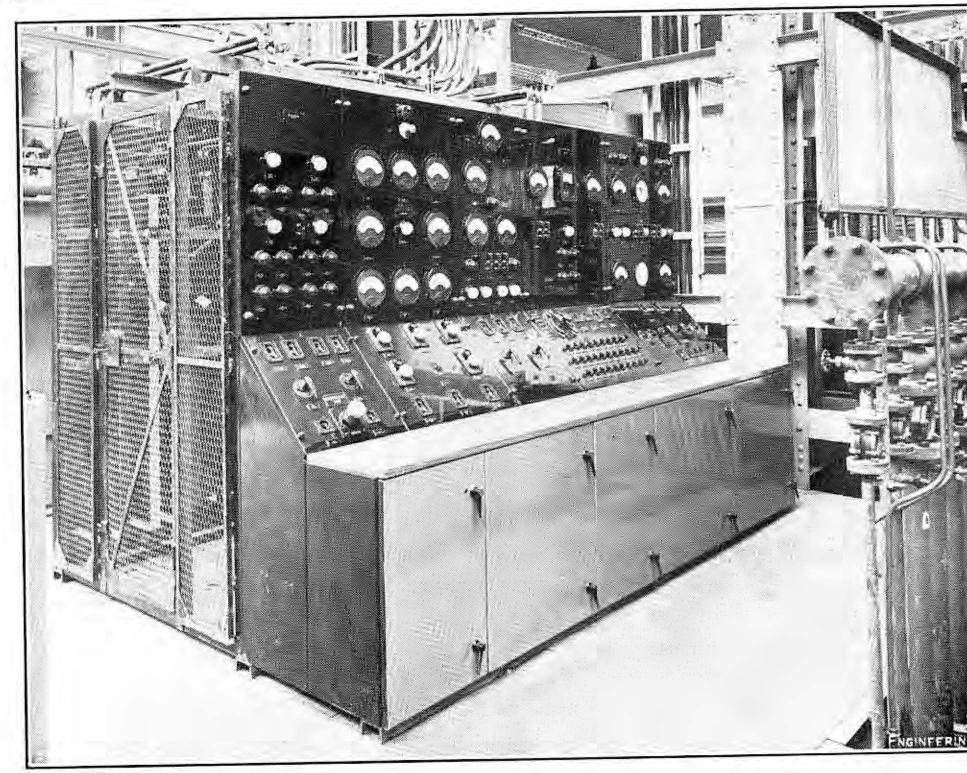


Fig. 5. Main Control Board for Turbo-Alternator Test-Bed.

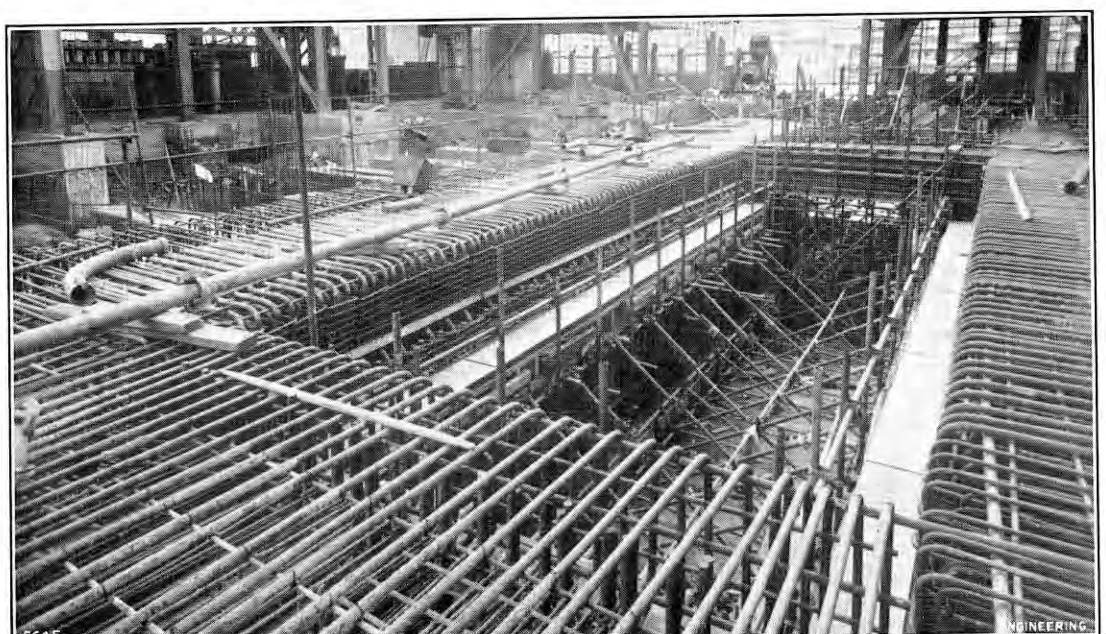


Fig. 6. Steel Reinforcement for Overspeed Pit.

Fig. 7. Interior of Overspeed Pit.

(*To face page* 619.)

HADFIELDS FORGE SHOP.

Fig. 10.

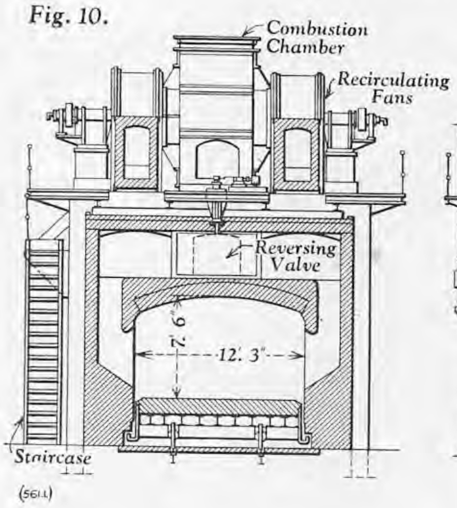
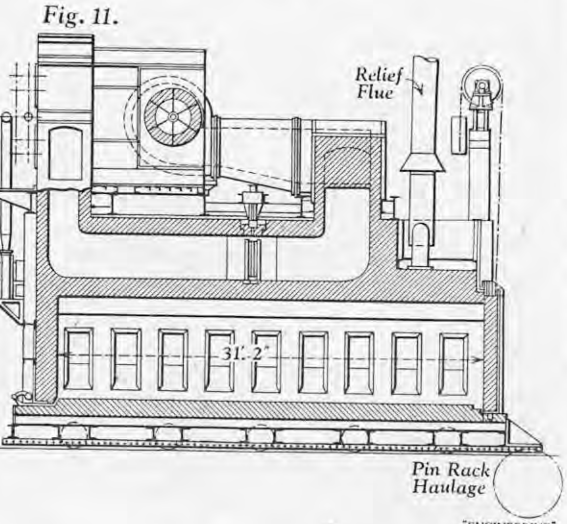


Fig. 11.



gallons capacity and measuring 40 ft. in length, 12 ft. in width and 10 ft. in depth, and two smaller rectangular tanks, each of 7,800 gallons capacity and measuring 14 ft. by 9 ft. by 10 ft. deep, are available in the heat-treatment bay. They were supplied by Fawcett Preston and Company, Limited, Bromborough, Cheshire, and their positions can be seen on the plan, Fig. 3, and also in Fig. 9, on page 618. In all cases, one of the twin tanks is employed for water and the other for oil quenching. River water is used for cooling the water tanks, the overflow being connected to the main drainage system of the shop. In the oil tanks, centrifugal pumps are employed for circulation purposes, on the closed-circuit principle. Adequate oil coolers are incorporated on the oil circuits to enable the temperature of the oil to be maintained within the required limits when quenching.

The incoming three-phase 50-cycles electricity supply to the forge shop is taken from the main substation of the works, by a feeder cable to the forge substation at a pressure of 11,200 volts, where it is connected through oil circuit-breakers of 150 MVA capacity, manufactured by A. Reyrolle and Company, Limited, Hebburn-on-Tyne, to two 1,500-kVA 11·2/3·3-kV oil naturally-cooled transformers, supplied by C. A. Parsons and Company, Limited, Newcastle-upon-Tyne. The secondaries of the transformers are connected to a 3·3-kV switchboard manufactured by Switchgear and Cowans, Limited, Manchester. The 3·3-kV supply is then reduced to 400 volts, the standard for all the motors in the shop, in two C. A. Parsons 500-kVA oil naturally-cooled transformers for distribution throughout the building through a switchboard supplied by Crompton Parkinson, Limited. A direct-current supply of 230 volts for the cranes is obtained through a 500-kW mercury-arc rectifier supplied by the General Electric Company, Limited. All cabling, the greater part of which is required for the furnace motors, has been supplied by British Insulated Callender's Cables, Limited, and is arranged in an underground trench, as is shown on the plan, Fig. 3. A 2-in. diameter compressed-air main, supplying air at a pressure of 100 lb. per square inch, serves the three main bays, connections being available at numerous points throughout the shop for such operations as scale blowing, chipping and grinding. An oxygen supply line has been installed by the British Oxygen Company, Limited, in the stock bay, for the surface treatment of ingots.

In addition to the hydraulic service, water is required for quenching and oil-cooling purposes in the heat-treatment bay, and also for the cooling of the exhaust and blowing fans and the air and gas reversing valves in the furnaces. As already indicated, both clean and river water are employed, the former being used for the accumulator plant, the presses, and in places where small-bore pipes are installed, while the latter is used for oil-cooling and quenching purposes and for cooling the air and gas reversing valves. The water service has been installed by William Press and Son.

THE ORGANISATION OF RESEARCH.

The organisation of scientific and industrial research has been the theme of a four-day International Symposium, organised by the Department of Scientific and Industrial Research and held in London this week. The meetings, which were attended by a large contingent of delegates from Western Europe, chiefly directors of scientific research, and presidents of scientific academies in the eleven continental countries represented, marked the conclusion of a five-weeks tour by a mission, sponsored by the Organisation for European Economic Co-operation (O.E.E.C.), which visited eight European countries to study the organisation and application to industrial purposes of scientific research in each. The visits of missions to the United States to study industrial productivity have become a familiar feature of recent years. Possibly as one result of these visits, and apparently somewhat belatedly, though we are none the less glad to record it, it has been discovered that the countries of Europe, the source of so many of the scientific discoveries on which the modern world depends, can learn from each other something to their mutual advantage. Thus, although productivity teams continue to visit the United States to study American industrial methods, increased attention is being given to conditions at home, in Europe, revealing a wealth of experience not only in the field of productivity, but also in that of scientific research applied to industry.

The delegates to the symposium were welcomed at Lancaster House on Monday, November 12, by the Lord President of the Council, who remarked that the occasion was the first on which the responsible leaders of industrial research in Western Europe had met together to discuss their problems. The present was particularly opportune for such discussion, for there was a pressing need to raise the industrial efficiency and economic well-being of Western Europe. Of all the factors which influenced international well-being, said Lord Woolton, fundamental science seemed likely to have the greatest effect in the long run. It had long been the policy of the British Government to support this branch of science by financial or other means, and to leave it free to develop. Applied research, however, presented a different problem. In this field, co-operation between scientists, engineers and economists was essential to the efficient use of money, material and manpower. Industry itself must be responsible for the bulk of applied research and development, but it had become established practice in Britain for a considerable proportion of applied research to be undertaken jointly by Government and industry through the medium of industrial Research Associations.

The field of applied science, however, said Lord Woolton, offered scope not only for national, but also for international, co-operation. Western Europe was at a disadvantage compared with larger countries, such as the United States, or Russia, by reason of her division into small political units. In the United States, for example, when a great and costly industrial development had to be undertaken, there was no need to erect a multiplicity of pilot plants or duplicate the engineering of prototype machines. One such plant or machine could serve the needs of states as widely separated as Massachusetts, Texas and California, for the sole reason that they were politically united. In Europe, however, where this unity was lacking, the same problem must be tackled independently by all the highly-industrialised countries.

There were a number of schemes, said the Lord President, particularly those connected with the exploitation of natural resources, which were suited to international co-operative research. One of these was low-shaft blast-furnace development, an expensive enterprise which, nevertheless, had attracted a number of countries who were willing to co-operate by providing money and manpower. Fuel research figured prominently in the list drawn up by O.E.E.C. and, among fuel problems, there might be mentioned total gasification of solid fuels and underground gasification of coal, both of which were of interest to many countries and required costly large-scale investigation if their economic possibilities were to be explored satisfactorily. In the sphere of raw materials, also, there were many problems of common interest. One of considerable immediate practical importance was the production of phosphate fertilisers with less, or even without, sulphuric acid. In this work, chemists, engineers, economists and agricultural experts were already co-operating.

The Lord President was followed by Sir Ben Lockspeiser, Secretary of the Department of Scientific and Industrial Research, who stressed that, at the present critical juncture, the future of Europe depended largely on the efficient organisation and application of science, by which alone standards of living could be maintained or improved. Fundamental research did not require organising but the same was not true of applied research. The latter was undertaken solely for the economic and social benefits to be derived from it and, if only because some of the objectives towards which it might be directed were preferable to others, it required organising. No single type of organisation, however, was likely to suit all countries, because, although the problems of all were similar in character, they were different when considered, as they must be, in the political, social and economic contexts of each country. In Britain, for example, the Government had assumed certain community responsibilities in fuel and power, agriculture, transport, food supply, health and housing, and a considerable scientific effort was maintained by the Government to promote the efficiency of these.

Research for the manufacturing industries, continued Sir Ben, was in a different category. Industries varied greatly in character; some had been based on science from the start, others had won through by empirical methods. Firms also varied considerably in size and, although size and efficiency did not necessarily go hand in hand, size affected a firm's ability to do its own research. In Britain, the small firm played a distinctive and vital part. The number of firms large enough to conduct their own research on a substantial scale was only some hundreds, but those too small to do so could be counted in thousands. Nearly three-quarters of the country's industrial undertakings employed less than 100 persons and, of these, more than half had less than 25 employees. It was for this reason that a co-operative research system, sponsored by the Department of Scientific and Industrial Research, had grown up in Britain in the past 30 years. In the United States, as in Britain, large firms with considerable financial resources, undertook most of the applied research, but there were also research institutes which undertook sponsored research on a confidential and, frequently, non-profit-making basis. In Canada, where industries were frequently separated by long distances, a very flexible system of government-sponsored research had grown up under the National Research Council, which also catered for local needs by the establishment of laboratories in, for example, the Prairie and Maritime Provinces. In all cases, however, the main problem was to bring science to the aid of firms which, for one reason or another, did not undertake research themselves. If every firm did, in fact, do so, there would be far too few scientists to go round. This was a basic reason for undertaking co-operative research. Similar considerations applied across national boundaries.

The turning of science, conducted outside industry, to industrial advantage remained an urgent problem, said Sir Ben. As was being increasingly realised, this did not happen by itself. Three of the major Research Associations had now set up companies to undertake the commercial development and exploitation of their work. Such companies must be run on strict commercial lines. Good science was not always good business, and great care was desirable in the selection of objectives. What was known as "operational research" could also be of great value, and could produce relatively quick returns by enabling industry to make the best use of what it had available. He thought that such research was worthy of the attention of scientists since, aided by statistical and other scientific methods, it had shown the way to better organisation, better management and a better use of existing resources.

At subsequent sessions, papers were read by delegates on co-operative and sponsored research, the administration of research and the application of its results in their various countries. One session was held at the National Physical Laboratory. The discussion concluded yesterday evening.

HEAVY ENGINEERING WORKS AT WITTON.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

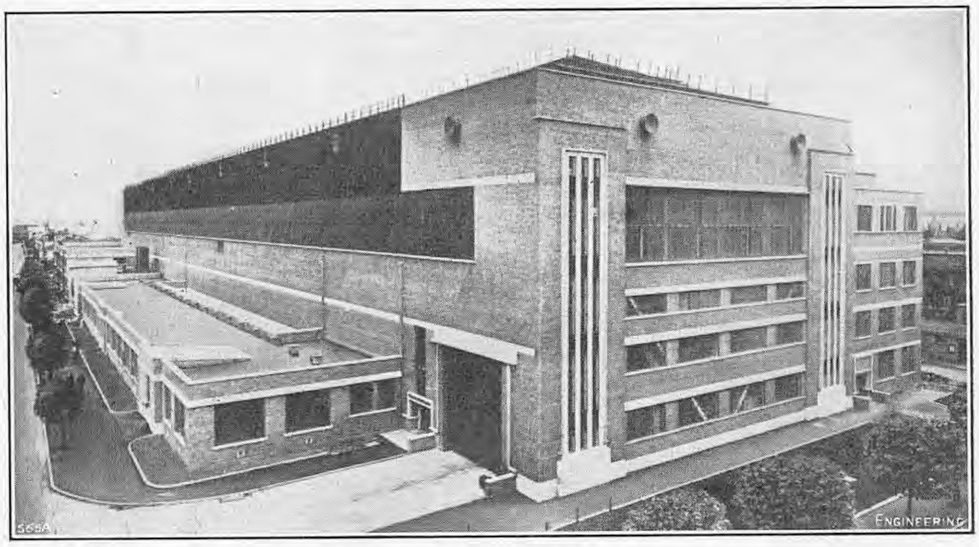


FIG. 1. GENERAL VIEW OF NEW WORKS.

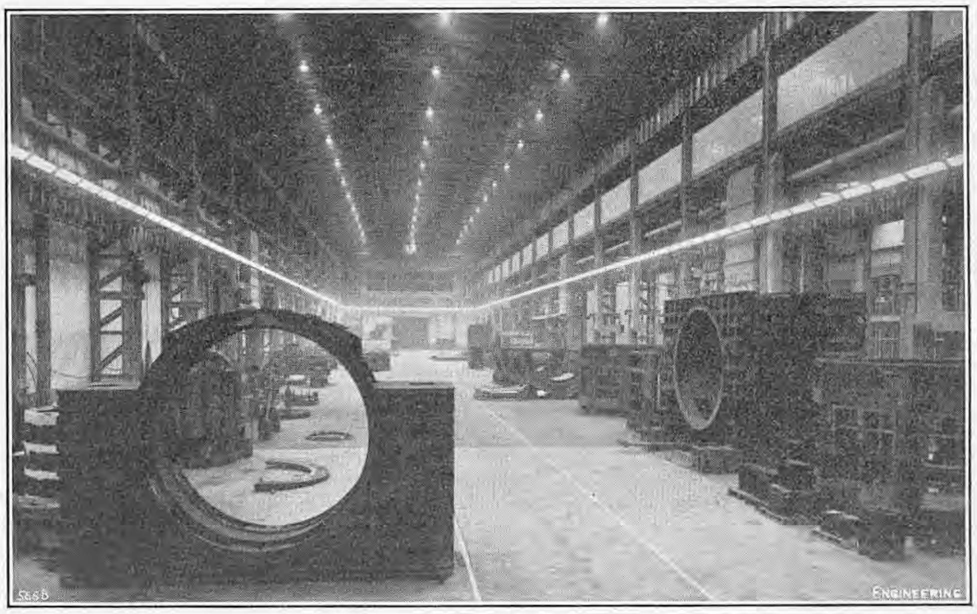


FIG. 2. MAIN ERECTION AND TEST BAY.

NEW HEAVY ENGINEERING WORKS OF THE GENERAL ELECTRIC COMPANY.

THE General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have made an important contribution to increase the country's manufacturing capacity of large electric generating and other plant by extending their works, both at Witton, near Birmingham, and at Erith, Kent. At the former place, where production has now been taking place for over 50 years, a new factory has been built for the erection and testing of large steam-driven and water-turbine driven alternators, as well as for motors for rolling mills, mine winders and ship propulsion. The existing transformer and high-tension switchgear works have been enlarged and a new press shop has been equipped. At Erith extensions have been made to the Fraser and Chalmers Engineering Works to give increased capacity for the production of steam turbines, mine winders and turbo-compressors.

The new heavy engineering works at Witton, a view of the exterior of which is given in Fig. 1, cover an area of about 2½ acres and are erected on a site which was used during the war to accommodate 34 underground air-raid shelters. Where these interfered with the foundations for the stanchions of the new building they were completely removed, while the others were broken, open filled and consolidated. Test holes revealed the presence of hard compressed sand at a depth of about 12 ft., with a complete absence of water. As this sand was suitable for a loading of 4 tons per square foot, piling was unnecessary and the main stanchions are therefore carried on concrete blocks varying in size from 22 ft. by 10 ft. to 24 ft. by 12 ft., which were sunk to a depth of 14 ft. At one end of the building, the ground was excavated to depths of 24 ft. and 30 ft. to provide room for the overspeed test pit and oil tanks, while over the rest of the area a layer of poor-quality soil was removed and replaced by a filling of pit slag followed by a surfacing of hard core.

The building is a steel-framed and brick-filled structure, the outer walls being faced with Blockley bricks. To secure adequate natural lighting and to reduce the heat losses, the roof is of the ridge type with three-tier glazing and is protected by metal sheeting with ½ in. fibre board. The cost of a north light roof was prohibitive, as the building runs east and west. The floor is constructed for loads ranging from 2 tons to 3 tons per square foot, the areas round the pits, test sections and stores being finished with concrete and the erection and winding sections with wood-block flooring.

The main erection test bay, which is illustrated in Fig. 2, is 525 ft. long by 100 ft. wide in a single span, the height to the eaves being 70 ft. It is served by two 110-ton travelling cranes, which can be used for a maximum lift of 200 tons. At the east end are four core-building pits, each of which is 6 ft. deep. These are equipped with hydraulic jacks for compressing the core stampings, three being designed for a total loading of 200 tons and the fourth for 50 tons. Facilities are provided for ring flux testing of the cores, both during assembly and when completed. On the south side is an electronic balancing machine which is capable of balancing rotors up to 50 tons in weight to an accuracy of one-tenth of an ounce at the periphery.

A photograph showing the test beds, where the stators and rotors meet after being assembled in single lines down the length of the shop, is reproduced in Fig. 3, opposite. They include a raised bed for turbo-alternators, an overspeed rotor test pit, and a test bed for water-wheel alternators. These beds are all situated at the west end of the bay and occupy a floor space of about 160 ft. by 100 ft. A bay, 40 ft. wide, runs along the full length of the building on the north side. About half of this is devoted to forming rotor windings and to certain finishing processes on the stator coils, while the remainder is used as offices and stores. Above the stores and winding sections is a floor, the greater part of which is devoted to the manufacture of stator coils and formers. This floor is served by a 5-ton dual-capacity lift, which is designed to handle loads of 2 tons at 150 ft. per minute or of 5 tons at 50 ft. per minute. The cage of this lift is 28 ft. long by 10 ft. wide, and accommodates an aluminium truck with a mahogany top, on to which the coils are loaded. Rails in the floor of the cage register with similar rails in the floors of the winding bays.

The main test bed for the turbine-driven alternators, which is illustrated in Fig. 4, Plate XLI, is 133 ft. long by 19 ft. wide. It comprises a central platform 8 ft. high, on either side of which is an alternator bed 50 ft. 6 in. long and 6 ft. 3 in. above the shop floor. One machine can therefore be erected or dismantled while a second is on test. Each of the alternator beds is built to form a pit below the machine and is provided with air ducts for the closed-circuit ventilation of air-cooled alternators. A hydrogen detraining tank also forms part of the test equipment so that alternators with this system of cooling can be run under operating conditions. All the testing can be effected at full voltage and current on all sizes of machine, two saturable reactors being provided whereby loads up to 100 MW at very low power factor can be imposed. Tubular copper 'bus-bars, with a diameter of 4 in. and ⅜ in. thick, connect the alternator to the reactors. These are suitable for voltages up to 22 kV, their large diameter minimising skin effect and eliminating any risk of corona. Particular attention has been given to the lubrication system. In the event of a breakdown of the oil pumps a header tank, designed for a working pressure of 50 lb. per square inch, and having a capacity of over 2,000 gallons, ensures an adequate supply of oil to the bearings during the time taken to shut down the plant.

For complete tests, constant speed with no risk of overspeed is essential. For this reason, the driving motor, which is mounted on the central platform, is of the induction type and is connected through two induction regulators and a 2,000-kVA step-down transformer to the 11-kV mains. The regulators give a variable voltage from 0 to 760 volts to meet the requirements of starting and stopping the plant on test. They may also be used to provide a supply when reactance measurements are being made on the stator windings. The motor is rated at 2,000 h.p. at a speed of 2,950 r.p.m. and has a double shaft extension so that it can readily be coupled to alternators mounted on either of the test beds. Should extra driving power be required, a second motor can be coupled in tandem.

A steel platform, which extends the full length of the test bed on the south side, is provided with two removable sections, each 20 ft. 6 in. long by 13 ft. 9 in. wide, adjacent to the alternator beds. The fans and coolers for air-cooled alternator ventilation systems are mounted on one of these sections; and the hydrogen and carbon-dioxide control panels and gas supplies for hydrogen-cooled alternators are on the other side. The control board from which the whole of the test plant is operated, is situated on the steel platform alongside the middle section of the test bed, and is illustrated in Fig. 5, Plate XLI.

The rotor overspeed pit, of which mention has already been made, is of heavily-reinforced concrete construction and is over 60 ft. long by 11 ft. wide between the concrete sides. The arrangement of the 300 tons of steel reinforcement used is illustrated in Fig. 6, Plate XLI. The sides of this pit are protected over a length of 37 ft. 6 in. by steel boxes which are filled with sand and set in panels 5 ft. 6 in. deep. A final facing of timber, 10 in. thick, completes the provision made to absorb the energy which would be released in the event of a large rotor bursting in an overspeed test. An escape tunnel, with entrances at each end, extends the full length of the pit. The pit is completely covered by seven slabs, each weighing 30 tons and constructed from rolled-steel joists and flange plates 1½ in. thick. The box section thus formed is filled with concrete. A sand-filled steel box, faced with thick timbers, forms the underside of the slab. These slabs are secured by heavy cast-iron wedges, so that the entire covering is dovetailed in position. Ventilation is provided by a centrifugal fan which draws air from the pit and discharges it to atmosphere through a circular duct under the stores floor. A general view of the interior of the pit is given in Fig. 7, Plate XLI.

Since variable speed is essential for overspeed testing, a direct-current motor arranged with Ward-Leonard

HEAVY ENGINEERING WORKS AT WITTON.

GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

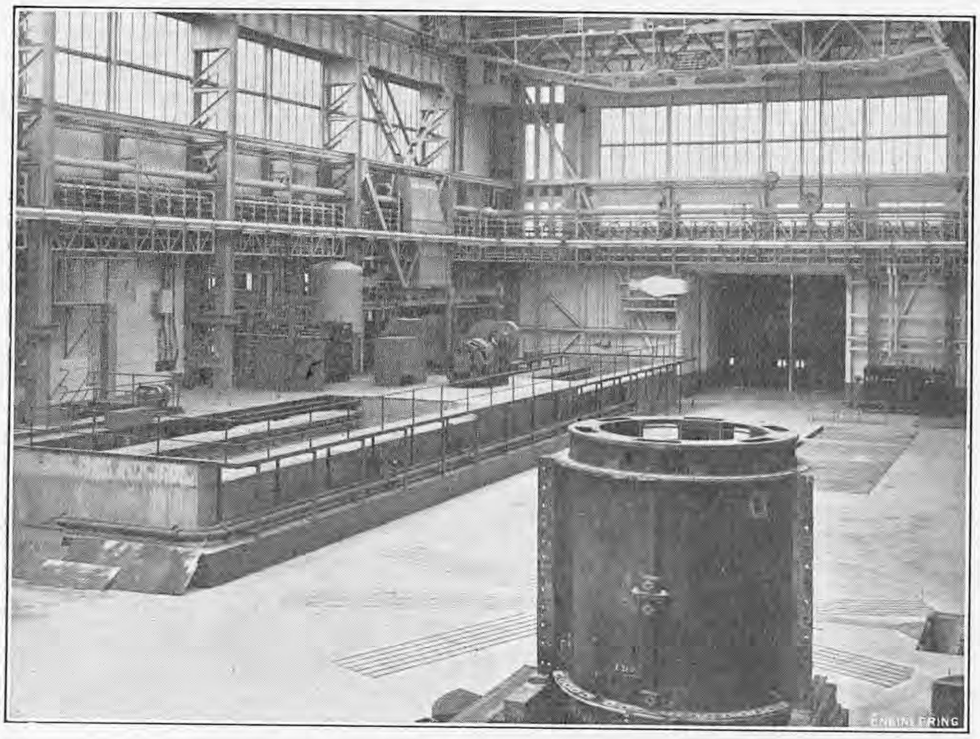


Fig. 3. General View of Test-Beds.

control is provided for driving the rotor through gearing. This motor is rated at 2,000 h.p. and is designed for a voltage range of 0/600/750 volts and for speeds up to 900 r.p.m. The motor and its gearing are mounted on a bedplate so that they form a self-contained transportable unit, which can be lifted readily from the pit, and used to drive a variable-frequency alternator for the overspeed testing of water-wheel alternators. The test control board is mounted on floor level to the west of the pit and is of the flat back type.

The test bed for water-wheel alternators covers a floor area of about 44 ft. in diameter and comprises a central pit 8 ft. in diameter and 6 ft. 6 in. deep. Cast-iron floor plates arranged symmetrically to form eight legs, as can be seen behind the 60-MW stator in Fig. 3, on which the alternator and test equipment are mounted, radiate from the pit, at the bottom of which is a 100-ton hydraulic jack. This jack is supported on a ball bearing to carry the weight of the rotor on starting. As soon as rotation begins the oil enters the Michell thrust bearing and the jack is released.

A 2,000-h.p. direct-current motor is mounted on top of the alternator in place of the exciter for driving purposes. It is Ward-Leonard controlled and provides a speed range from 0 to 800 r.p.m., so that in many cases it can be used for running the alternator at overspeed. Where higher speeds are required, the alternator with the exciter in position is run as a synchronous machine, and is supplied from a 5,000-kVA, 5,000-volt alternator at a frequency up to 150 cycles. As already mentioned, this machine is driven by the 2,000-h.p. direct-current motor, normally used in the overspeed test pit.

The power plant for all test requirements, which includes two motor-generators, two induction regulators and a grid-controlled rectifier, is housed in an indoor substation adjacent to the test beds. This substation also contains the high- and low-voltage switchgear for test and works supplies. Adjacent to this building is an outdoor substation in which seven transformers and two saturable reactors are installed. Two air-blast water spray coolers are also situated in this area. One is for the water for the oil cooler and the hydrogen and air coolers in the closed ventilating circuits of the alternators on test, and the other for the electrolyte from the liquid starter of the 2,000-h.p. driving motor on the alternator test bed. Supplies are obtained at 11 kV from the mains and from the works power station. A 460-volt, three-wire direct-current supply for the cranes and general works services is also available, and there is an emergency 400-volt three-phase four-wire feeder for the essential test-plant auxiliaries, which is brought into service automatically should the main supply fail.

The main power unit comprises a 750-h.p. 440-volt, synchronous induction motor, which is directly coupled to a 4,000-kVA alternator, a 2,000-kW direct-current generator and two exciters. The motor is connected to the 11-kV supply through a 750-kVA step-down transformer, and the alternator is specially wound to generate at voltages of 11 kV, 6·6 kV, 5·5 kV or 3·3 kV, according to the stator connections used. This plant has two main functions. Firstly, it can be run as a motor-generator for the Ward-Leonard control of the 2,000-h.p. motor in the overspeed test pit or the driving motor for water-wheel alternators. When so used, the alternator is connected to the 11-kV supply and operates as a synchronous motor to drive the 2,000-kW generator, the 750-h.p. motor being used solely for bringing the set up to synchronous speed. Secondly, the 4,000-kVA machine may be driven as an alternator for supplying current for ring flux tests on stator cores, and for stator reactance measurements. In both cases the power factor is very low so that the 750-h.p. synchronous induction motor will usually provide a satisfactory drive. If necessary, additional driving power can be obtained by running the direct-current generator as a motor. Excitation current for the machines under test, is obtained from a 360-kW, 400-volt motor-generator, which also supplies direct-current for heating the rotor windings while they are being compressed in the slots.

A variable-voltage alternating-current supply for the 2,000-h.p. driving motor on the alternator test bed is obtained from a 2,000-kVA 11,000/380-volt outdoor transformer, in conjunction with two motor-operated induction regulators. Each is rated at 500 kVA and provides a voltage range from 0 to 760 volts. The two outdoor saturable reactors, which provide the load on the alternators on test, are rated at 75 MVA at 22 kV and 11 kV, or at 37 MVA at 6·6 kV. They can also operate at 100 MVA at 15 kV on a three-hour rating. Direct-current for saturating the reactors is obtained from a 325-kW grid-controlled pumpless steel tank rectifier in the indoor substation.

There are a total of seven transformers in the outdoor substation, all of which operate at 11 kV. The largest of these is rated at 4,000 kVA and is used to give a heavy current supply to the test bay. This unit receives power from the 4,000-kVA alternator of the main motor-generator set in the indoor substation. The secondary winding can be connected in star or delta to give a voltage of 880 or 550.

Three transformers, two rated at 1,000 kVA and one at 500 kVA, are installed to supply the 440-volt alternating-current distribution system, and a 750-kVA unit provides power for the 750-h.p. driving motor of the main motor-generator set. The remaining units supply the induction regulators and grid-controlled rectifier and are rated at 2,000 kVA and 600 kVA, respectively.

The switchgear in the indoor substation comprises an eight-panel metal-clad switchboard, with circuit breakers of 250 MVA rupturing capacity, which are remotely controlled from a board in the substation. It controls the two incoming and the six outgoing feeders. The 440-volt alternating-current distribution system, and the essential test auxiliaries, are controlled from an 18 panel air-break switchboard, the various panels on which are in single, double or four tiers, depending upon the size of circuit breaker and the type of equipment involved. Flat-back switchboards are provided for the heavy-current alternating- and direct-current supplies to the test beds and core pits, and for the 460-volt direct-current distribution system.

Power cables and heavy current 'bus-bars in the main erection and test bays are supported from the stanchions at high level. The heavy current 'bus-bars are of aluminium strip or channel, depending on the current capacity. For the 5,000-ampere bars, 8 in. by 3½ in. channel was chosen, as it provides more efficient cooling and reduces the skin effect when the bars carry alternating current. The three 'bus-bars are arranged in triangular form, the lower bar being suspended from a plate which bridges two porcelain insulators and also carries the insulators which support the two upper bars. Slots in the supporting plates and in the 'bus-bars allow for any movement due to expansion. The expansion joints consist of aluminium strip arranged in packs of eight, with three packs for each 'bus-bar. Similar expansion joints are used for the 'bus-bars made from 4 in. by ¼ in. aluminium strip. All the 'bus-bars are painted mat black to assist radiation and thus to increase their current-carrying capacity. For essential house services, such as works lighting and office fans, the totally-enclosed "plug in" 'bus-bar system is used. The 'bus-bars are enclosed in a sheet-metal casing with tap-off units at 3 ft. intervals, and run down each side of the works above the crane walkway.

Other essential services, which are also run at high level, include a 150 lb. per square inch steam main for process work, a low-pressure steam main for heating, the condensate main, and compressed-air and gas mains.

The heating and ventilating system in the new factory is designed to maintain an internal temperature of 65 deg. with an outside temperature of 32 deg. F. The total heating load is over 12½ million B.Th.U. per hour. Heat is distributed by units of the blower type with outlets 14 ft. above the floor. These heaters are supplied from a low-pressure ring main, the flow being regulated automatically by a thermostatically controlled motor-operated valve. The fresh air and recirculating air ducts are fitted with motor-operated dampers, which, together with the two-speed fan motors, are remote controlled from a master switchboard. Further regulation of the rate of air change is provided by extractor fans, which are mounted at high level and are arranged for group control from this board. In order to provide supplementary heating, and to reduce the height, a double 3-in. pipe is run immediately below the vertical glazing on the south side of the building. An axial-flow fan and heater is placed at each of the main doors. These fans are started automatically when the door opens, so that a blanket of warm air is provided.

As shown in Fig. 2, the main erection and test bay is lighted by 48 1,000-watt high-pressure mercury-vapour discharge lamps, which are mounted at a height of 70 ft. above the floor. These lamps are spaced at 30-ft. centres in three rows 31 ft. apart. This lighting is supplemented by continuous lines of 80-watt low-brightness fluorescent lamps, which are arranged round the sides and ends of the bay in Perspex trough reflectors at a height of 30 ft. In this way a high intensity of illumination is maintained over the fitters' benches and on the vertical surfaces of the machines under construction. The average service illumination resulting from the two systems of lighting is 25 lumens per square foot.

The alterations to the transformer works at Witton consist of an extension of 175 ft. to the main erection bay, the addition of a new drying stove, which will accommodate the largest transformers, and new oil-treatment plant and storage tanks. The west bay of the works has also been extended to house the core-preparation section and a new bay has been added to accommodate the dispatch department, stores and light winding and small assembly sections. The high-tension switchgear works has been extended by 300 ft., part of which provides the greater head-room necessary for the production of very high voltage circuit breakers. The fabrication section has also been extended by 175 ft.

1,700-kV Impulse Generator: Erratum.—We are asked to say that the material used for the tanks in which the transformers, capacitors and other units of the 1,700-kV impulse generator, described on page 555, *ante*, was Paxolin synthetic-resin bonded-paper, manufactured by Micanite and Insulators Company, Limited, and not Bakelite.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Shipbuilding Activities.—Scottish shipbuilding firms in the first 10 months of 1951, up till the end of October, were responsible for a launching total nearly 6,000 tons greater than that of the corresponding period last year. The tonnage rate was maintained, although 13 fewer ships were launched, the larger types of tankers under construction accounting for the higher output figures. Six vessels, aggregating 54,850 tons, were launched from Clyde yards during October, making a total of 58 vessels, comprising 329,654 tons gross, in the first 10 months of 1951, compared with 68 ships, making together 330,466 tons gross, in the corresponding period of 1950.

Hydro-Electric Plant in Perthshire.—A scheme for using the water of a new reservoir under construction at Upper Glendevon, Perthshire, for generating electricity, has been approved by Fife Water Supplies Committee. The county engineer, Mr. C. Huddleston, estimates that it should produce not less than 1,500,000 kWh a year. For a similar amount of current to be produced by a generator at Dunfermline, 2,000 tons of coal would be needed.

The Need for Further Power Stations.—Mr. T. Lawrie, general manager, North of Scotland Hydro-Electric Board, speaking in Glasgow on November 7, at the annual dinner of the Glasgow and West of Scotland branch of the Electrical Contractors Association of Scotland, said that more power stations would have to be built, and built faster, if this country were to improve her agricultural production, maintain her industrial position, and reduce frustration and drudgery in the home. The present rate of construction should be doubled now, he added, and doubled again in 1961, to put an end to power cuts.

Glasgow Water-Supply Developments.—A 36-in. water main to extend supplies to new areas of industrial and housing development in the West of Glasgow has now been laid to about half its length between the Mugdock reservoir and the Forth and Clyde canal at Cloberhill. Later it will be continued to, and then under, the River Clyde, and extended as far as Crookston, which is expected to be reached about the end of 1953. The continuation of the line from Cloberhill awaits approval, by the Department of Health for Scotland, of the Corporation's plans to construct the necessary tunnel under the Clyde. The project is estimated to cost 1,000,000*l*.

Road Transport of Distillation Column.—A distillation column—part of a plant being installed at a new chemical factory at Grangemouth—132 ft. long and weighing 40 tons, arrived at Grangemouth on November 7, after being brought by road from London in 11 days, namely, two days ahead of schedule. It was carried by two 100-h.p. Diesel lorries from the works of the makers, G. A. Harvey & Co. (London), Ltd., London, S.E.7. A film-making unit of the British Transport Commission recorded the journey.

Repairs to Ordie Viaduct.—Ordie Viaduct, Perthshire, which carries the main railway line from Perth to the North over the valley of the Ordie, is being strengthened and repaired by engineers of British Railways. One-half of the 300-ft. long viaduct, which is more than 100 years old, has been closed, but temporary arrangements enable the full volume of traffic, normally heavy, to be carried.

Shipments of Coal.—During the year up till the end of September, 400,129 tons of cargo and bunker coal were shipped from Glasgow. This compared with 362,003 tons for the corresponding period of 1950. In the six months to June 30, 1939, shipments were 1,708,761 tons, and for the corresponding period of 1913, 4,016,070 tons. Commenting on these figures on November 6, Sir Patrick Dollan, chairman of the Scottish Fuel Efficiency Committee, said there would never be a properly balanced economy in this country, no matter what Government were in power, until the quantity of coal exported was equivalent to that exported in 1939.

CLEVELAND AND THE NORTHERN COUNTIES.

Traffic on Tees.—At a meeting of the Tees Conservancy Commissioners, held at Middlesbrough last week, statistics submitted revealed that exports from the Tees in September were the lowest recorded in any month since August, 1949. The total was 40,000 tons less than in September last year, owing principally to the decrease in coastwise shipments of coal and in loadings of manufactured iron and steel for overseas destinations. Alderman B. O. Davies, who presided, agreed with a remark that they were obviously passing through a " bad patch " at present, but he thought that there was better weather ahead on the horizon. He added that, last year, this country bought from Germany 2,000,000 tons of scrap, and that, this year, so far, it had been possible to obtain only some 500,000 tons.

'Bus Depot at Newcastle.—In 1949, the Corporation of Newcastle-upon-Tyne purchased a hangar from an aircraft factory, at a cost of 9,500*l*., for the purpose of converting the material into a 'bus depot. The hangar has been dismantled and conveyed to a 5-acre site at Statyford-lane, Newcastle, but these operations and the work of re-erection brought the cost up to 31,115*l*. A contract for finishing the building, at a cost of 153,832*l*., has now been let, but it is stated that the total cost of the scheme, including plant and equipment and the purchase price of the land, is 281,533*l*. Against this, however, it is anticipated that the closing down of the old depots at Haymarket and Wingrove will result in considerable economies in operational costs, as well as in labour charges. Unfortunately, for a number of reasons, it has been announced that the new depot cannot be opened and brought into service for about two years.

The Late Mr. J. L. Carr.—We regret to record the death of Mr. John Liddle Carr, which occurred at Timperley, Cheshire, on Sunday, November 4, at the age of 62. Mr. Carr was educated at Durham University, and subsequently held positions with the Newcastle-on-Tyne Electricity Supply Company and the Bradford Corporation Electricity Department. He served with the Royal Engineers during the 1914-18 war and joined the Manchester Corporation Electricity Department in 1919. He was appointed chief electro-technical engineer in that Department in 1927 and distribution engineer in 1944. Four years later he became technical and research engineer of the North Western Electricity Board. Mr. Carr was elected an associate member of the Institution of Electrical Engineers in 1919 and was transferred to the class of member in 1943. He was a frequent contributor to the proceedings and had been awarded Paris Electrical Exhibition, Institution and Transmission Section, premiums.

LANCASHIRE AND SOUTH YORKSHIRE.

Italian Labour in the Mines.—It was hoped that, by the end of December, there would be 1,500 Italians working in Yorkshire collieries, but, so far, the number is only 84. At 114 Yorkshire pits, which could take Italians, the miners refuse to work alongside them in spite of the overtures of miners' leaders. The 84 Italians are working at 13 pits, including Bullcroft Main, where 22 are employed. Eight other pits have stated that they will take Italians.

Decline in Steel Production.—A Board of Trade report states that steel production in Sheffield shows signs of a further decline, and that steel manufacturers continue to refuse new orders. Grave concern is expressed at the shortage of scrap, and, on account of the great uncertainty concerning the supply of raw materials, it is becoming increasingly difficult to retain firms' interest in overseas markets. Rolling mills are refusing to accept orders for 1952, pebding the introduction of a steel rationing scheme.

Rolling-Stock Construction.—The carriage and wagon shops of British Railways at Doncaster are very short of steel and a special appeal has been made to the Government for supplies. It has been necessary to direct some skilled men to the labour pool, and it is feared that the number of employees affected may reach 300 if, as seems likely, the 1952 programme for building 100 coaches has to be retarded.

THE MIDLANDS.

The Size of Birmingham Factories.—The first annual abstract of statistics recently published by the Central Statistical Office of the City of Birmingham clearly confirms that small factories still predominate in the city. The statistics show that in December, 1948, 1,490 factories in Birmingham employed between 10 and 25 persons each, and 841 had 25 to 50 employees. A further 512 factories employed 50 to 100, and, in the medium-sized group, between 200 and 300 were employed by each of 107 factories. Two factories had between 7,500 and 10,000 employees, and only one had more than 10,000.

A New Lightweight Motor-Car.—The Reliant Engineering Co., Ltd., of Twogates, Tamworth, have developed a new three-wheeled motor-car, designed with particular regard to economical running. It has a 747·5 c.c. water-cooled engine and a four-speed gearbox, and is stated to do over 50 miles per gallon. The first vehicle is being exhibited at the Cycle and Motor Cycle Show at Earl's Court, London. Production is expected to begin next summer.

Conference on Nickel Plating.—A one-day conference was held at the Midland Institute, Birmingham, on November 6, by the Institute of Metal Finishing (incorporating the Electrodepositors' Technical Society). The purpose of the conference was to discuss the ban on many uses of nickel, which came into force on October 1. The question of alternative materials also came under review, but it was stated that none of the alternatives so far put forward had been a success. The conference decided that the Minister of Supply should be asked to discuss the question of saving nickel rather than prohibiting its use. It was pointed out that recent research has made it possible to achieve the desired protection of metals with a much reduced consumption of nickel, and that, by using this newly acquired knowledge, more nickel would probably be saved than by the present prohibition of certain uses.

Transmission Line on Malvern Hills.—The proposal by the Midlands Electricity Board to erect a power line over the Malvern Hills is being resisted by the National Trust, which holds covenants over much of the land in the area. The proposed power line is to be carried overhead on towers, and it is this feature to which the Trust objects. The Minister of Fuel and Power decided recently that 600 yards of the line, which would have been prominent on the skyline, should be taken underground, but the Trust has asked for a further 500 yards to be so laid, to preserve the amenities. The Electricity Board have not acceded to the request, and the National Trust has now issued a writ, seeking an injunction to restrain the Board from erecting an overhead line at the point in dispute.

Iron and Steel.—Supplies of iron and steel for manufacturing purposes in the Midlands continue to be a source of great difficulty, and two deputations from the area are to go to the Ministry of Supply to state the case of the manufacturers. The Midland Branch of the National Union of Manufacturers is to send one deputation, and the Midland regional committee of the Engineering Industries Association are also collecting evidence from its members to support their own claim for special consideration. The smaller firms, in particular, are in urgent need of assistance. In the case of the re-rollers, short-time working is the general rule, and conditions show no signs of improving. The Wednesbury Employment Committee stated recently that some of the re-rollers will be forced to close down completely unless supplies of semi-finished steel are received soon.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Horizon-Mining Schemes.—After two years' work, the neighbouring mining valleys of Aberdare and the Rhondda have been linked by a 3,250-yards long tunnel, 400 ft. underground. It marks the close of the first stage in the 4,000,000*l*. scheme for horizon mining at the Mardy Colliery in the Rhondda and the Bwllfa Colliery in the Aberdare Valley. More than 100,000 tons of spoil have been removed from the tunnel, which is 15 ft. wide and 11 ft. high. About 2,800 men will eventually be employed in the 12 seams of the two collieries, which has coal reserves estimated at 120,000,000 tons. Daily production will reach 4,000 tons.

Boring for Anthracite.—Boreholes will be sunk shortly in the Dulais Valley to find the best sites for new pits in the South Wales anthracite area. Under the National Coal Board's development plans, announced last year, seven new pits will be sunk in South Wales, four of them in the anthracite area.

Prospect of a Wales-Eire Air Service.—Members of the Welsh Advisory Council for Civil Aviation flew to Dublin during the past week to discuss the possibility of a new air service linking Wales with Eire. Discussions were with representatives of the Aer Lingus Company. The prospects for the inception of the new line depend on the availability, next summer, of the new Rhoose airport, near Cardiff.

Employment in Aberdare Vallies.—When a deputation from Aberdare Urban Council and various trade unions met Capt. H. P. K. Oram, Board of Trade Controller for Wales, to discuss redundancy caused in the Valley by the closing of a radio factory, it was stated that negotiations with a prominent firm to take over an empty factory at Robertstown were reaching the closing stage and that this step would provide employment for a large number of workpeople.

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.—Monday, November 19, 5.30 p.m., Victoria-embankment, W.C.2. Informal Meeting. Discussion on "Light Electrical Engineering and the Mechanical Engineer," opened by Mr. T. E. Goldup. *Mersey and North Wales Centre:* Monday, November 19, 6.30 p.m., Town Hall, Chester. "Fibrous Glass for Electrical Insulation," by Mr. A. M. Robertson. *London Students' Section:* Monday, November 19, 7 p.m., George Hotel, Reading. "Medical and Industrial Uses of Radio-Frequency Energy," by Mr. H. Burton. *Measurements Section:* Tuesday, November 20, 5.30 p.m., Victoria-embankment, W.C.2. Three papers on "Universal High-Speed Digital Computers," by Professor F. C. Williams and others; and "Position Synchronisation of a Rotating Drum," by Professor F. C. Williams and Mr. J. C. West. *East Midland Centre:* Tuesday, November 20, 6.30 p.m., Electricity Service Centre, Irongates, Derby. Joint Meeting with Institution of Mechanical Engineers (*East Midlands Branch*). "Diesel Locomotives," by Mr. A. P. Goodman. *Southern Centre:* Wednesday, November 21, 6.30 p.m., 17, New Canal, Salisbury. Informal Meeting. *Utilization Section:* Thursday, November 22, 5.30 p.m., Victoria-embankment, W.C.2. "Electrical Control of Dangerous Machinery and Processes: Part III.—Remote Supervisory Control," by Mr. W. Fordham Cooper.

Illuminating Engineering Society.—*Sheffield Centre:* Monday, November 19, 6.30 p.m., The University, Western Bank, Sheffield, 10. "Home Lighting," by Miss M. Wardlaw. *Bradford Group:* Thursday, November 22, 7.30 p.m., Yorkshire Electricity Board Offices, 45-53, Sunbridge-road, Bradford. "Lighting of Departmental Stores," by Mr. A. W. Jervis.

Institution of Production Engineers.—*North-Eastern Section:* Monday, November 19, 7 p.m., Neville Hall, Newcastle-upon-Tyne. "Gear-Cutting Procedure," by Mr. H. Pearson. *Derby Section:* Monday, November 19, 7 p.m., School of Art, Green-lane, Derby. "Artistic Metal-Box Production," by Mr. G. F. Gledhill. *Manchester Section:* Monday, November 19, 7.15 p.m., College of Technology, Manchester. "The Electron Microscope," by Mr. M. Venner. *London Graduate Section:* Tuesday, November 20, 7.15 p.m., 36, Portman-square, W.1. "Cold Forging and Thread Rolling," by Mr. T. C. Parker. *Birmingham Section:* Wednesday, November 21, 7 p.m., James Watt Memorial Institute, Birmingham, 3. "Management and Production," by Professor J. R. Immer. *Edinburgh Section:* Wednesday, November 21, 7.30 p.m., North British Station Hotel, Edinburgh. "Selection and Application of Electrical Equipment," by Mr. N. V. Pestereff. *Coventry Graduate Section:* Thursday, November 22, 7.15 p.m., Geisha Café, Hertford-street, Coventry. "Production of a British Sports Car," by Mr. J. Silver.

Sheffield Society of Engineers and Metallurgists.—Monday, November 19, 7.30 p.m., The University, St. George's-square, Sheffield. "American Alloy-Steel Rolling Practice," by Mr. R. Stewartson.

Chemical Engineering Group.—Tuesday, November 20, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Recent Trends in Chemical Engineering," by Professor D. M. Newitt.

Institute of Fuel.—Tuesday, November 20, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Automatic Control Systems for the Coal Feed of Gas Producers," by Dr. S. A. Burke and Mr. G. A. Sparham. *Midland Section:* Tuesday, November 20, 6 p.m., James Watt Memorial Institute, Birmingham, 3. Film Display. *North-Western Section:* Wednesday, November 21, 6.30 p.m., Engineers' Club, Manchester. "Comparative Tests on Commercial CO_2 Recorders," by Mr. L. J. Flaws and Mr. W. Hill. *Yorkshire Section:* Wednesday, November 21, 6.30 p.m., The University, Leeds. "Boiler Research," by Dr. E. G. Ritchie.

Institution of Engineers-in-Charge and Association of Supervising Electrical Engineers.—Tuesday, November 20, 6.15 p.m., Magnet House, Kingsway, W.C.2. "High-Frequency Heating," by Mr. M. O'C. Horgan.

Institution of Engineers and Shipbuilders in Scotland.—Tuesday, November 20, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "The History and Development of Machinery for Paddle Steamers," by Mr. G. E. Barr.

Institution of Heating and Ventilating Engineers.—*North East Coast Branch:* Tuesday, November 20, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne, 1. "Air Conditioning in Textile Factories," by Mr. A. L. Longworth. *Birmingham Branch:* Thursday, November 22, 6.30 p.m., Imperial Hotel, Birmingham. "Gravity and Forced-Air Heater Batteries," by Dr. A. Rowan.

Institute of Road Transport Engineers.—*North East Centre:* Tuesday, November 20, 7 p.m., Dunelm Hotel, Durham. "Vehicle Development During the Last Decade," by Mr. W. C. Wilson. *Midlands Centre:* Tuesday, November 20, 7.30 p.m., The Crown Inn, Birmingham. "Vacuum and Air Brakes," by Mr. S. H. Edge. *North West Centre:* Wednesday, November 21, 7 p.m., The Victoria Hotel, Wigan. "The Performance of Heavy-Duty Oils," by Mr. M. Towle. *Institute:* Thursday, November 22, 6.30 p.m., The Royal Society of Arts, John Adam-street, W.C.2. "The Trend of Brake Design as It Affects Service," by Mr. J. W. Kinchin.

Iron and Steel Institute.—Wednesday, November 21, 10 a.m. and 2.30 p.m.; and Thursday, November 22, 10 a.m., 4 Grosvenor-gardens, Westminster, S.W.1. Autumn General Meeting. For programme, see page 461, *ante*.

Royal Society of Arts.—Wednesday, November 21, 2.30 p.m., John Adam-street, W.C.2. "The Reclamation of Abandoned Industrial Areas," by Professor L. Dudley Stamp.

Royal Meteorological Society.—Wednesday, November 21, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. "Cold Fronts Over the British Isles," by Mr. H. W. Sansom; and "The Apparent Diurnal Temperature Variation in the Lower Stratosphere," by Mr. R. H. Kay.

Newcomen Society.—Wednesday, November 21, 5.30 p.m., Institution of Civil Engineers, Great George-street, Westminster, S.W.1. Annual Meeting. "Peter William Willans (1851 to 1892)," by Mr. K. W. Willans.

Institution of Locomotive Engineers.—Wednesday, November 21, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Diesel Rail Traction," by Mr. R. W. Stuart Mitchell.

British Institution of Radio Engineers.—*London Section:* Wednesday, November 21, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Developments in High-Frequency Transmitter Cables," by Mr. R. C. Mildner.

Institution of Structural Engineers.—*Yorkshire Branch:* Wednesday, November 21, 6.30 p.m., Great Northern Hotel, Leeds. "The Baitings Reservoir," by Mr. T. E. S. White. *Institution:* Thursday, November 22, 6 p.m., 11, Upper Belgrave-street, S.W.1. "The Structural Engineer as Arbitrator, Expert Witness and Advocate," by Mr. Gower B. R. Pimm.

Institution of Mechanical Engineers.—*Southern Branch:* Wednesday, November 21, 7.15 p.m., Royal Aircraft Establishment Technical College, Farnborough. "Problems in the Manufacture of Experimental Gas Turbines," by Mr. L. H. Leedham. *Institution (Steam Group):* Friday, November 23, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "The Control of Boilers Fired by Solid Fuels in Suspension," by Mr. Llewellyn Young. Automobile Division.—*Scottish Centre:* Monday, November 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.1. Address by Centre chairman, Mr. A. Craig Macdonald. *North-Eastern Centre:* Wednesday, November 21, 7.30 p.m., The University, Leeds. General Discussion Meeting, opened by Mr. H. N. Tuff.

Institute of British Foundrymen.—*North-East Scottish Section:* Wednesday, November 21, 7.30 p.m., Imperial Hotel, Keptie-street, Arbroath. "Foundry Sand Control Technique," by Mr. W. Y. Buchanan.

Institution of Sanitary Engineers.—Thursday, November 22, 5.30 p.m., Conference Room, National Hall Gallery, Olympia, W.14. "One-Pipe Plumbing: Some Recent Experimental Hydraulics at the Building Research Station," by Mr. A. F. E. Wise.

Institute of Refrigeration.—Thursday, November 22, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "The Place of Carbon Dioxide in the Field of Refrigeration," by Mr. N. W. Kennedy.

Institute of Metals.—*Birmingham Local Section:* Thursday, November 22, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Metal Economics," by Professor A. J. Murphy.

Royal Aeronautical Society.—Thursday, November 22, 7.30 p.m., St. Mary's College, Cheltenham. "Problems of Transonic Flight," by Mr. A. N. Clifton.

British Society of Rheology.—Friday, November 23, 2.30 p.m., Institute of Physics, 47, Belgrave-square, Westminster, S.W.1. "Soil Mechanics, as Related to the Performance of Cross-Country Vehicles," by Mr. J. Evans and Mr. P. Payne.

North East Coast Institution of Engineers and Shipbuilders.—Friday, November 23, 6.15 p.m., North of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle-upon-Tyne. "An Analysis of Ship Vibration Using Basic Functions," by Dr. J. E. Richards.

Junior Institution of Engineers.—Friday, November 23, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Annual General Meeting, and Annual General Meeting of the Benevolent Fund.

PERSONAL.

The Rt. Hon. Oliver Lyttelton, D.S.O., M.C., M.P., has relinquished the chairmanship of Associated Electrical Industries, Ltd., Crown House, Aldwych, London, W.C.2, on his appointment as Secretary of State for the Colonies. Sir George E. Bailey, C.B.E., M.I.Mech.E., M.I.E.E., M.I.P.E., has been elected chairman in his stead.

Mr. A. Lewis Cochrane, M.I.N.A., has been elected President of the Shipbuilding Employers' Federation, 1, Chester-street, Grosvenor-place, London, S.W.1, in succession to Mr. Charles Connell, M.A., M.I.N.A. Mr. J. G. Stephen, M.I.N.A., becomes senior vice-president, while Mr. T. Eustace Smith, T.D. J.P., M.I.N.A., and Mr. C. A. Winn, M.I.N.A., have been appointed vice-presidents. Mr. Robert Cousland, M.I.N.A., and Mr. H. H. Hagan, M.I.N.A., have been elected, respectively, chairman and vice-chairman of the Conference and Works Board.

Mr. S. F. Holroyd and Sir John Rigby, Bt., have been elected directors of the Exors. of James Mills Ltd., Bredbury Steel Works, Woodley, near Stockport, Cheshire.

Sir Charles McLaren, K.C.B., has retired owing to ill-health after nearly 13 years as director-general of Ordnance Factories. As a temporary arrangement, Mr. T. E. Harris, C.B., C.B.E., will officiate as director-general.

Mr. F. de B. Hart, M.I.E.E., has retired from his positions as executive director and joint manager of the developments and special projects department of British Insulated Callender's Construction Co., Ltd., but will retain his seat on the board of directors.

Mr. Lawrence Halpin and Mr. John H. Osborn, elder son of the late Mr. S. Eric Osborn, who were appointed local directors of Samuel Osborn & Co., Ltd., Clyde Steel Works, Sheffield, 3, in January, 1951, have now been elected to the board of directors.

Mr. P. W. Painter, M.I.R.S.E., director and general manager of Metropolitan-Vickers-G.R.S., Ltd., 132-5, Long Acre, London, W.C.2, has retired and has been succeeded by Mr. J. C. Kubale, M.B.E., A.M.I.Mech.E., A.M.I.E.E., M.I.R.S.E.

Mr. J. Jones, M.I.Mech.E., has been made managing director of the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne. Mr. C. F. Barnard has been appointed general manager and elected a director and the Hon. A. C. Geddes has relinquished his position on the board.

Mr. R. W. C. Reeves, M.I.E.E., has joined the board of the Belmos Co., Ltd., electrical engineers, Bellshill, Lanarkshire.

Mr. A. J. Budd, B.Sc.Tech., has been appointed assistant superintendent, motor department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Mr. J. H. Dyde, Mr. G. Le B. Diamond, C.B.E., Professor F. H. Garner, O.B.E., and Dr. F. J. Dent have been made members of the research committee of the Gas Council, 1, Grosvenor-place, London, S.W.1. Mr. F. M. Birks, C.B.E., is to continue to serve on the committee.

Mr. E. Toon, formerly works manager of Weldall and Assembly, Ltd., Stourbridge, has been appointed works director of the firm.

Mr. George Baker, chairman of John Baker and Bessemer, Ltd., Rotherham and Kilnhurst, has retired after nearly 50 years of service. Another director, Mr. Edward Baker, has also retired. Mr. S. E. Baker has now been elected chairman and Messrs. Henry, Bernard and R. C. Baker have been appointed to the board.

Mr. F. C. Burstall, formerly export director, has been appointed joint general manager, Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7. Mr. R. H. G. Lee has been appointed to the post of export director.

Mr. J. W. F. Russel, M.I.Struct.E., 2, Grosvenor-place, Newcastle-upon-Tyne, has been appointed technical adviser and agent to Marbello & Durus, Ltd., and the Concrete Case Hardening Co., Ltd. Mr. D. R. Snape has been made contracts manager for both companies.

As from November 1, the mechanical drives section of the Package Sealing Co., Ltd., Ealing, and Messrs. H. D. Engineers, Gerrards Cross, Buckinghamshire, are to be known as Industrial Drives Ltd., 44, Uxbridge-road, Ealing, London, W.5.

John Harper & Co., Ltd., Albion Works, Willenhall, have purchased the foundry known as St. James Works, Poole, Dorset, previously operated by Poole Foundry Ltd., to help to meet the demand for Harper castings.

The Technical and Scientific Register of the Ministry of Labour and National Service has been moved from York House, Kingsway, London, W.C.2, to Almack House, 26-28, King-street, St. James's-square, London, S.W.1. (Telephone: TRAfalgar 7020.)

240-MW POWER STATION UNDER CONSTRUCTION AT BANKSIDE.

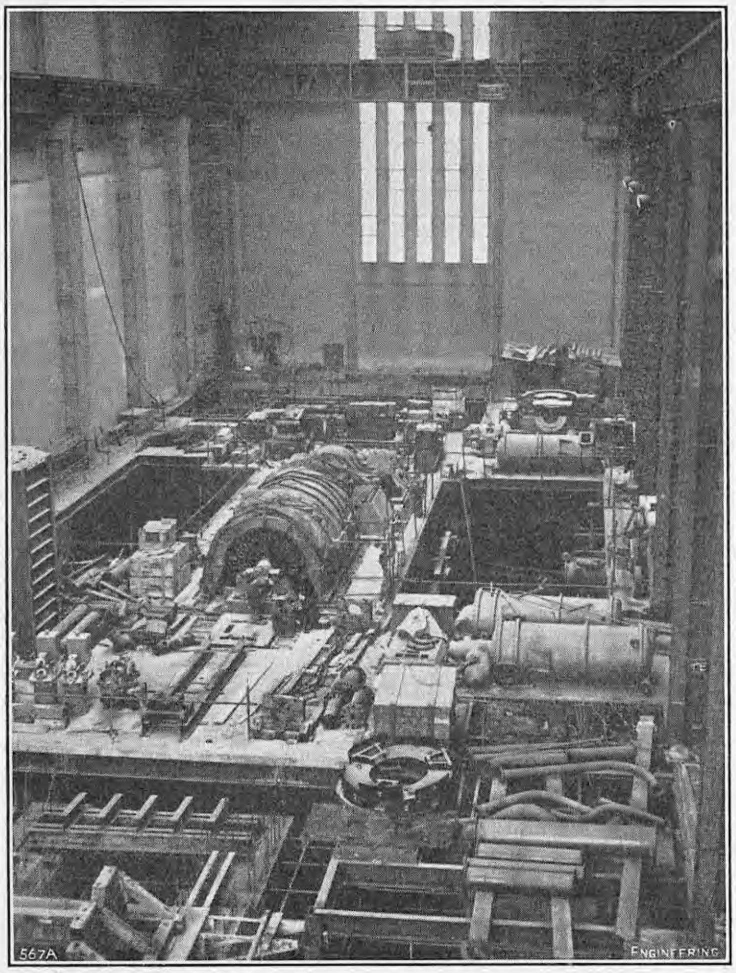


FIG. 1. INTERIOR OF TURBINE ROOM.

FIG. 2. NEW JETTY; ST PAUL'S CATHEDRAL IN BACKGROUND.

240-MW POWER STATION AT BANKSIDE, LONDON.

WE are now able to give some further details of the new Bankside power station in the London Division of the British Electricity Authority, a brief description of which was published on page 564 of our 171st volume. There has been a power station on this Thames-side site, opposite St. Paul's Cathedral, for over 50 years and, even before the war, it had been decided to re-build it. The implementation of this decision, however, encountered considerable public opposition, but the shortage of generating plant and of suitable sites in the London area secured Government approval on condition that oil, instead of coal, was used as fuel. Experiments were also made on models in a wind tunnel at the National Physical Laboratory to determine the conditions necessary for the exhaust gases to clear the dome of the Cathedral.

The station is being built in two halves to a design by Sir Giles Gilbert Scott, R.A., and, as the illustrations on this page show, its construction is proceeding apace. Fig. 1 shows the interior of the generating house with the first of two 60-MW turbo-alternator sets, supplied by the British Thomson-Houston Company, Limited, Rugby, in position. The complete station will have four units of this capacity. The main building will have a total frontage to the river of 543 ft., and, before it, there is now being constructed the jetty illustrated in Fig. 2. Access to the jetty from the station will be through a tunnel of 9 ft. 8 in. diameter. Similar tunnels are being built to carry the circulating water.

There will be eight boilers in the completed station, six of which will supply sufficient steam to operate all four turbo-alternators at full load. The first four of these boilers now under construction by Messrs. Foster Wheeler, Limited, Ixworth-place, London, S.W.3, will each have a normal output at their economic rating of 300,000 lb. of steam per hour at a pressure of 950 lb. per square inch, and a temperature of 925 deg. F., when burning 21,300 lb. per hour of heavy fuel oil having a calorific value of 18,250 B.Th.U. per pound.

The two turbines under construction are two-cylinder units, the low-pressure cylinders of which are of double-flow type. They will operate at an inlet steam pressure and temperature of 900 lb. per square inch and 900 deg. F., respectively. The condensing and feed-heating plant is being supplied by Messrs. Richardsons, Westgarth and Company, Limited, West Hartlepool, and will employ a closed-feed system.

The alternators will be air-cooled by external fans and will generate three-phase 50-cycle alternating current at 15 kV. Each generator will be onnected to a 66,000-kVA transformer. The main switchgear will be suited on three floors of the switchhouse.

Fig. 3 shows girders in position for the 320-ft. chimney-stack. The flue gases will be scrubbed in two towers with river water to which finely-divided chalk will be added.

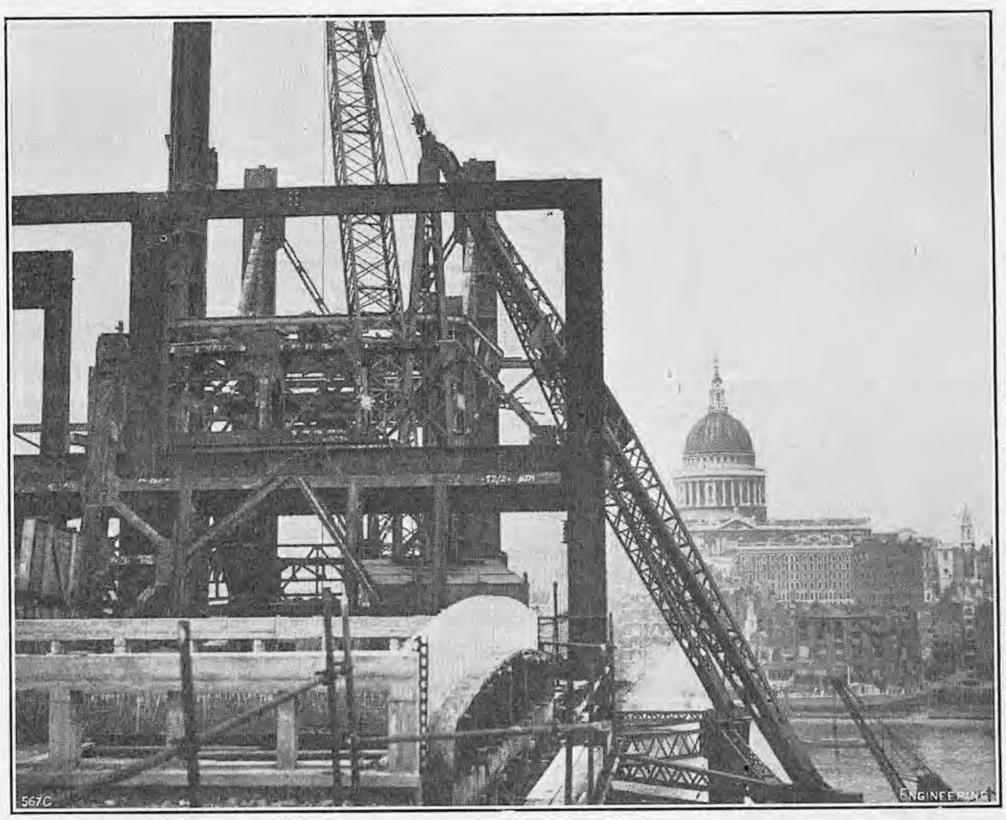


FIG. 3. GIRDERS FOR 320-FT. STACK IN POSITION.

ENGINEERING,

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Telegraphic Address:
"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers:
TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to "ENGINEERING" Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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ENGINEERING

FRIDAY, NOVEMBER 16, 1951.

VOL. 172. No. 4477.

"RARE" METALS.

THERE can hardly be a man occupying a responsible position in engineering who has not felt an effect or a repercussion of the insufficiency of metals and alloys since the war. The cause of this irksome diversion from the normal work of engineers is not the near-exhaustion of the mineral resources of the earth's crust, since fears on this account, which have been expressed many times in the past, have recently been almost dispelled; it is rather that the output from mines and furnaces has not kept pace with the demand. The capital invested in the metal-producing industries has been inadequate in relation to that invested in the metal-consuming industries, largely due to rearmament in the 1930's, followed by the war and now by another period of rearmament.

In London, a discussion on "Metal Economics" was held under the auspices of the Institute of Metals last month; it was reported on pages 519, 553 and 596 of our issues of October 26, November 2 and 9, respectively. Professor A. J. Murphy, who took the chair, gave an opening address, in which he said that a movement of the balance between the supply of and the demand for the principal non-ferrous metals had been manifest since the beginning of the century. The basic forces sprang from three elements, the first being the increasing population of the world, the second the essentially exhaustible, non-renewable character of mineral resources, and the third the world-wide demands for higher standards of living. Of the commonly-used metals, he said, lead, zinc and copper were gradually moving into the class of the relatively scarce materials, while iron, aluminium, magnesium and titanium were likely to remain plentiful for a much longer period. The three questions which he put to the meeting were: what could be done to improve available supplies, how could better use be made of present resources, and what substitute could be used in the place of metals which were becoming difficult to supply?

Since that discussion was held, the Anglo-American Council on Productivity have published the report* of a team which visited the United States in June and July this year to "inquire into measures being taken and planned in the engineering and allied industries in the United States for the conservation and efficient utilisation of scarce materials, and to concern itself primarily with the immediate short-term problem but also to be put in touch with any long-term steps (involving basic changes in design) being currently planned." It is to be hoped that this report will be even more widely read than the many previous productivity-team reports, because it deals with a situation that affects the whole of the engineering industry, and because a definite course through the maze of factors can only be taken if clear thinking and actions proper to the circumstances are widespread.

The productivity team, consisting of eight members led by Sir Graham Cunningham, K.B.E., have been specially mindful of the effects of rearmament. They point out, too, that although efforts are being made to expand the production of numerous scarce raw materials, these are mainly long-term measures, and they are, moreover, limited by shortages of labour, productive equipment and capital resources. The short-term policy must therefore be to encourage the conservation and efficient use of the scarce materials. The team found that in the United States the expression "very short supply" is defined as an availability of up to nearly 80 per cent. of true demand (though "true demand" itself is apparently not defined). An availability of this order may not appear to be very serious, but the priority accorded to defence production aggravates cuts in civilian and export consumption. Thus, in a case where there is a total availability amounting to, say, 70 per cent. of total demand, and the defence requirements, to be met in full, constitute 20 per cent. of the total demand, then civilian consumption must be cut by rather more than one-third.

The productivity team report that great progress has been made recently in the United States with the use of very low-alloy or plain carbon steels containing small additions of boron, mainly for components of small section. The addition of boron to suitable steels in this country could save scarce ferrous alloys or other alloying elements, and they recommended that precise information should be obtained on the potential savings. On the other hand they found that American industry lagged behind British industry in the use of a smaller proportion of scarce alloying elements in the manufacture of jet engines for aircraft. The shortage of some non-ferrous metals in the United States appeared already to be impeding industrial production. Aluminium and magnesium showed considerable prospects of rapid expansion and should replace scarce non-ferrous metals. Vigorous short-term conservation measures were being taken, particularly with nickel, lead, and tin, and the team suggest that these measures deserve further study by interested British industries. The conservation of plastics and their use as alternatives to metals

* *Saving Scarce Materials: Report of a Specialist Team which Visited the United States of America in June and July*, 1951. Anglo-American Council on Productivity (U.K. Section), 21, Tothill-street, London, S.W.1. [Price 2s. post free.]

did not appear to have made substantially greater progress in the United States than in this country. One interesting development, they found, was the use of plastics, alone or in combination with steel or aluminium, for economising in lead in the sheathing of light-duty electrical conductor cables. The last conclusion of the team—a rather unexpected conclusion—is that a study by American industry of joint consultation as practised in Britain might prove helpful in securing a better understanding between management and workmen of the problems created by shortages of materials. Evidently the team realised that, in the matter with which they were concerned, the flow of ideas must be two-way across the Atlantic.

The first of their recommendations, which follow, to some extent, from the conclusions, is that existing steel conservation committees in the United Kingdom should give renewed attention to the properties of lower alloy-content steels and to special techniques for their hardening and heat treatment as at present employed on a substantial and increasing scale in the United States. Mechanical and electrical engineering and the motor-car industry appeared to be the industries particularly concerned. Secondly, the close existing contacts between aircraft manufacturers in both countries should be used for a thorough exploration of differences in design and metallurgical practice, particularly in the use of alloying metals for jet-engine production. The question of the manufacture of a jet engine of shorter life, using lower proportions of scarce metals, appeared to deserve renewed consideration. Thirdly, the conservation measures being taken in the United States with copper, nickel, lead and tin should be further studied by British industries concerned, including those making motor-cars, metal containers and heat exchangers, and by all branches of mechanical and electrical engineering employing these metals. The fourth recommendation is that three new British techniques should be more widely known in the United States, namely, the electro-deposition of combinations of tin-zinc and tin-nickel; the use of ceramic-tipped cutting tools; and the use of precision-cast milling cutters. Finally, the redesign of manufactured products with particular regard to the conservation of scarce materials is recommended as a continuous activity.

The discussion arranged by the Institute of Metals showed that some major steps have been taken in this country to deal with the metal shortages problem. On British Railways, for example, as Mr. C. Dinsdale described, nationalisation has made it possible to standardise metallurgical practices throughout the railway workshops. The number of different bronzes and brasses has been reduced to five; the number of whitemetals from 18 to four; and the number of non-ferrous alloys used as metallic packings from seven to three. Though these changes should simplify production, they will not have a very profound effect on economy in metals.

The productivity team devoted some attention to the long-term problem. While in Washington they met some members of the Materials Policy Commission (the Paley Commission), which was recently appointed by the President of the United States "to find to what extent our shortages of any production materials are likely to impair the economic growth or to jeopardise the security of the United States and the free world over the long run." The Commission are at present reviewing the period covering the next 25 years.

Though the whole problem, so far-reaching, is genuinely a matter for committees and discussions, engineers and metallurgists throughout industry will need to inform themselves as fully as possible and act on their own initiative if the shortage of materials is to cause the least possible dislocation of industry and if the hopes and aims of the free countries are to be realised.

INTERLINGUAL TECHNICAL DICTIONARIES.

Most, if not all, scientific workers find it necessary to keep in touch with advances made in their particular subjects in countries other than their own. Their requirements in this matter are to a considerable extent catered for by the various abstract journals, of which there are now large numbers, and which, in sum, cover a major part of the whole scientific and technical field. The purpose of an abstract journal, however, is to indicate the nature of selected articles appearing in the publications with which it deals. From its nature, it cannot reproduce any article *in extenso*, no matter what its importance; one of its main purposes is to direct users to original sources. A research worker, reading an abstract which appears to him to refer to a matter of interest, will obtain, or attempt to obtain, a copy of the publication in which the abstracted article appeared. Having obtained it, however, he may well find that he cannot read it. *The Engineering Index*, published jointly by the leading American engineering societies, refers to articles appearing in more than 20 languages and even the most linguistic worker is not likely to be able to read them all.

Many research organisations and information departments have staff members able to deal with the more common European languages, but when it becomes necessary to ascertain the contents of an article written, say, in Turkish it may be necessary to obtain outside assistance. Usually it will not be easy to find a translator familiar with such a language as Turkish and also having knowledge of the vocabulary of a specialised scientific or technical subject and it will be necessary to have recourse to a Turkish-English technical dictionary, if such a thing can be found. It is not only in difficult cases of this kind that translating dictionaries are valuable; they are equally so in dealing with the more common languages. A reader may be truly bilingual, but that is not to say that he will necessarily be familiar with all the minutiae of the vocabulary of a specialised scientific or technical subject.

In July, 1949, a report on interlingual technical dictionaries, written by Dr. J. E. Holmstrom, was circulated in mimeographed form by the United Nations Educational, Scientific and Cultural Organisation (Unesco) and some account of it was given in an article in the issue of Engineering of October 7, 1949. The report* has now been made available to a wider circle in a second edition, and in a more convenient form, and is accompanied by a valuable bibliography of technical dictionaries. Both of the publications are printed by the offset process, with 25 per cent. photographic reduction in size from a typewritten master copy. Dr. Holmstrom points out that this method of reproduction has the merit that checking and the insertion of special accents and signs by hand can proceed *pari passu* with the typewriting under the compiler's constant personal supervision; there is no possibility of printers' errors occurring afterwards. He states that up to about 2,000 copies can be produced by this process at a cost amounting to "a fraction of that required for printing from set type." This matter should be of particular importance in connection with multilingual technical dictionaries, since, as Dr. Holmstrom points out in the report, present-day costs make the publication of such works, if printed by conventional methods, commercially impossible. This matter was discussed in our earlier article.

The bibliography gives details of 1,044 scientific and technical dictionaries and Dr. Holmstrom remarks that it may cause surprise to learn that there are so many. It is not to be supposed, however, that all are immediately available, though secondhand copies of those which are out of print might be obtainable if sufficient trouble is taken, or they might be found in some special libraries. A specific indication is given in cases in which it is known that a volume was out of print in 1950. It is quite possible that even this extensive list is not complete, and additions and corrections are invited. The dictionaries listed cover 45 languages and their contents are classified under 224 subject heads. The range of languages is indicated by the fact that the list contains Icelandic, Lettish and Siamese. Engineers and physicists will not suppose that the whole of the 1,044 dictionaries deal with their subjects. The definition of a scientific and technical dictionary adopted by Dr. Holmstrom, in addition to many branches of engineering and physics, also covers those dealing with such subjects as veterinary science, printing and brewing. In the engineering field, however, there are, for instance, the names of nine translating dictionaries dealing with welding terms, the languages covered being English, German, Spanish, French, Polish and Russian. Welding is a relatively specialised branch of engineering and some matters of broader scope are represented by many more entries. There are 31 dictionaries listed under radio communication.

No doubt some of the publications in this extensive bibliography are not of high quality, but in attempting to obtain information about the technical terms of a remote language any information will be of value. Many of the dictionaries listed do not include English as one of the languages covered, but the information department of any large engineering firm may be expected to be able to make effective use of, say, a German-Polish dictionary. The name of a dictionary of this type naturally does not appear in English, but the subject of all the publications listed may be ascertained by anyone as in all cases the Universal Decimal Classification number is given. In most cases, the name of the publisher is appended, but some dictionaries are included in which it has not been possible to trace this. In cases of this kind, the name of the dictionary is quoted from bibliographical lists compiled by such authorities as the Science Museum or the Library of Congress. Some references have also been obtained from the British Council. It is clear that a very extensive research has been necessary in order to complete this remarkably extensive bibliography.

In the first edition of the report, it was pointed out that all the important interlingual technical dictionaries now require revision, especially in connection with such rapidly-advancing subjects as electronics, and it was suggested that an international terminological bureau should be set up. This would keep in touch with such bodies as the International Electrotechnical Commission and the Permanent International Association of Road Congresses. Bodies of this kind should be in the best position to compile interlingual vocabularies covering the specific terms of their fields of interest. These vocabularies would be collected and maintained by the international terminological bureau and it was suggested that the material accumulated should be free for use by commercial publishers, subject to indication of the source. It is stated in the second edition that the International Organisation for Standardisation, at Geneva, has established a technical committee to deal with terminology and to collaborate with committees appropriate to each special subject, but that nothing has yet been published as a result of this procedure. So far, this matter concerns only German, English and French. In the preface to the report it is stated that "it is published in the hope of eliciting comment from a wider circle, which may further help towards formulating Unesco's policy."

* *Report on Interlingual Scientific and Technical Dictionaries* and *Bibliography of Interlingual Scientific and Technical Dictionaries.* Unesco, 19, Avenue Kléber, Paris, 16. Obtainable from H.M. Stationery Office. [Prices, respectively, 1*s*. 6*d*. and 4*s*.]

NOTES.

The Institution of Mechanical Engineers.

The general meeting of the Institution of Mechanical Engineers, which was held at Storey's Gate, London, on Friday, November 9, was devoted to a paper from the Hydraulics Group of the Institution. It was presented by Mr. G. A. Wauchope and Mr. H. P. Humphreys, B.Sc.(Eng.), and dealt with "The Design of Large Pumping Installations for Low and Medium Heads." The chair was taken by the Chairman of the Hydraulics Group, Mr. T. E. Beacham, B.Sc.(Eng.). The importance of the classes of pumping plant discussed, the authors premised, was indicated by the fact that, in Great Britain, about 30,000 h.p. of such plant was in service for land drainage, and the power of the main circulating pumps controlled by the British Electricity Authority was probably in excess of 100,000 h.p. In dock and harbour electrical installations, too, it was usually the case that the supply required for dry-dock pumping was a very large proportion of the total load. In selecting the most suitable type of pump, therefore, it was necessary to take into account not only the first cost of the pumping station, the pumps, the driving and auxiliary equipment, and the cost of the total energy consumed; where the load factor was low, the maximum demand for energy might also be an important consideration. The paper covered pumps having specific speeds ranging from those of the axial-flow type, for low heads, to centrifugal pumps for the higher heads. The characteristics of the various types were assessed in accordance with their physical shape and their hydraulic properties, and consideration was given to the relative significance of first cost and operating cost, with special reference to three particular cases. The three examples taken were those of typical power-station circulating pumps, in conjunction with their associated culverts; dry-dock de-watering pumps; and systems in which several pumps were discharging through one pipe. Some general observations were appended also on pressure surges in pipe lines, and on methods of controlling pumping plant—automatically in the case of small installations, and by supervisory staff in the larger plants, probably assisted by a system of electrical interlocks as a safeguard if the arrangement of valves and pipes was complicated. The paper evoked considerable discussion, in which particular emphasis was laid on the economics of plants with low load-factors and characterised by intermittent operation. It is also open to written discussion, which should reach the secretary of the Institution not later than January 15, 1952.

Symposium on Welding and Riveting Aluminium Structures.

On Tuesday last, the 13th instant, the Aluminium Development Association held an interesting and valuable symposium for the reading and discussion of four papers on the welding and riveting of the larger aluminium structures. The symposium, which was attended by about 150 members, was held at Claridges, Brook-street, London, W.1, the members being received by the President of the Association, Mr. E. Austyn Reynolds, B.A., A.M.I.Mech.E., A.F.R.Ae.S., and the Vice-President, Mr. H. G. Herrington. Dr. Maurice Cook, F.I.M., took the chair at the morning session and the first paper presented was entitled "Recent Researches on the Arc Welding of Thick Aluminium-Alloy Plate," by Mr. P. T. Houldcroft, B.Sc., Mr. W. G. Hull, A.I.M., and Dr. H. G. Taylor, D.I.C., M.I.E.E., F.Inst.P. The welding processes referred to in this paper were the metal arc, the argon arc and two other processes in which an inert gas is used to shield the weld pool. These two processes have been called the self-adjusting arc and the controlled arc processes, respectively. In the former, the arc is struck between the workpiece and a thin wire electrode fed at a constant speed. No external control device is required in this process, as the length of the arc is kept constant by a self-adjusting phenomenon discussed in the paper. In the second process, the arc is struck between the work and a wire electrode which is fed at a speed controlled by external apparatus to keep the arc length constant. The special problems involved in thick-plate welding, including gas porosity and cracking, were discussed in the paper and the present position was summarised. The second paper, by Mr. J. R. Handforth, M.Sc., discussed "The Practical Aspects of the Argon-Arc Welding of Aluminium Alloys." This paper surveyed the practical advances in the subject and stated the essential problems of the process. The equipment required was discussed in detail and practical recommendations were made on such matters as electrode diameters for different welding currents, argon-gas consumption in machine welding, filler-rod sizes, etc. On the conclusion of Mr. Handforth's paper, both papers were discussed together, after which the meeting was adjourned for luncheon. At this, the chair was occupied by the President, who referred to the practical research work being carried out by the Association and by several other bodies, such as Government departments and universities. At the afternoon session, the chair was taken by Dr. C. J. Smithells, M.C., F.I.M., and two papers on riveting were read and discussed. The first paper was by Mr. J. C. Bailey, B.Sc., A.I.M., and dealt with "The Properties and Driving of Large Aluminium-Alloy Rivets." It referred to the use of rivets larger than $\frac{3}{8}$ in. in diameter and explained that fabrication by means of aluminium-alloy rivets up to $\frac{7}{8}$ in. in diameter was now a practical proposition. Cold driving, the author stated, was preferred for aluminium-alloy rivets, but as the maximum rivet size that could be readily closed cold by standard equipment was $\frac{5}{8}$ in. in diameter, hot driving had been investigated for the larger sizes. The last paper, by Professor S. C. Redshaw, Ph.D., M.I.C.E., F.R.Ae.S., was entitled "The Design Characteristics of Aluminium-Alloy Riveted Joints," and was presented by the author. The two papers were then discussed jointly and at the conclusion of the discussion the President invited the members of the symposium to the Association's neighbouring offices, at 33, Grosvenor-street, W.1, to see some demonstrations of argon-arc welding, some examples of aluminium riveted joints, and a colour film of argon-arc welding just completed by the British Oxygen Company, Limited, with the collaboration of the Association. We understand that the papers and discussions at the symposium will be reprinted by the Association as soon as possible.

The Old Centralians.

Some 220 members and guests of the Old Centralians—the association of former students of the City and Guilds Engineering College and of its forerunner, the Finsbury Technical College—attended the 41st annual dinner held in London on Monday, November 12, in the hall of the Worshipful Company of Grocers, under the chairmanship of the President, Mr. E. M. Rich, C.B.E. The senior Collegian present was Mr. Henry Shoosmith, who entered the College in 1886, and there were no fewer than 11 others who could claim a standing of 50 years or more. The guest of honour was Field Marshal Sir Claude Auchinleck, G.C.B., who, in proposing the toast of "The Old Centralians and the City and Guilds College," remarked that his early ambition had been to be a sapper ("a species of engineer") because, in those days, a sapper could live on his pay, which no one else in the Army could do. In the event, he had become an infantryman, but he soon learned that, though the Army in general might not comprehend all the mysteries of engineering, it did produce men. In his war-time experience, in India and elsewhere, he was impressed by the fine type of men produced in the United States, but he still felt that "we, of all peoples in the world, are the best at improvising." In India, Britain had been responsible for immense feats of engineering, but, for 300 years or so, the "man on the spot" there had had the comforting feeling that he was supported by "the British Raj"; now, he had to stand on his own feet. That Britain had lost the Indian territory did not matter; India still needed British brains and skill, and preferred Britons to provide advice and help, because they had a long reputation for honesty and fair dealing. Of all the people who could provide that advice and skill, engineers came first. The President, in replying, mentioned that Captain A. M. Holbein, during a recent visit to South Africa, had taken the opportunity to approach the 50 or so Old Centralians there and to form a South African Branch, which, in characteristic fashion, had signalised its formation by having a dinner; one member had travelled 1,000 miles to attend it. The association, he added, had some 2,000 members, of whom 500 were life members. Professor Willis Jackson, Dean of the College, who also responded, averred that there was no college in the country to compare with the City and Guilds, the standard of which was fully equal to those of the much vaunted Continental technical colleges. In recent years, a personal interview with candidates had supplemented the usual entrance qualifications. About a third of the applicants were accepted for admission; a circumstance which indicated that, if some future decree required the College to double its present size (811 students in the present year), the result could only be achieved by a decline in quality, which could not be considered for a moment. The only other toast, that of "The Guests," was proposed by Mr. P. W. Foster, M.C., A.M.I.E.E., in a speech of refreshing originality, and was acknowledged by Mr V. Harbord, F.R.I.C., President of the Royal School of Mines Assoc ation.

First International Conference of Manufacturers.

A team of 30 leading British industrialists, formed by the Federation of British Industries and the British Employers' Confederation, will be leaving shortly for the United States to attend the first International Conference of Manufacturers in New York from December 2 to December 5. The team will be led jointly by Sir Cuthbert Clegg, President of the B.E.C., and Sir William Rootes, acting as personal deputy for the President of the Federation of British Industries. The Conference is being organised by the E.C.A. in collaboration with the National Association of Manufacturers of America and the National Management Council of America. At their invitation, other European industrial organisations participating in the Council of European Industrial Federations will also be sending delegations of industrialists. The purposes of the Conference are to enable leading industrialists of the United States, Britain and Western Europe to secure, by a personal exchange of views, a better understanding of each others' problems; to discuss the efforts now being made to promote higher productivity; and to consider ways of continuing those efforts in the future. Delegations have been nominated from the following countries: Austria, Belgium, Denmark, Eire, France, Germany, Greece, Holland, Iceland, Italy, Luxembourg, Norway, Sweden, Switzerland, Turkey and the United Kingdom. Various sessions of the New York conference will deal with policies on production, marketing, employee relations, finance, competition, and public relations. Delegates from this country include Sir William Rootes, Colonel E. G. Angus, Major-General K. C. Appleyard, Dr. Horace Clarke, D.Sc., Mr. Charles Connell, Sir Vincent Z. de Ferranti, Sir Ernest Fisk, Sir Norman Kipping, Sir George Legh-Jones, Mr. E. H. Lever, Mr. T. F. Lister, Mr. R. O. Lloyd, Mr. F. A. Martin, Sir George Nelson, Mr. W. H. Pilkington, Mr. W. R. Verdon Smith, Mr. D. D. Walker, and Mr. Harold Wilmot.

Encouragement of Technical Writing.

The encouragement of the writing and publication of technical articles dealing with progress in the field of radio and electronics was the theme of speeches made at a luncheon given by the Radio Industrial Council at the Café Royal, Regent-street, London, W.1, on Monday, November 12. In a speech addressed primarily to the technical representatives present, Mr. E. M. Lee, chairman of the technical directive board of the Council, drew attention to the shortage of good articles suitable for publication in technical and other journals. In spite of difficulties arising from security, both national and commercial, the Council felt that more could be done and, accordingly, had decided to initiate a scheme of awards for technical writing. An average of six awards, each of 25 guineas, would be made annually to the authors of published articles which, in the opinion of a panel of judges appointed by the Council, deserved commendation by the industry. These articles would normally be of a more popular nature than papers presented before learned societies and their preparation, therefore, would involve less time. The Institution of Electrical Engineers had consented to the authors of papers in their *Proceedings* offering to editors shortened or popularised versions of their papers in advance of the publication of the latter by the Institution provided that actual publication of the popular version did not take place before the publication of the complete paper; and provided also that reference was made to the latter. By this means, it was hoped that some of the inevitable delay in publication might be avoided. Mr. W. M. York, chairman of the public relations committee of the Council, and Professor Willis Jackson, stressed the importance of encouraging engineers to express themselves lucidly. In technical writing, confused thinking and bad style were commonplace but, although there was no excuse for lack of clarity on the part of the authors, readers must be prepared to make the often considerable effort needed to assimilate new material. It was a national duty to publicise the very considerable achievements of British science and technology, Sir Ernest Gowers, well known for his advocacy of "plain words" said, in an amusing speech, that officialese was not necessarily bad. Officials, unfortunately for themselves, were uniquely vulnerable to attack; but they often had a good excuse, for it was undeniable that a little prudent ambiguity was essential to those who would run a parliamentary democracy. The same argument, however, was not open to scientists. The only excuse for a scientist who wrote obscurely was that he was a humbug and adopted this method to avoid being found out. He could warmly commend Professor Kapp's "Presentation of Technical Material," "an admirable book with a revolting title." Mr. J. W. Ridgeway, chairman of the Council, who presided, explained that all non-professional writers would be eligible for the awards and that the articles might be published at home or abroad. Writers and editors were invited to submit published articles to the Secretary, Radio Industry Council, 59, Russell-square, London, W.C.1. The panel of judges, however, would also consider unsubmitted published articles.

Production and Consumption of Sulphur.

The Ministry of Materials have issued figures recently released by the Sulphur Committee of the International Materials Conference, Washington, U.S.A., showing, for the first time, the total "free-world" production and consumption of sulphur for the period 1948-49-50 and estimates for the years 1951 and 1952. This compilation has been made possible as a result of the information received in replies to questionnaires which the Committee had sent out to all governments interested in the matter. The statistics compiled indicate that, in 1951, the world requirements of sulphur, both crude and refined, will amount to approximately 7,134,200 tons, whereas it is expected that production will amount to 5,862,300 tons, leaving a shortage of 1,271,900 tons. The estimated requirements for 1952 total 7,596,300 tons and the production, as far as can be foreseen, will be 6,255,600 tons, leaving a shortage of 1,340,700 tons. The demand for sulphur is rising steadily not only on account of expansion in the use of sulphuric acid, sulphur dioxide and carbon bisulphide in many industries but because of its increasing consumption, in the form of dusts and insecticides, in agriculture and, in various forms, in the rubber, dyestuffs, explosives, and other industries. The Committee point out that the discovery of sulphur-bearing deposits in the State of Louisiana does not relieve the necessity for the vigorous prosecution of measures for the conservation of sulphur and the full expansion of all possible sources of production. It is anticipated, moreover, that a proportion of the production from Louisiana, which is not expected to commence until late in 1953, will, in fact, be offset by declining output in several of the mines now under exploitation. The Committee are making every effort to encourage Governments to increase their production of sulphur and sulphur-bearing materials and all countries are urged to make the most economical use of sulphur.

OBITUARY.

SIR T. PEIRSON FRANK.

The news of the death of Sir Thomas Peirson Frank, which took place suddenly on November 12 at his home in Putney, London, S.W.15, will be received with regret by engineers in all parts of this country. Sir Peirson, who had served as Chief Engineer and County Surveyor, London County Council, from 1930 until his retirement under the age limit in 1946 and had subsequently been a partner in the firm of Coode, Vaughan-Lee, Frank and Gwyther, consulting engineers, London, was the eldest son of the late Thomas Peirson Frank and was born at Kirkby Moorside, York, on July 23, 1881. He received his general education at a private preparatory school and at Pickering Grammar School, and from 1894 until 1899 studied engineering at Huddersfield Technical College. After a period of three years' practical training under Mr. K. F. Campbell, the Borough Engineer of Huddersfield, Mr. Frank, then 22 years of age, became chief assistant to Mr. Henry Dearden,

Photo: Elliott & Fry, Ltd.

The Late Sir Peirson Frank.

Borough and Water Engineer of Dewsbury, and Engineer to the Dewsbury and Heckmondwike Waterworks Board. For the subsequent five years he was engaged on work connected with tramway-track construction, the erection of a new covered market, the laying of water mains and sewers, extensions of sewage-disposal works and general highway construction and maintenance.

In 1908, Mr. Frank took up his first independent post, that of City Engineer and Surveyor of Ripon, where his duties included the construction of two river dams, walls and the extension of sewage-disposal works. In 1912, he was made Borough Surveyor and Water Engineer of Newark-on-Trent, where he was responsible for plans for proposed new intercepting and outfall sewers. Early in 1915, Mr. Frank moved to Stockton-on-Tees, where he took up the post of Borough Engineer and Surveyor, but in December of that year he joined the Royal Engineers unit of the University of London and, in February, 1916, obtained a commission. After service with the 237th Field Company in France, he was given command of the 196th Land Drainage Company and was eventually demobilised with the rank of Captain. Towards the end of 1919, he became Borough Engineer and Surveyor of Plymouth, where he was engaged on the construction of roads and sewers for housing schemes, the planning of electricity-station extensions, a reinforced-concrete landing stage and other works. In May, 1923, Mr. Frank was appointed City Engineer of Cardiff, in which capacity he supervised the construction of new roads, bridges and sewers and other public-utility works. In 1926, he was selected from 45 applicants for the post of City Engineer and Surveyor of Liverpool, and during his four years' tenure of this position he was also honorary surveyor to the South-West Lancashire Regional Town-Planning Committee.

As stated above, Mr. Frank was appointed to the post of Chief Engineer and County Surveyor, London County Council, in 1930. Two years later he became a member of the Departmental Committee of the Ministry of Health on Garden Cities and Satellite Towns, and, in 1935, was appointed a member of the Highways Research Board of the Department of Scientific and Industrial Research. In 1935, also, his "Report on Greater London Drainage" was published. During the whole of the war years, 1939-45, he was co-ordinating officer, Road Repairs and Public Utility Services, London Civil Defence Region. From 1942 until 1944 he was a member of the Ministry of Works National Consultative Council for the Building and Civil Engineering Industries. For his services in these and other capacities, he was created a knight in 1942.

Sir Peirson retired from his position of Chief Engineer of the London County Council on July 23, 1946, and became a partner in the firm of Messrs. Coode, Vaughan-Lee and Gwyther in the following month. During the subsequent five years he was principally concerned with operations connected with various flood-prevention and sea-defence schemes in this country and abroad, and also prepared a report in connection with the storage of water for irrigation purposes and the design of bridges in Nigeria. He was, moreover, occupied on civil-engineering work in connection with power stations in Malaya, Singapore, and Melbourne, and latterly was engaged on the piercing of a tunnel under the River Thames at Long Ditton, for the Southern Gas Board. Sir Peirson was elected an associate member of the Institution of Civil Engineers in 1906, transferred to the class of member in January, 1922, and was President in the year 1945-46. He joined the Royal Institution of Chartered Surveyors in 1906 and was made a Fellow in 1913. He was also a member of the Institution of Municipal Engineers and of the Town Planning Institute, and a Fellow of the Royal Sanitary Institute. He was elected President of the Town Planning Institute in 1944, and vice-chairman of the Automobile Association on November 23, 1950.

MR. W. F. ANGUS.

News of the sudden death, on October 14, of Mr. William Forrest Angus, President of the Dominion Bridge Company, Limited, and Dominion Engineering Works, Limited, Montreal, has recently reached us from Canada. Mr. Angus, who would have been 78 years of age on October 28, was the son of the late Mr. R. B. Angus, who was one of the original promoters of the Canadian Pacific Railway. After graduating as a civil engineer at McGill University, Montreal, Mr. W. F. Angus began his long association with the Dominion Bridge Company in 1896, when he was appointed engineer and draughtsman. Some years later he joined the Lawrie Engine Company and subsequently became a member of the staff of the Canada Switch and Spring Company, later incorporated into the Montreal Steel Works, of which Mr. Angus became, in due course, vice-president and managing director. This company was eventually taken over by Canadian Steel Foundries, a subsidiary concern of the Canadian Car and Foundry Company, Limited. In 1911, Mr. Angus became vice-president and managing director of Canadian Steel Foundries, and, in 1921, was made vice-president of the Canadian Car and Foundry Company, Limited. Meanwhile, in 1917 he had rejoined the Dominion Bridge Company as vice-president. In 1936, he was elected President of this company and of its associate company, Dominion Engineering Works, Limited, and continued in these capacities until his death. Mr. Angus was also a director of the Bell Telephone Company, the Northern Electric

Company, the Canadian Locomotive Company, and other concerns. He was a member of the Engineering Institute of Canada.

PROFESSOR ALLAN FERGUSON.

We also note with regret the death of Professor Allan Ferguson, general secretary of the British Association from 1936 until 1946, who died at his home in Bishop's Stortford, Hertfordshire, on November 9. Ferguson was the eldest son of Mr. A. C. Ferguson, a calico printer of Glasgow, and was born at Entwistle, near Bolton, Lancashire, on May 11, 1880. He received his education at the Harris Institute, Preston, afterwards passing on to University College, Bangor, and obtaining the degrees of M.A. (Wales) and D.Sc. (London). After a period as assistant lecturer in physics at University College, Bangor, he was appointed lecturer in the same subject in the College of Technology, Manchester, and finally assistant professor of physics at Queen Mary College, London, E.1. From this last appointment he retired, under the age limit, in 1945. Professor Ferguson will perhaps be remembered chiefly for his work for various technical journals and learned societies. For a period he was editor of the *Philosophical Magazine* and advisory editor for physics and engineering of *Chambers's Encyclopædia*, and, in 1939 and 1940, was advisory editor of *Nature*. As noted above, he served as general secretary of the British Association from 1936 to 1946 and was President of Section A in 1936. From 1928 until 1938 he was secretary of the Physical Society and served as President from 1938 until 1941. Professor Ferguson was examiner in natural philosophy to the University of Glasgow from 1940 until 1944, and was a Fellow of Queen Mary College.

DR. H. S. ROWELL, O.B.E.

A wide circle of engineers will learn with regret of the sudden death of Dr. H. S. Rowell on Sunday, November 11, in his sixty-sixth year. Henry Snowden Rowell, who was born at Heaton, Newcastle-on-Tyne, on December 9, 1885, combined an attractive and genial personality with great technical and scientific ability and independence of judgment. This latter quality was well illustrated in a report entitled "The Influence of British Motor Taxation on Petrol-Engine Design," which he prepared as a result of a request from a committee of a society of motor manufacturers. The report was published in our issues of March 7 and 21, 1930. It had been generally contended that the British rating formula encouraged engines of a high stroke/bore ratio, but a detailed examination of French, Italian and German practice showed that this was not correct. This was by no means the only contribution made to our columns by Dr. Rowell, and in the inter-war period articles appeared dealing with such a variety of subjects as screw viscosity pumps, the kinematics of laminated springs a high-speed fatigue testing machine, thread rolling, and cable controls for motor vehicles. The paper entitled "The So-Called Metric System," which he read at the Brighton meeting of the British Association in 1948, and which was reprinted in our issue of October 8, 1948, well exhibited his independence of mind and, incidentally, his impish humour. This paper aroused much interest and led to a long correspondence in our columns, Rowell's contributions to which were frequently very amusing.

After early general education in Newcastle, Rowell served an apprenticeship at the Elswick Works of Armstrong-Whitworth from 1900 to 1906, spending the first three years in the shops and the latter three in the drawing office. During this period, he studied at the Elswick Institute, Newcastle, and obtained many prizes, being First King's Prizeman in 1905. From 1906 to 1909 he was at the Royal College of Science, and in the latter year obtained a Whitworth Scholarship, being third on the list. The scholarship at that time had a value of 125*l*. a year for three years and Rowell took full advantage of the opportunity afforded. He spent twelve months in the engineering department of the National Physical Laboratory, being concerned with the design and erection of apparatus for the aeronautical department. He then studied for two years on the Continent, first at the University of Göttingen and then at Charlottenburg Technische Hochschule, incidentally adding a sound knowledge of German to his technical qualifications. Returning to England, he was appointed as an assistant lecturer at Leeds University in 1912 and as senior lecturer at Bradford Technical College in 1914.

The latter appointment was of short duration, as on the outbreak of the first World War, Rowell immediately volunteered and was graded as 2nd Lieutenant in the R.A. in October, 1914. He had a distinguished military career, serving in Egypt, Gallipoli, the Sinai Peninsula and France. He was mentioned in dispatches "for great zeal and exceptional administrative ability." He was appointed Assistant Superintendent at the Royal Laboratory, Woolwich Arsenal, on January 1, 1917, and Deputy Director of Armaments Production, Admiralty, in June of that year. It was during these administrative years that Rowell's attention was first specifically directed to the metric system as a result of an official request that he should

The Late Dr. H. S. Rowell, O.B.E.

investigate the saving likely to be secured by its adoption in this country. The conclusions he reached and his very individual experience of them are well known.

Rowell's best-known work, after his return to civil life, was probably carried out during his position as Director and Secretary of the Research Association of British Motor and Allied Manufacturers. Most of his contributions to our columns were made in the course of this period. This Association was ultimately dissolved and Rowell had no connection with the present Motor Industry Research Association. After leaving the research field, he became chief designer to John I. Thornycroft and Company, Limited, Basingstoke, holding this appointment from 1931 to 1934. In the following year he took up an appointment as Assistant Director of Industrial Planning (Scientific Instruments) at the War Office, which he held until 1939, when he joined Armstrong Siddeley Motors, Limited, becoming director and general manager. He retired in 1945. His connection with technical education, however, endured to the last, and he was giving series of lectures to first- and third-year students at the City and Guilds College at the time of his death. Rowell had many letters after his name. He was made an O.B.E. for his war work and in addition to his Whitworth Scholarship and Doctorate was an A.R.C.S., M.I.Mech.E., F.Inst.P. and M.S.A.E. He took an interest in the British Association and was Recorder of Section G for two years from 1948.

LETTERS TO THE EDITOR.

DETERMINATION OF CRITICAL LOADS OF STRUTS.

To the Editor of Engineering.

Sir,—Sir Richard Southwell's method of plotting the results of strut tests, by which the Euler critical load can be obtained without destroying the strut, is now well known and widely employed (*Theory of Elasticity*, 1st edn., page 429. Oxford University Press). Observations are made of the lateral deflection w of the strut when supporting a compressive load P, and if the quantity $\frac{w}{P}$ is plotted against w an approximately straight line is obtained. The equation to this straight line is:

$$P_1\left(\frac{w}{P}\right) = w + w_1, \qquad (1)$$

where w_1 is the coefficient of the first term in the Fourier expansion for the "initial imperfection" of the strut when unloaded and P_1 is the Euler critical load, which is thus given by the slope of the plotted line.

In practice, it is often found that the line obtained is not straight except over a limited range of values of w, and some difficulty may be experienced in selecting the straight line which best represents the results. It is clear from the theory that, on the one hand, the straight line will not be obtained unless the stresses are throughout within the limit of proportionality, and, on the other, that if observations are made when the end load is very small compared with the first Euler critical load, these will not fall on the required straight line. The complete expression for the lateral deflection of a pin-ended strut of length l, taking origin for x at one end is:

$$w = \frac{P\,w_1 \sin\frac{\pi x}{l}}{P_1 - P} + \frac{P\,w_2 \sin\frac{2\pi x}{l}}{P_2 - P} + \sum_{n=3}^{\infty} \frac{P\,w_n \sin\frac{n\pi x}{l}}{P_n - P} \qquad (2)$$

where P_n stands for the critical load of the strut when deflected into n loops $\left(= n^2 \pi^2 \frac{EI}{l^2}\right.$, where EI is the flexural rigidity).

The straight-line formula is derived by neglecting all but the first term in this series, but if P is small and successive coefficients $w_1, w_2, \ldots w_n$ are of the same order of magnitude—as they may be—the second term is of the order 25 per cent. $\left(\frac{1}{2^2}\right)$ of the first, the third term of the order 11 per cent. $\left(\frac{1}{3^2}\right)$, and so on; and thus the observed deflection may differ appreciably from the value required by equation (1). Observations for small end loads are also liable to error from another source, which is probably more important in practice. Many compression testing machines permit some sideways movement of the specimen in the early stages of loading and this may be mistakenly recorded as part of its lateral deflection.

Both these difficulties can be overcome by starting the test not from zero load, but from a load P_0, which is an appreciable part, say, half or two-thirds, of the critical load, chosen so that there will still be room for a sufficient number of observations before the material reaches the limit of proportionality. In place of equation (1) we then have:

$$(P_1 - P_0)\left(\frac{w}{P - P_0}\right) = w + \overline{w}_1 \qquad (3)$$

where w now represents the deflection measured from the position of the strut under load P_0 as origin, and $\overline{w}_1$ is the appropriate coefficient in the series representing the shape of the strut under this load. The gradient of line obtained is thus $P_1 - P_0$, so that any given error in measurement of the gradient produces a much smaller percentage error in P_1. A footnote in Southwell's original paper (*Proc. Roy. Soc.*, Series A, vol. 135, page 601 (1932)). indicates that he was aware of this possibility, which clearly eliminates completely the error due to lateral slackness in the machine employed, and much reduces the mathematical error due to neglect of the second and higher terms in the series (2). In practice, for a material which obeys Hooke's Law with precision over a substantial range, the critical load can usually be found with an accuracy nearly equal to that of the testing machine employed. A similar method can be employed in plotting the results of any test on an elastically unstable system.

Yours faithfully,
D. G. Christopherson,
Professor of Mechanical Engineering.

The University,
Leeds, 2.
October 22, 1951.

PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

To the Editor of Engineering.

Sir,—Dr. D. C. Sweeney's investigation of hydraulic lock, reported on pages 513 and 580 in your issues of October 26 and November 9, will be of great interest to engineers concerned with hydraulic transmission. In discussing this subject, there is often some confusion between hydraulic lock and what might be termed "muck-lock," i.e., the wedging of fine particles of dirt in the clearance between the piston and the bore. The latter condition is quite common when the initial clearance is of the order of 0·001 in.; it is unlikely to occur with an initial clearance of the order of 0·0001 in. at low pressures, but it may occur at high pressures due to dilation of the clearance. Thus, at pressures of several hundred atmospheres, one may have both types of lock in combination. Pure hydraulic lock is distinguished by the fact that the piston becomes free again a short time after pressure has been released.

It is clear that Dr. Sweeney has reproduced pure hydraulic lock; I am gratified that his work has confirmed my early conjectures on this subject, and this has encouraged me to enlarge upon them. It seems probable that the major factors contributing to hydraulic lock are the *method* of producing the surfaces of the piston and bore, and the degree of surface finish. For instance, if the surfaces of both piston and bore are produced by cylindrical grinding, the surfaces will tend to mesh and this will be favourable to hydraulic lock. On the other hand, if the surfaces of piston and bore are produced by lapping and honing, they will be less likely to mesh and therefore hydraulic lock will not occur so readily. Indeed, I would go so far as to suggest that, if Dr. Sweeney were to lap and hone a piston and cylinder such as those illustrated in his Fig. 3, he would find it difficult to produce hydraulic lock at pressures below 500 lb. per square inch; furthermore, he would eliminate the wide differences in the locking force at various axial positions of the piston.

Having produced surfaces which will not readily mesh, the next factor of prime importance is to choose materials which will not readily mate or fuse at the peaks of contact. Finally—and this may be almost equally important—the materials should be such as to support and maintain the oil film between the surfaces.

If we accept Dr. Sweeney's thesis, it would appear that the critical pressure at which hydraulic lock begins to occur will vary inversely as the square of the piston diameter, assuming geometric similarity and like materials. It is doubtful whether such exact similarity can be reproduced in practice, but I believe that it is general experience that small pistons are very much less liable to hydraulic lock than large ones.

No doubt the above observations will seem somewhat obvious to those skilled in the art, but I do wish to emphasise that hydraulic lock is not inevitable; it can be entirely eliminated by proper design, workmanship and materials; and we can be greatly helped to that end by imaginative research, such as this which you have published.

Yours faithfully,
F. H. Towler, M.I.Mech.E.

Towler Brothers (Patents), Limited,
Electraulic Works,
Rodley, near Leeds.
November 12, 1951.

TWIN-DIESEL MARINE GEARBOX.

THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON.

(*For Description, see opposite Page.*)

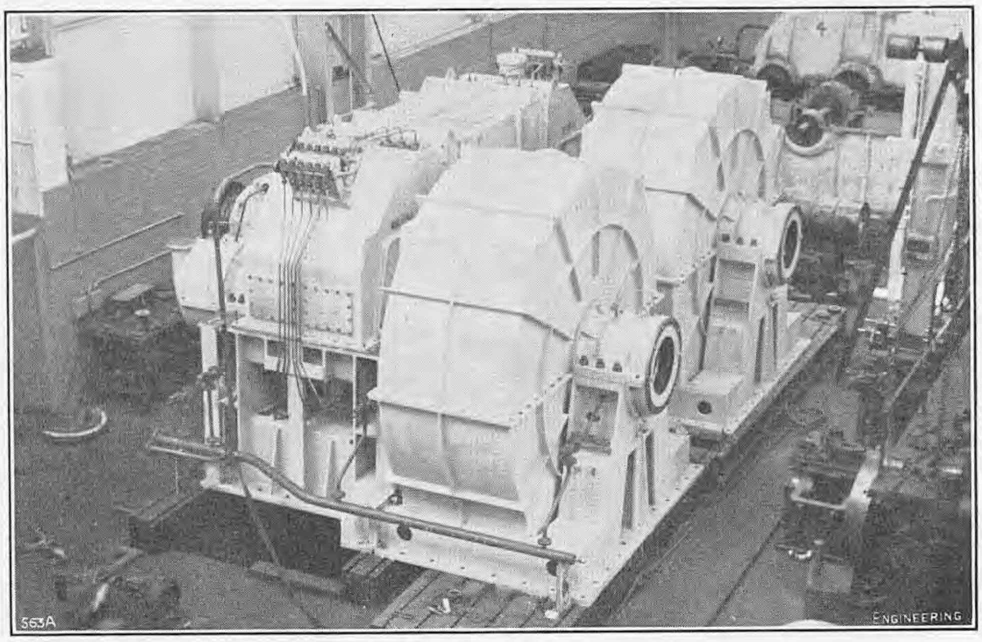


Fig. 1. Gearbox Complete.

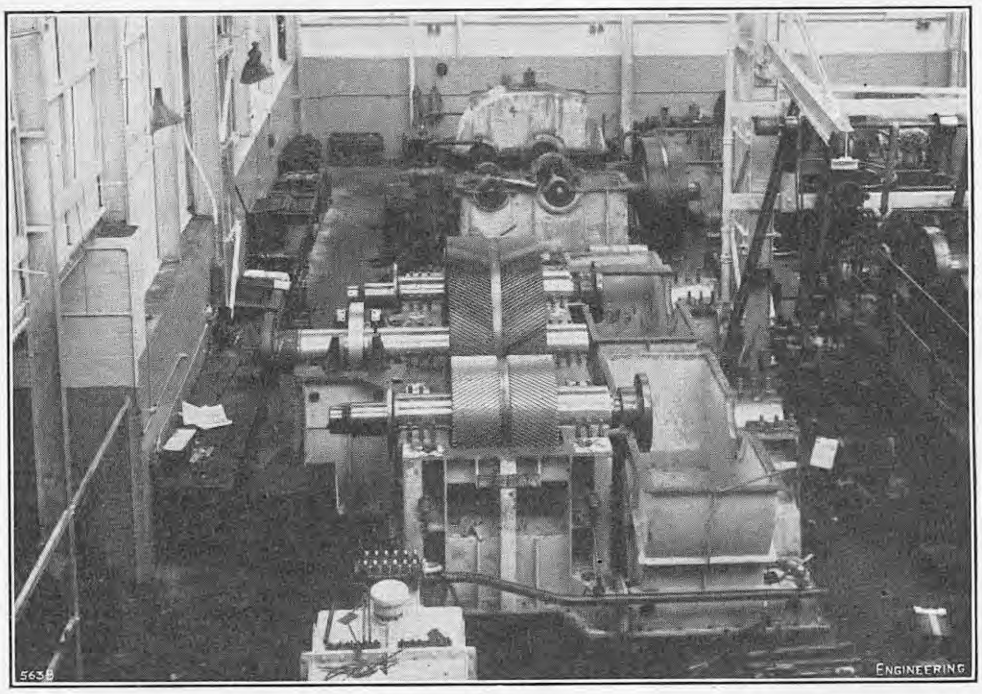


Fig. 2. Gearbox with Covers Removed.

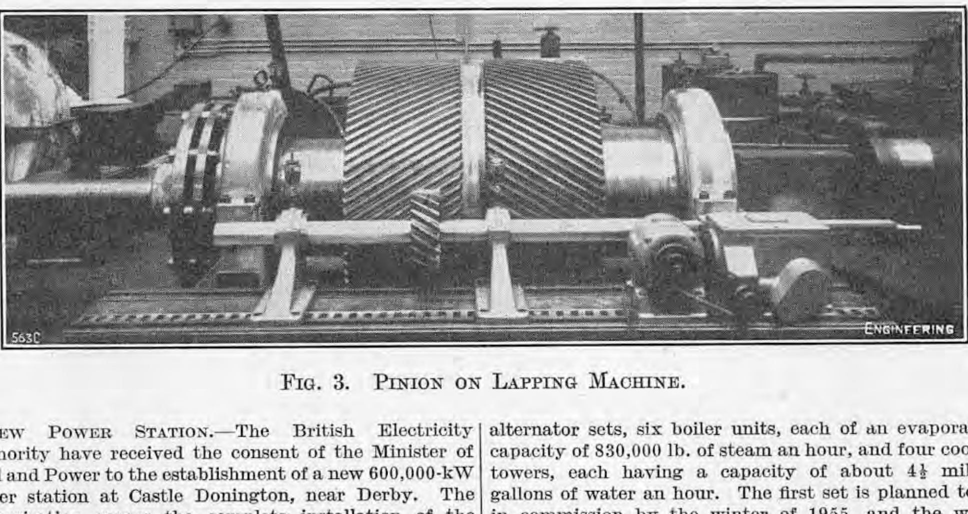


Fig. 3. Pinion on Lapping Machine.

New Power Station.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the establishment of a new 600,000-kW power station at Castle Donington, near Derby. The authorisation covers the complete installation of the station, which will comprise six 100,000-kW turbo-alternator sets, six boiler units, each of an evaporative capacity of 830,000 lb. of steam an hour, and four cooling towers, each having a capacity of about 4½ million gallons of water an hour. The first set is planned to be in commission by the winter of 1955, and the whole station is expected to be running by 1960.

GEARBOX FOR TWIN MARINE DIESEL ENGINES.

THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON.

Fig. 4. SECTION THROUGH HIGH SPEED SHAFT.

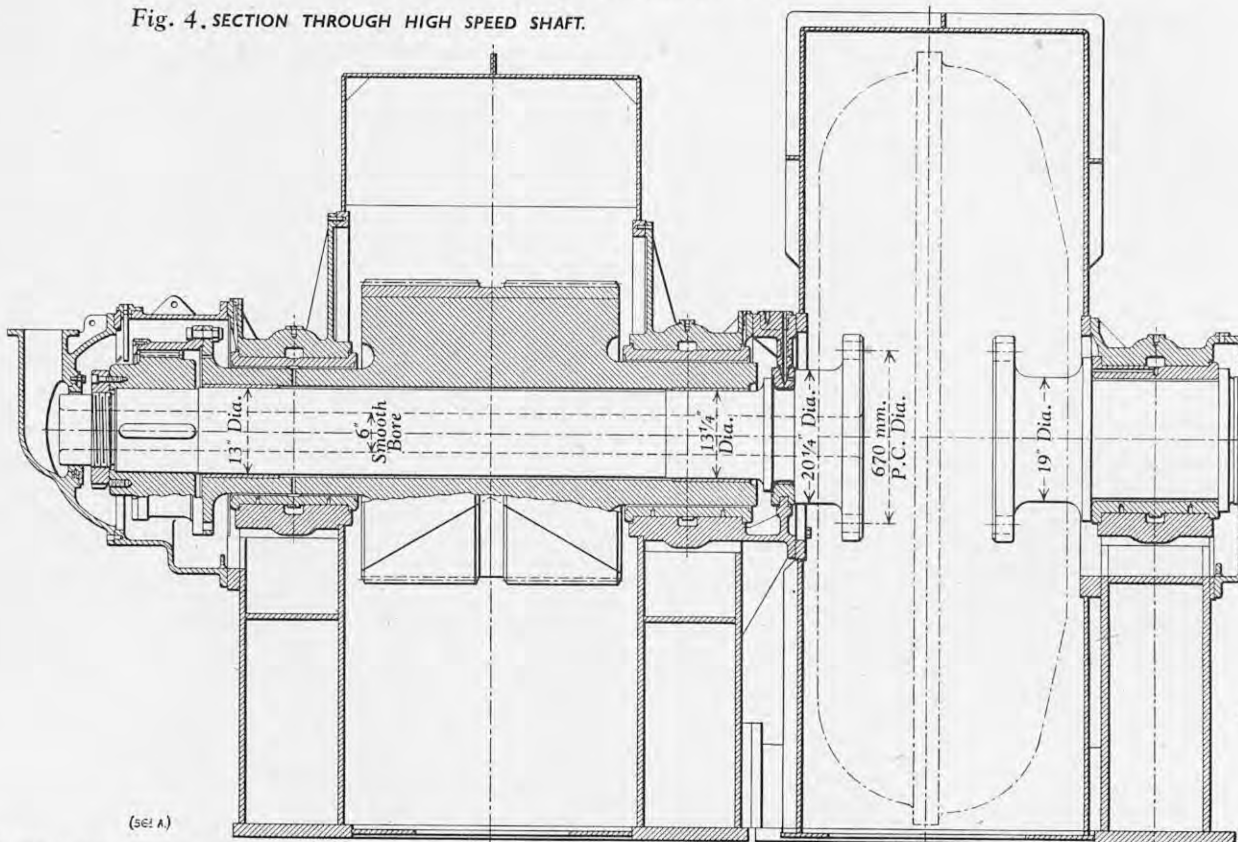


Fig. 5. ARRANGEMENT OF GEARS. LOOKING FORWARD, AHEAD ROTATION SHEWN.

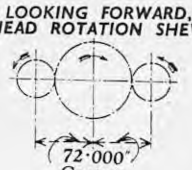
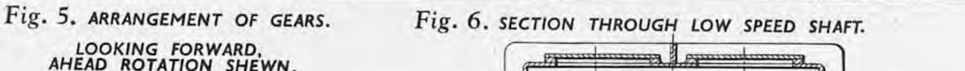


Fig. 6. SECTION THROUGH LOW SPEED SHAFT.



GEARBOX FOR TWIN MARINE DIESEL ENGINES.

The advantages that reasonably can be claimed for the use of geared Diesel engines for the propulsion of various classes of merchant vessels have been referred to from time to time in Engineering. Possibly the most important advantage is that it provides a convenient means for transmitting a high power through a single shaft without having to build an engine of excessive size; it permits, therefore, a high horse-power to be transmitted through a single screw and at the same time effects a saving in the space normally occupied by the engine, which, in some cases, may be as high as 20 per cent. Other advantages which may be mentioned are a lower first cost, a more convenient size of engine to overhaul, and greater reliability, particularly on single-screw vessels, as in an emergency an engine can easily be disconnected from the gearbox and the necessary repairs carried out without stopping the propeller. The motorship Cornwall, which is being constructed for the New Zealand Shipping Company, Limited, 138, Leadenhall-street, London, E.C.3, by Messrs. Alexander Stephen and Sons, Limited, Linthouse, Glasgow, is therefore of particular interest, as she will be propelled by twin Diesel engines geared to a single shaft and is believed to be the first vessel of this type to be built for the owners. She is one of three sister vessels each of which will be powered by two Sulzer engines geared together to give a total output of 8,000 h.p. at 100 r.p.m. of the propeller.

The gearbox for the Cornwall was constructed by the Power Plant Company, Limited, West Drayton, Middlesex, and the design incorporates certain novel features. The general form of construction will be clear from Figs. 1 and 2, opposite, which show the unit complete and with the covers removed, respectively. It will be noted that it is of the horizontal type with a double-helical pinion disposed at each side of the main gearwheel, the centres of the wheel and pinions being in the same horizontal plane; this arrangement is shown diagrammatically in Fig. 5, herewith. The unit is designed to transmit continuously the power from the two Diesel engines; these operate at 217 r.p.m., which is reduced to 100 r.p.m. at the propeller shaft, the total output, as previously mentioned, being 8,000 h.p. The engines will be arranged at 12-ft. centres and each will be coupled to its corresponding pinion shaft by a Vulcan hydraulic coupling. These, however, are being supplied by Messrs. Barclay, Curle and Company, Limited, Whiteinch, Glasgow, and their position will be apparent from the drawing reproduced in Fig. 4, above, which shows a longitudinal section through one of the pinion assemblies. Each coupling is 3,005 mm. in diameter, and the input and output half couplings are bolted to two 780 mm. flanges.

As will be seen from Fig. 4, the hub of each pinion is integral with its shaft. These components are machined from 35-ton steel forgings and have shrunk on to them rims made from a 55-ton alloy steel. The pinions have hollow centres so as to accommodate the shafts which transmit the power from the output sides of the fluid couplings to the pinions, each shaft being coupled to its respective pinion assembly at the after end. Turbo-type couplings are employed between the transmission shafts and the pinion shafts so as to permit free movement of the pinions and thus take up their correct positions in relation to the main gearwheel when, due to the clearance in the thrust block, it moves from the ahead to the astern position. This arrangement ensures uniform loading across the full width of the gear teeth, regardless of whether moving ahead or astern, and also avoids the possibility of any thrust loads being imposed on the fluid couplings. The turbo-type couplings were designed and manufactured by the Power Plant Company, Limited. Each consists of driving and driven members in the form of gear pinions with external teeth, which engage with a sleeve, or "muff," having internal teeth, the teeth engaging completely round the pitch-circle circumference. It will be apparent that with this arrangement, free lateral movement is possible between the pinions and their associated sleeves, while the shape of the teeth and tooth clearances allow the connecting sleeve to rock slightly and thereby counteract any misalignment between the two halves of the coupling.

The main gearwheel is of the built-up type, the rim, which is rolled from a 35-ton steel, being bolted to two circular plates which, in turn, are secured to two flanges machined on the main shaft. This form of construction will be clear from an examination of the drawing reproduced in Fig. 6, on page 631, which shows a longitudinal section through the main gearwheel assembly. The shaft is machined from a 35-ton steel and incorporates a collar for the thrust block. This is of the Michell type and is designed to take an estimated total thrust load of 150,000 lb., the collar diameter being 42½ in., the total thrust surface 650 sq. in., and the thrust pressure 231 lb. per square inch. Journal loads are taken by cast-steel shells lined with Admiralty-grade whitemetal. The bearings at the ends of the pinion shaft have a diameter of 19 in. and those between the couplings and pinions a diameter of 22 in., the length remaining constant at 20 in. The bearings for the main-wheel shaft are 20 in. in diameter and, like those for the pinion shafts, have a length of 20 in. The transmission shafts are located in their correct positions inside the pinion assemblies by means of gunmetal bushes, which receive a supply of lubricant from the pinion bearings. The casing is of composite fabricated construction, the bearing and thrust-block housings, which, as previously mentioned, are made from steel castings, being welded into the main structure. The double-helical gear teeth have a spiral angle of 30 deg. and a pressure angle of 20 deg., the pinions having 91 teeth and the main wheel 196 teeth. The overall face width is 40 in. and the active face width 36 in. The set is provided with the necessary piping for delivering lubricant to the gears on both the ahead and astern faces and, when in service, will be fitted with a full range of pressure gauges, oil-flow indicators, etc. All gears were lapped after machining, on the rig illustrated in Fig. 3, on page 630.

CONGRESS ON THEORETICAL AND APPLIED MECHANICS, TURKEY.

The Eighth International Congress on Theoretical and Applied Mechanics, sponsored by the International Committee for the Congresses of Applied Mechanics, will be held at the University of Istanbul, Turkey, from August 20 to 28, 1952. The work of the Congress will be divided into five sections, the first of which will be devoted to elasticity, plasticity and rheology, the second to fluid mechanics, the third to the mechanics of solids (including ballistics, vibrations, friction and lubrication), the fourth to statistical mechanics, thermodynamics and heat transfer, and the fifth to the mathematics of physics and mechanics and to methods of computation. Membership of the Congress is open to all qualified engineers and physicists and each member may present a maximum of two papers. Abstracts of contributed papers, which should not exceed 400 words in length, must be submitted on forms obtainable from the secretary of the Congress and be in the hands of the organising committee not later than June 1, 1952. The official languages of the Congress are English, French, German and Italian. The organising committee intend to invite a number of outstanding physicists and engineers to deliver addresses and there will also be a lecture by a specialist in each of the five sections of the Congress, the main object of these being to present research in fields in which great advances have been made in recent years. The chairman of the organising committee of the Congress is Professor Kerim Erim, and all communications should be addressed to the Eighth International Congress on Theoretical and Applied Mechanics, P.O. Box 245, Istanbul, Turkey. It is of interest to recall that the seventh Congress of the series was held in London in September, 1948.

The Late Mr. H. Coope.—The Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17, have informed us of the sudden death of Mr. Herbert Coope, manager of their Cardiff office. Mr. Coope, who died at his home at Penarth on October 20, was in his 65th year and had had an exceptional record of service with the company. This dated back to July, 1902, when the British Westinghouse Co. was in its earliest days. After completing his apprenticeship at Trafford Park, Mr. Coope spent some years in the London erection department, but transferred to the sales side of the organisation in 1919. After short periods of district-office work at Manchester and Stoke-on-Trent, he moved to Cardiff in 1922, becoming manager of the district office there and of its sub-offices at Swansea, Bristol, and, subsequently, Plymouth. In the late war he was Director of Industrial Electrical Equipment for South-West England and South Wales. Mr. Coope was elected an associate member of the Institution of Electrical Engineers in 1931 and transferred to the class of member in 1942. He was chairman of the Western Centre of the Institution in 1943-44. He joined the South Wales Institute of Engineers in 1923, becoming a member of the Council in 1939 and a vice-president in 1947. Mr. Coope was for 13 years chairman of the South Wales branch of the Electrical Industries Benevolent Association.

LABOUR NOTES.

Renewed assurances of the desire of the Trades Union Congress to co-operate with the new Government were given by an assistant general secretary to the T.U.C., Mr. Victor Feather, in an address to the Midlands Federation of Trades Councils, at Burton-on-Trent, on November 10. He expressed the view that only naïve people imagined that economic problems could be wafted away simply by a change of Government. It should be well known to all trade unionists that increased exports, price stability and an improved standard of living for the nation generally could come only from industry. The Government which helped most was that which created or maintained an atmosphere in which industry could function smoothly and efficiently. It was the job of the T.U.C. to help its affiliated unions to maintain and improve the living standards of working people. To discharge this duty effectively, the General Council of the T.U.C. would co-operate as fully with the present Government as it had done with previous Governments.

Clear indications of the intention of the Government to continue the practice adopted by recent Chancellors of the Exchequer of maintaining close consultation with both sides of industry on economic matters were given at the end of last week. Mr. R. A. Butler, the new Chancellor, and Sir Walter Monckton, the Minister of Labour, met five leaders of the Trades Union Congress on November 8 for an informal discussion of problems now confronting industry. The meeting took place at Mr. Butler's invitation and it is understood that no proposals were made, or asked for, by either side. The Chancellor briefly reviewed the economic situation, on the lines described in his statement to the House of Commons on the preceding Wednesday. The trade-union officials undertook that the contents of that speech would be examined with close attention by the appropriate committee of the T.U.C. and that Congress would afford what help it could. It is probable that the Chancellor's remarks will be considered in the near future, against the background of the economic situation generally, by the T.U.C. special economic committee. The T.U.C. was represented on the occasion by Mr. Arthur Deakin, C.H., the chairman, Sir William Lawther, Mr. Tom Williamson, Mr. George Woodcock, and Sir Vincent Tewson, C.B.E., the general secretary. It was announced subsequently that further consultations between the Chancellor and the T.U.C. would take place when necessary.

The informal exchange of opinions on the country's economic position was continued on the following day, November 9, when the Chancellor met representatives of the Federation of British Industries at the Treasury. Mr. Butler was accompanied on that occasion by Sir Arthur Salter, G.B.E., the Minister of State for Economic Affairs, and the Federation was represented by Sir Archibald Forbes, its President, Sir Robert Sinclair, K.C.B., Lord Dudley Gordon, past-President I.Mech.E., Sir Clive Baillieu, K.B.E., Sir Norman Kipping, M.I.E.E., the director-general, Mr. D. L. Walker, the general secretary, and Mr. R. Glenday. An announcement issued after the meeting stated that this preliminary exchange of views would be followed later by other meetings, after fuller consideration had been given to the requirements of the situation. The third of the present series of discussions on the industrial matters took place yesterday, when it was arranged that the Chancellor and Sir Walter Monckton should confer with representatives of the British Employers' Confederation on man-power problems.

The extreme urgency of the national man-power situation was referred to at the quarterly meeting of the National Joint Advisory Council of the Ministry of Labour in London on November 7, when Sir Walter Monckton met representatives of the British Employers' Confederation, the Trades Union Congress, and the nationalised industries for the first time since his appointment as Minister of Labour. Sir Walter stated that there had not yet been sufficient time for him to formulate a policy to meet the difficulties arising from the scarcity of labour and intimated that he hoped to consult officials of these three sections of industry separately during the next few weeks. He would then arrange a meeting of the joint consultative committee of the N.J.A.C. to consider the Government's plans for dealing with the problem. The committee, it may be remarked, comprises members of the same organisations as the Council, but it is a much smaller body.

Statistics supplied to the N.J.A.C. by Sir Walter showed that there were 446,000 jobs waiting to be filled on August 29 last, some 80,000 more than in November, 1950. There were 110,000 vacancies in the engineering, metal-manufacture, vehicle-building and aircraft group of industries. These included 36,000 vacancies for skilled engineers, 20,000 more than there were in August, 1950. Of the total vacancies existing in August last, 20,000 were in respect of jobs in the railway service, including 10,000 in the operating grades. It was emphasised that these demands for labour were likely to increase and that the rearmament programme, when in full swing, would absorb between 400,000 and 500,000 extra employees. In spite of this increasing shortage of workpeople, the total number of persons employed throughout the country had risen by 280,000, an increase of approximately 1 per cent. during a period of about twelve months.

Other information placed before the Council by Sir Walter indicated that the amount of short-time working performed in August last was rather less than in June, 1950, and that the amount of overtime had been much greater, particularly in the engineering, electrical-goods, and printing industries. The Council decided to discuss the questions of redundancy and short-time working at its next meeting, when it was expected that figures for September last would be available. It was stated that there was some evidence of an increase of employees on short time in the furniture, clothing and textiles industries during that month. A resolution was passed by the Council suggesting that employees in charge of fuel-using plants should be encouraged to attend educational courses designed to secure the most efficient use of fuel. Where such attendance could not be arranged, the Council urged that lectures and film shows should take place at works.

The reactions of industry to the Government's intention to de-nationalise the steel industry will be watched with much interest during the coming weeks. Apart from the threats issued in certain quarters that the industry will be nationalised again when the opportunity arises, probably on less favourable terms than previously, and the effect that these threats may possibly have on the willingness of investors to purchase shares in steel undertakings on the return of these to private ownership, discussion has centred mainly on what kind of organisation will replace the Iron and Steel Corporation. The necessity for a large measure of public control on the policies of the steel industry as a whole seems to be generally recognised. The return of the industry to private hands is based largely on the belief that, unless this is done, the industry will be unable to make its maximum contribution to the national effort and that it will accordingly be handicapped in relation to its overseas competitors.

It appears to be the desire of many sections of the industry, therefore, that there should be set up, with the aid of the Government, such a body as would combine a large degree of public control of general policy with the greater efficiency and flexibility which accompany private ownership. One obvious requirement of any new organisation would be that it should be able to make plans for the industry as a whole for some way ahead. It is felt that if the new body is to give effective direction in this way, its members must include representatives of management, labour and consumers in the industry, and of the Government. There is a demand that political control of the new body should be reduced to a minimum. Its powers should probably include those of compelling private firms to enlarge their plants and buildings where necessary, and the authority to fix prices.

Recommendations of the Railway Staff National Tribunal for an all-round wage increase of 8 per cent. were announced on November 7. No provision was made in the Tribunal's terms of reference in regard to this dispute, however, that its findings should be binding, and the award requires the approval of the parties concerned to make it effective. If the Tribunal's findings are implemented, the increases will be back-dated to September 3 and will add nearly fourteen-and-a-half million pounds to the annual wage bill of British Railways. In all, some 352,000 members of the railway staff in the conciliation grades and some 90,000 salaried employees will benefit. It may be recalled that the three principal railway unions asked for an all-round increase of 10 per cent. This claim was rejected by the Railway Executive, which made a counter offer giving various increases for different grades. Although some grades would have benefited by more than 8 per cent., many would have obtained less. The average increase offered was about 5 per cent.

Under the terms of the Tribunal's findings, the lowest-paid provincial rate of 5*l.* 2*s.* 6*d.* will be increased to 5*l.* 11*s.*, compared with the Executive's offer of 5*l.* 7*s.*, while the wage for an engine driver, earning the maximum pay for his grade, will be increased from 7*l.* 9*s.* 6*d.* to 8*l.* 1*s.*, against an offer by the Executive of 7*l.* 15*s.* The increases will be taken into consideration in the calculation of remuneration for Sunday work, night duty, and overtime, but no adjustments will be made in connection with bonus payments.

RADIO-FREQUENCY EDGE-GLUING MACHINE.

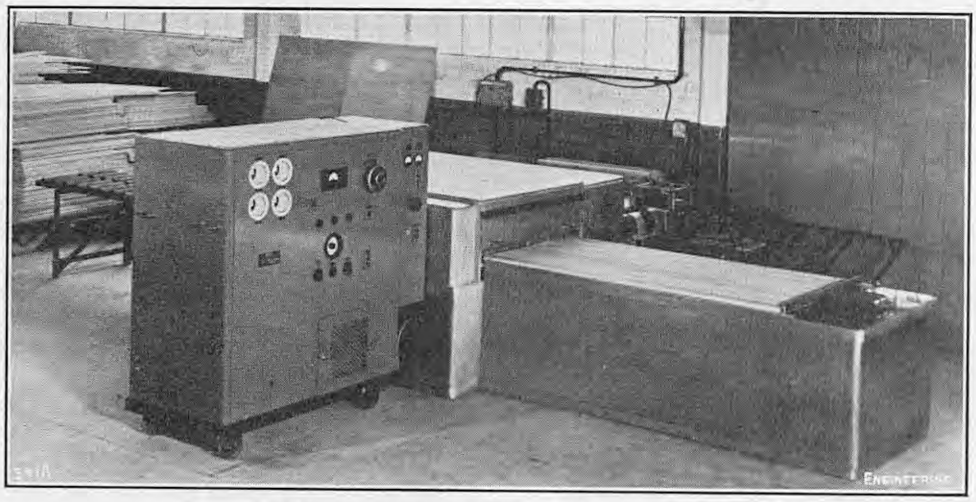


Fig. 1. General View of Machine.

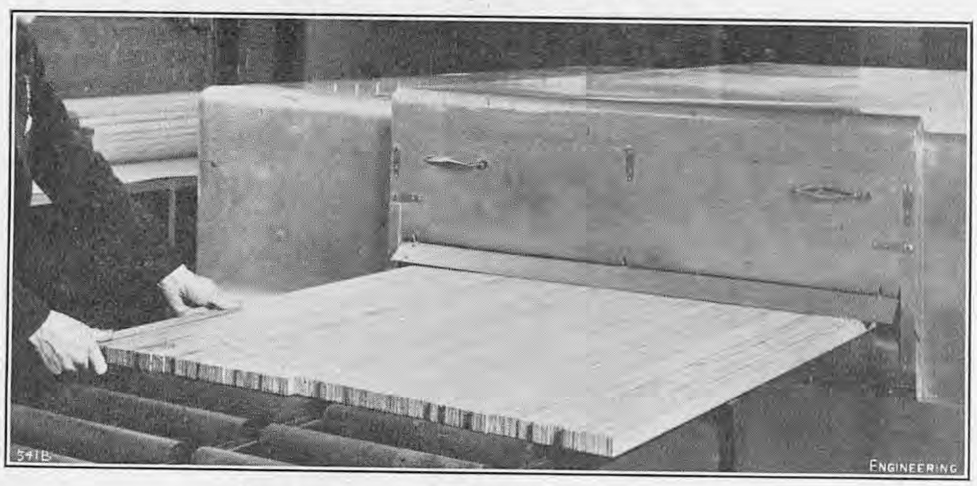


Fig. 2. Finished Board Being Ejected.

RADIO-FREQUENCY EDGE-GLUING MACHINE.

The radio-frequency edge-gluing machine which has been developed jointly by Messrs. Fielding and Platt, Limited, Gloucester, and the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, is intended for use in the manufacture of blockboard and similar products. The main advantages claimed for this system of heating, which has been employed for some time in other sections of the woodworking industry, are speed and economy. It enables considerable thicknesses of material to be heated uniformly within a short time, besides enabling the heat to be concentrated in the glue line (where it is wanted) and not wasted in heating a large mass of wood.

The machine, of which a general view is given in Fig. 1, consists of a pneumatically-operated press (with a feed table and loader) to which power is supplied at radio frequency through a matching unit from a 5-kW generator. A simple glue spreader is also included in the installation. Further, an electrically-driven air compressor and a reservoir for supplying air for automatically operating the press are incorporated in the plant. The feed table, which has a stainless-steel top, is provided with stops along the edges so that the strips coming from the glue spreader can be laid up. The load-matching unit enables the heat to be adjusted up to a maximum irrespective of the dimensions of the boards being treated and this ensures the most efficient use of the generator.

Operation is simple, it being only necessary, once the prepared strips have been assembled on the feed table, to press a button. This sets an automatic loader arm in motion, so that the board is fed into the press. The remainder of the cycle is then carried through in the correct sequence and the completed board is automatically ejected as shown in Fig. 2, when the next assembly enters the press. Only two operators are necessary, one of whom feeds the strips into the glue spreader and also stacks the completed panels when these are ejected from the machine. The other takes the glued strips from the spreader and assembles them on the feed table. Once an assembly has been fed into the press the loader arm returns to its original position and another board can be assembled, while the previous one is undergoing heat-treatment.

The machine has been designed for producing boards from 36 in. to 80 in. long, up to 40 in. in width and from ⅜ in. to 2 in. thick from scantlings and off-cuts. The strips may be of any convenient width and single boards can be made up from strips of various widths, providing the thicknesses are uniform. Production rates depend on the size of the boards and also vary with the moisture content of the wood and the type of glue. Tests have shown that the last factor is of great importance, since some glues set more rapidly than others of the same general type. Boards measuring 80 in. by 40 in. by 1 in. thick have been made from strips 2 in. wide in 5 minutes. The boards coming from the machine are quite ready for the next process. No jigs or clamps are needed as the boards do not have to be stored while the glue sets.

Experimental Stress Analysis.—We have received intimation of a course of 15 public lectures on the above subject, to be given in the civil and mechanical engineering department of the Northampton Polytechnic, St. John-street, London, E.C.1, on Monday evenings from 7 p.m. to 9 p.m., commencing on November 26, 1951. The course is intended for engineers and physicists engaged on research, development or design which involves the consideration and measurement of stress, and the aim is to give a general account of the experimental methods and their use in industry and elsewhere. The emphasis throughout will be on general principles, and, where appropriate, the subject will be illustrated by lantern slides or practical demonstrations. There will also be opportunities for discussion. The list of topics includes a revisal of basic stress-strain theory, theory and causes of mechanical failure, extensometers, strain gauges and strain-gauge techniques, photo-elastic methods in two and three dimensions, lacquer techniques, the detection of faults by radiological, magnetic and ultrasonic means, the investigation of strain by X-rays, the use of elastic models, and dynamic-stress measurements by means of resistance strain-gauges. Applicants for the course, which costs 30s., or 15s. to students attending another course at the Polytechnic, should have some previous experience or training in the subject. Applications for enrolment will be accepted by post, and should be made on the appropriate form, to be obtained from the college.

THE INSTITUTION OF CIVIL ENGINEERS: PRESIDENTIAL ADDRESS.*

By A. S. Quartermaine, C.B.E., M.C., B.Sc. (Eng.).

(*Concluded from page 600.*)

At Paddington, the original station was built in 1838 in rural surroundings just west of Bishops-road, on the site which Brunel intended for the goods depot. This was due to the delay experienced in obtaining powers for the road diversions necessary to enable the station to be built on its present site. In 1850, the directors decided to provide a more suitable terminus, together with administrative offices and an hotel. The station was opened in 1854 and is an admirable example of Brunel's ability to design engineering structures of simple and graceful appearance. It is illustrated in Fig. 2, on page 634.

The original roof, which forms the major portion of the present station, was 700 ft. long by 240 ft. wide, comprising a centre arch span of 102 ft. rising to a height of 62 ft., and two side spans of about 69 ft. each, 43 ft. high, crossed at two points by transepts 50 ft. wide. In addition, there was on both the up and down sides a further 50 ft. width of flat roofing, 20 ft. high. The three arch spans are roughly elliptical in shape and composed of wrought-iron ribs at 10-ft. centres, springing from light lattice girders supported on columns 30 ft. apart. The ribs taper from about 18 in. deep at the crown to 2 ft. 6 in. near the springing, and are formed of light angles and web plates, with ornamental holes cut in the webs round the soffit to enhance the light appearance. The wide expanse of glazing, running for the full length of all spans and transepts and occupying nearly 70 per cent. of the roof area, was of the ridge and furrow style adopted by Sir Joseph Paxton in his 1851 Exhibition building. The roof covering served the requirements of the station until 1914, when an additional span of 109 ft., of the same design, was added on the arrival side.

Since the roof was completed in 1854, no serious maintenance work, other than painting and resheeting, was needed until 1914, when some of the cast-iron columns were replaced by built-up steel ones, the remainder being replaced in 1924. Since then, slight repairs have been carried out to some of the ribs, and the glazing renewed in two spans. In 1940 and 1941, tie rods were provided at arch springing level to minimise the effect of bomb damage, and in 1944 a rib in the eastern transept was severed by a bomb, without consequential effect on the remainder of the roof, one 20-ft. length of one rib only having to be replaced. The roof in other respects remains to-day substantially as constructed by Brunel.

There is not time to refer in any detail to the many other works of Brunel, including his notable timber viaducts in Cornwall, his unsuccessful atmospheric system of propulsion for the South Devon Railway, his first steamship, the Great Western, 2,300 tons displacement, launched in 1837, and his famous steamship the Great Eastern, 680 ft. long and 27,400 tons displacement, launched broadside in 1858. I cannot, however, omit reference to the last and greatest of his railway works, the Royal Albert Bridge across the Tamar at Saltash, extending the Great Western Railway from Devon into Cornwall.

A proposal was made in 1844 to take trains into Cornwall by means of a train ferry, but in 1847 Brunel stated it would be practicable to bridge the Tamar at Saltash, where the river is about 1,000 ft. wide and 70 ft. deep at the centre at high water. After consideration of the site conditions, and the requirements of the Admiralty for naval vessels passing up and down the river, Brunel finally decided on two main spans of 455 ft., with a centre pier in deep water and 17 approach spans, making a total length of 2,200 ft., the main spans being 100 ft. clear above high water. The bridge was built to carry only one track, Brunel's view being that, in the case of such an expensive structure, the extra cost of a double line, 100,000*l*. at that date, could not be justified for this short length. It remains to-day the only piece of single line between Paddington and Penzance, and is not really an inconvenience, as the traffic margins are sufficient.

Apart from the design and erection of the main spans there was the difficult problem of constructing the centre pier. A description of this work was given by R. P. Brereton, Brunel's principal assistant, in his paper to the Institution of Civil Engineers in 1861. The work included the sinking of a wrought-iron cylinder, 37 ft. in diameter, 90 ft. high, and weighing 290 tons, in 70 ft. of water through about 16 ft. of silt to reach a reliable foundation on the rock in the middle of the river. Within the cylinder was constructed the masonry pier, 35 ft. in diameter, carried up to 12 ft. above high water level. On this stand four cast-iron octagonal columns, nearly 90 ft. high, support-

* Delivered in London on Tuesday, November 6, 1951. Abridged.

RAILWAY CIVIL ENGINEERING.

Fig. 2. Paddington Station.

ing the upper arched section of the pier, through which the trains pass and on top of which the tubes are carried.

The two main spans, each 455 ft. long, were designed as a development of an earlier Brunel bridge over the Wye, at Chepstow, in a way which made use of a wrought-iron tubular arch in effective combination with suspension chains, so that the pull of the chains is resisted by the tubular arch. The track-carrying girders are suspended on hangers from the tubes and the chains, alternate hangers being connected to both tube and chain. The hangers are braced transversely and longitudinally, and the finished truss forms a remarkably rigid structure, but presents an extremely difficult problem in stress calculation. In the general design, Brunel made the rise of the tube, 28 ft. 9 in., approximately the same as the fall of the chains, 27 ft. 6 in., both forming flat parabolic curves and giving a pleasing appearance. The arch is a single wrought-iron oval tube, 16 ft. 9 in. wide and 12 ft. 3 in. high, from which hang four suspension chains, each having a cross section of 14 7-in. by 1-in. wrought-iron links. The weight of the ironwork in each span is over 1,000 tons.

The erection was carried out by constructing the trusses on the Devon shore, and floating each out on pontoons to its correct position, where it was jacked up in short lifts, the masonry of the shore pier and the cast-iron columns of the centre pier being built up under the truss as the work progressed (see Fig. 3, opposite). The total lift was nearly 90 ft., and, as the trusses are 455 ft. long, 72 ft. high, and less than 20 ft. wide, the work must have been planned and executed with great care. The top of the tubes is 260 ft. above the river foundation, which is 35 ft. in diameter. The bridge cost 225,000*l*. and was opened by the Prince Consort in 1859. Since then, the decking of the bridge has been renewed, the approach spans reconstructed, additional horizontal bracing added to the main trusses, and some repairs carried out at the attachment of the verticals to the tubes. Otherwise, the bridge remains as constructed, a monument to the skill and courage of the designer.

Brunel, who was a senior vice-president of this Institution, and would have become President but for his early death at the age of 53, displayed throughout his life almost tireless energy and enthusiasm for his work, and much of the comfort and leisure we now enjoy is derived from the strenuous labours of men of his tenacity. The spread of industrialism to almost all countries, the effect of two world wars, and the present tragic international situation is depriving us of our advantages. The position to-day demands that we call to mind the indomitable character of those who helped to build our industrial prosperity, as it seems evident that we can only hope to retain the benefit of our heritage by a revival of the unconquerable spirit of the Battle of Britain and the energy of such men as Brunel.

Brunel's works stand as proof of his designing skill, and also show how much thought he gave to the appearance of his structures, using to the full his remarkable eye for proportion. This has not always been followed by his successors, and six valuable lectures were delivered at the Institution in 1944 on the "Aesthetic Aspect of Civil Engineering Design," with the object of stimulating among civil engineers and students an appreciation of this phase of their work. The key-note to-day is economy, and we find it beyond our means, even if it were our desire, to provide the fine stone capitals seen in such structures as the Wharncliffe Viaduct; but the beauty of much of Brunel's elliptical arch work was achieved without additional cost, and without the assistance of the Royal Fine Art Commission, or the approval of the Town and Country Planning Authority.

Though Brunel had very many difficult technical problems to solve, he did not restrict himself to one at a time, as, for example, when he built the steamer Great Western at the very time when he was engaged on the construction of the Great Western Railway. Nevertheless, he found time to study Nature and art, and to acquire knowledge of the world and its affairs, and he combined administrative ability with his exceptional engineering talent. To-day, the field of engineering knowledge and research is so wide that it encompasses not only the whole of an engineer's working time, but much of his leisure hours, to the exclusion of other interests.

On the other hand, the increasing extent to which the work of the engineer affects almost every aspect of the life of the community requires that he should be more frequently among those who hold administrative posts and are represented on the governing bodies of the nation. The engineer's readiness to get on with his own job, and to leave to others the less arduous task of talking about it, is understandable; but this natural inclination, increased by the desire to avoid anything approaching self-advertisement, results in his being too readily and too automatically excluded from the administrative side of affairs. We do not want a board of directors, a County Council, or a House of Commons composed of engineers, as this would be not only a scandalous waste of engineering talent, but as unsatisfactory as a House full of doctors, accountants, scientists, or even professors of economics. On the other hand, the present scanty representation of professional engineers in administration and government is neither good for the country nor the profession.

The breadth of view and knowledge needed for successful administrative work is, however, not acquired by technical education alone. Contact with those engaged in a variety of activities, and interest in social science, philosophy, law, economics, industrial relations, and even the art of speaking and report writing, are all helpful, and to some extent necessary. The Railway Executive have included engineers among those who attend the Administrative Staff College at Henley, and this is a valuable step in the right direction. In many industries such as the railways, where engineers control a large number of men and collaborate with many departments, administrative ability is required to perform successfully the engineer's own work, quite apart from its value in a purely administrative post. It has to be admitted that the technical and scientific information of which the young engineer has to obtain a working knowledge is now so varied and extensive that one hesitates to suggest he should add to this a determination to acquire more general knowledge. It may sound unreasonable, and much cannot be expected in the early stages of his academic career, but it is for the very reason that his technical education never ceases that it is necessary for him to resist the tendency to exclude everything else.

During the Nineteenth Century, construction was the great objective. Railways were projected and built in every direction, until, by the end of the century, the country was traversed by a network of lines serving all districts. Now the position is that the railways exist, and it is sometimes said without thought that their days are numbered, as they will inevitably be superseded by road and air transport. I do not subscribe to this view, and I would like to give some indication of the position as I see it.

Dr. Glanville, in his presidential address, referred to the congestion which already occurs on the roads, particularly in and around large cities. A five-year programme has since been recommended to the Minister of Transport by the London and Home Counties Traffic Advisory Committee, involving an initial expenditure of about 20*l*. million in London at the earliest possible moment, and confirming the approaching critical situation in the London area. Every addition to road traffic adds still more to the inevitable difficulties which must arise in a country the size of Great Britain when the number of vehicles on the roads is increased at a much greater rate than the improvement of roads to carry them. Partly as a result of two world wars, the rate of production of road vehicles has been increased, and the construction of roads had been delayed through lack of labour. It may be said that this will cure itself in a few years by expenditure on road improvements throughout the country, and, no doubt, much could be done in this way. What is really happening is that construction work, even on arterial and by-pass roads, which was too slow before the war, is now by force of circumstance reduced beyond recognition. The more serious problem, however, of dealing with any considerable increase of road traffic into major towns is a far greater one, involving unpredictable delay and vast expense. In the London area, surface traffic at peak hours has reached saturation point and for such traffic further tube railways will doubtless prove the quickest and cheapest, and probably the most certain means of improvement. It seems essential that an early start should be made with the most urgent section of new tube railway, followed by steady progress with a long-term programme.

The main-line railways carry an immense amount of traffic, though it may not be remembered except at holiday times. In 1950, the main lines handled 1,000 million passenger journeys and 22,000 million net ton-miles of freight. During the morning rush-hour at the main-line termini in London, 3,300 passengers arrive per minute. If this traffic were gradually transferred to the roads, it is clear that transport throughout the country and the approach to large towns would become chaotic, in spite of all the prodigious efforts which might be made, and the crippling expenditure which would be incurred in an attempt to match the roads to the traffic. Lengthy journeys by car at busy times already involve joining queues travelling behind slow-moving lorries, while each car awaits an opportunity to pass in safety. On the long stretches of main roads of two-car width, the delay in passing is often prolonged, and a further queue is reached at no great distance ahead. If the railway passengers and freight were added to these queues, and to the congestion entering and leaving large towns, the speed of transport would fall, and the disastrous story of road accidents, estimated to cost about 100*l*. million per annum, would become an even greater national tragedy. Furthermore, the strategic value of the railways would be lost, and the burden carried by them during the war, when the traffic was so heavy that intending passengers were exhorted to avoid rail travel, would, if placed upon the roads, be a menace to our security.

It is not my intention to argue a case for rail in preference to road traffic, but to indicate that both forms of transport are essential in this highly industrialised and heavily populated country. The British Transport Commission are applying themselves to the difficult task of integrating all forms of transport, and this is clearly the urgent problem with which we are faced.

The existing railway system, which would cost about 3,000*l*. million to construct to-day, is an invaluable heritage which must be not only maintained and used to the best advantage, but also improved wherever necessary to ensure that the country reaps the greatest benefit from it. By this I do not infer that there are not many railway branch lines and stations which can no longer justify their existence. Such deadwood

RAILWAY CIVIL ENGINEERING.

Fig. 3. Erection of Saltash Bridge, in 1858.

should be, and is being, cut out of the railway tree. The rest of the tree, however, should be nurtured and fertilised, and not starved into a state of unfruitfulness, to the everlasting detriment of the nation's economy. Reduction in operating and maintenance expenditure is essential, but wise capital investment on improvements is equally necessary. The confidence of all associated with the actual running of the railways needs to be strengthened by the certain knowledge that the industry must and will advance, and that policy will be directed to this end. The present unavoidable curtailment of capital expenditure, if pushed too far, may not only retard the post-war convalescence of the railways, but set them back so far as to cripple them permanently. With all the commitments facing the country, efficient transport by rail and road is of first importance, and expenditure on revitalising this in a co-ordinated manner is imperative. The late Minister of Fuel and Power said that rearmament must not be allowed to check investment in the mines because coal is a vital defence requirement. May I add, so also is transport. The railway engineer desires to assist in the wise planning and speedy execution of construction works to provide better, quicker and, if possible, cheaper service. By various methods he is achieving some success in handling the problem of labour shortage, but, like many others, he wants a much higher place in the queue for materials.

The ever-present problem to which the engineer directs his thoughts and energies is the vast and varied task of maintaining the existing way and structures. In general, this might be described as the more economical design, use of materials, and execution of civil engineering work, the better organisation of the considerable manpower employed, constant research into improved methods, and the most effective application of mechanical equipment. The annual civil engineering bill for maintenance is over 50*l*. million, and to ensure every effective reduction in this without loss of efficiency necessitates the employment of staff with engineering training, experience, and ability of a high order.

During the 100 years or more that many of our railways have been in existence, much has been done to improve the standard of construction by replacing original timber and cast-iron structures by stronger and more lasting ones, providing heavier permanent way and better curves, improving signalling, track formation, and many other features. This work does not cease with the passage of time, as structures continue to wear out or deteriorate to a point beyond which it is no longer practicable nor economical to repair them, and renewal becomes necessary. In addition, many stations, goods sheds, locomotive depots, and similar works need reconstruction on modern lines. Reconstruction and modernisation is normally undertaken in a way which will give the best and most lasting results for the least expense in first cost and subsequent maintenance. On the other hand, there are sometimes cases where it is reasonably certain that change of traffic or policy will render a structure redundant in a comparatively short time. Long life is not then one of the essentials, and the cheapest building to meet the requirements is all that is needed. It is necessary, nevertheless, to inject some engineering economics into the department asking for cheap buildings, otherwise the money saved in the cheapening process may have to be spent subsequently by the unfortunate engineer on the costly maintenance of these utility models.

British Railways have over 60,000 bridges of all shapes and sizes up to the largest, the Forth Bridge, and of ages from one to over 100 years. Many of the old masonry and brick arch bridges and viaducts are almost as good as when constructed; others develop a variety of defects. The more usual, such as bulging spandrels, cracked arches, perished brickwork, and decomposition of mortar, can be dealt with by well-established practices. Foundation settlement and distorted arches afford more scope for ingenuity in repair. Most of the oldest metal bridges are of wrought iron, and many are over 90 years old. These have some of the characteristics of the old soldier, but they do ultimately expire, as do the less aged steel structures. There are, in consequence, plenty of opportunities for evolving improved designs, based on experience of the behaviour of old bridges, and present knowledge of riveted or welded steelwork, reinforced concrete, and prestressed concrete of various forms and methods of fabrication. The present need for conserving steel is an added incentive to the greater use of reinforced concrete; and always before us is the desire to find new and better materials and forms of construction, the guiding principle being reasonable first cost, long life, and low maintenance expense. The problem of speedy erection, however, generally affects the design, as the actual replacement of most bridges carrying the railway must be undertaken on Sundays and may have to be completed in a few hours.

There are on the British Railways 1,085 tunnels, with a total length of 310 miles. Many of these are approaching or over 100 years old, and most have withstood the passage of time well. Their principal defects, the deterioration of mortar and scaling of brick or masonry linings, are repaired by deep pointing, or cutting out and replacing one or more defective rings in short lengths as necessary. Less frequently, a tunnel may require drastic treatment due to serious distortion of the arch or side walls, involving a new invert or complete relining, or it may even be necessary to construct an entirely new tunnel. At the present time, there is in hand the construction of a double-line tunnel, just over three miles in length, on the Manchester-Sheffield line through the Pennines, between Woodhead and Dunford Bridge stations. The lining of the existing twin tunnels, after 100 years life, has deteriorated so much that further economic maintenance under intensive traffic conditions has become impracticable. The construction of the tunnel was commenced in March, 1949, and the pilot heading completed last May. Such works are fortunately exceptional, but the railways are never without tunnel problems somewhere. In two recent cases the side walls settled and moved inwards, involving, in one tunnel, very heavy inverting and relining, and, in the other, the complete opening out of the length affected.

Efficient and economical maintenance of the permanent way presents a serious drainage problem which is still the subject of experimental research. Water is very frequently a source of trouble to the engineer, and it is particularly so under the railway track. In theory, rain water should drain through the ballast and pass harmlessly to the side drains or ditches. Much of it behaves in this way, but where the formation is a cohesive material such as clay, of low shear strength when the moisture content is high, it is a constant fight between the clay's readiness to increase its moisture content beyond stability, and the engineers' efforts to remove the water before this occurs. Once the clay gains a lead on the engineer, it rapidly takes charge, as the resulting slurry holds the water and passes into the open joints of drains, impeding or stopping further water reaching the drains. This is the beginning of what might be described as "Operation Porridge," as the slurry rises up through the ballast, rendering the engineer almost powerless until he removes the track and digs out the mixture of ballast and slurry down to a level at which the clay is in its undisturbed state (Fig. 4). On this new formation he must start afresh, carrying out a process known as "blanketing." In the past, a layer of ashes was tried with little success, and fine sand proved to be a better material. Now it is considered that more lasting results will be obtained by a thickness of a foot or more of stone dust, rolled or tamped mechanically before adding a layer of coarser material, graded upwards to the size of ballast, on which the ballast itself is spread and the track replaced. At the same time, the side drains must be renewed at a suitable level to draw off the water before it ever reaches the clay again. Other methods have been tried, including cement grouting, sand piling, sand infiltration, and even laying concrete slabs on the formation. Considerable lengths now require treatment, due to neglect during the war and subsequent shortage of labour. While lasting results are essential, we need to find means of expediting the work and reducing the cost. The restoration of defective track formation and drainage cannot be deferred if we are to provide better running and a subsequent decrease in maintenance expense.

Improvement of the railways and reduction in the cost of maintaining the way and works can only be achieved by combining hard-headed railway experience with a progressive spirit of research and development. This involves investigation of the problems by skilled and well-trained engineers. Mediocrity and accountancy will not be sufficient. Opportunities are accordingly provided to graduates and young men of matriculation standard for training under agreement in accordance with the Institution requirements; at a later stage, selected young engineers showing more than average competence are picked for further special training or for brief tours on Continental railways, or to attend courses or international conferences on engineering subjects. With the clear necessity for making the railways more efficient, whether it be by the extension of electrification, the mechanisation of goods working, the improvement of design to reduce cost, the wider application of modern techniques, the profitable expansion of the use of mechanical plant, or any other advance on older methods, an essential need is for engineers who are skilled in their work and carry it out in a way which inspires their staff with confidence, enthusiasm, and pride of achievement.

It is a compliment to the railways that many young men, aspiring to become qualified engineers, recognise that railway work is a valuable training ground, and it is necessary that the best of these should not be attracted away from the service. In an organisation so vast, care is needed to ensure that centralised instructions and standards, necessary and desirable as they are, do not discourage the inception and development of new ideas amongst the staff of the Regions. Good engineers live and thrive on the success of their ingenuity and inventiveness, and the morale of the many excellent men, young and old, on the engineering staff would be lowered if their initiative were unduly restricted. Any impression that the work of a railway engineer is lessening in interest and opportunities is wrong, and there must be no room for doubt that railway service is attractive as a permanent career.

Technical and organising ability is more than ever necessary when receipts are not keeping abreast of rising costs. The railways, unlike other nationalised industries, cannot freely raise the price of the commodity they sell, because of the statutory restrictions placed upon them, and because the commodity is not like coal, gas, and electricity, which the public must buy whatever the price. Railway engineers of to-day are impressed with the importance of reducing costs, and I commend their efforts to achieve this while faithfully carrying their heavy responsibilities. No praise or criticism, however, and no amount of skill and training will be sufficient unless we add also something of the spirit of Brunel. He lived at a time when this nation was creating its greatness, and recognised that only by unflinching determination and incessant effort could obstacles be overcome. Such a spirit is needed more than ever to-day, both on the railways and in other spheres. We are proud of our famous engineers and now, when it seems that our greatest effort is required, we can, perhaps, draw guidance and inspiration from them. May I, therefore, in conclusion, recall the words spoken by Joseph Locke, President of this Institution, at the meeting on November 8, 1859, after the deaths of Isambard Kingdom Brunel and Robert Stephenson: "We at least, who are benefited by their successes, who feel that our Institution has reason to be proud of its association with such names as Brunel and Stephenson, have a duty to perform and that duty is to honour their memory and emulate their example."

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Fig. 4. Removal of Slurry from Water-logged Formation.

International Mechanical Engineering Congress, 1952.—The 4th International Mechanical Engineering Congress will be held in Stockholm from June 4 to 10, 1952; the papers and discussions will be centred on improvements of materials used in engineering manufacture. The Congress is organised by the trade associations serving the mechanical-engineering industry of 12 European countries (Belgium, Denmark, Finland, France, Western Germany, Great Britain, Italy, Netherlands, Norway, Spain, Sweden and Switzerland). A meeting of the organising committee, comprising representatives of all these countries, was held in London this week under the chairmanship of Mr. A. W. Berry, Director of the British Engineers' Association, 32, Victoria-street, London, S.W.1, from which address information concerning the Congress is available. Visits to a number of works near Stockholm have already been arranged, and in the week following the Congress there will be optional tours to the principal industrial centres of Sweden.

Scottish Business Equipment and Management Exhibition.—The Office Appliance and Business Equipment Trades Association inform us that the Scottish Business Equipment and Management Exhibition, which was due to take place at Edinburgh in February next, as announced in our list of Forthcoming Exhibitions and Conferences" on page 535, *ante*, has had to be postponed. The Association will now hold their major Business Efficiency Exhibition for 1952 at Bingley Hall, Birmingham, from Wednesday, February 20, to Saturday, March 1. It is hoped by the Association that an exhibition under their auspices can be arranged at Edinburgh later in 1952. The address of the Association is 11-13, Dowgate-hill, Cannon-street, London, E.C.4.

CONTRACTS.

The 14 Diesel-electric locomotives of 955 brake horsepower, and 3 ft. 6in. gauge, recently ordered by the Commonwealth Government Railways from the Birmingham Railway Carriage and Wagon Co., Ltd., Smethwick, Birmingham, 40, and Sulzer Bros. (London), Ltd., 31, Bedford-square, W.C.1, are to be of the A1A-A1A wheel arrangement, with a maximum axle load of 10 tons and a total service weight of 60 tons. The top service speed is to be 45 m.p.h., and the maximum tractive effort, 26,800 lb. The locomotives are to have single-end drive and will have a length, over headstocks, of 41 ft. 10 in. The oil engine is to be of the Sulzer 6 LDA 28-type and pressure-charged.

The Nevelin Electric Co., Ltd., are to provide two 250-kW glass-bulb mercury-arc rectifiers to be installed in the Houses of Parliament, to the order of the Ministry of Works, to provide supplies of direct current to maintain various services, following upon a change-over scheme which is being carried out in the area.

During October the British Electricity Authority have placed contracts for equipment for power stations, transforming stations and transmission lines amounting, in the aggregate, to 3,347,670*l*. The principal contracts include orders for 33-kV cables and accessories for Barking "C" power station, with Malcolm and Allan (London), Ltd.; generator transformers for Marchwood power station, near Southampton, with Ferranti, Ltd.; modifications to 132-kV 1,500 MVA switchgear and protective equipment for Hams Hall "A" power station, near Birmingham, with the General Electric Co., Ltd.; condensing and feed-heating plants for a 30,000-kW turbo-generator for Huddersfield power station, with Richardsons, Westgarth and Co., Ltd.; a 45,000-kW turbo-generator and transformer for Thornhill power station, near Dewsbury, with the English Electric Co., Ltd.; piling for the main foundations of Stella North station, Newcastle-upon-Tyne, with the Franki Compressed Pile Co., Ltd., and 132-kV 3,500-MVA switchgear for the same station, with A. Reyrolle and Co., Ltd.; 132-kV 2,500-MVA switchgear for Smethwick substation, Staffordshire, with the General Electric Co., Ltd.; 132-kV 2,500-MVA switchgear for Clydes Mill substation, Glasgow, with the Metropolitan-Vickers Electrical Co., Ltd.; and 132-kV overhead lines from Portishead, Bristol, to Lockleaze, from Bathgate to Junction X, South-East Scotland, and from Clydes Mill to Newarthill, South-West Scotland, with W. T. Henley's Telegraph Works Co., Ltd.

PRODUCTION AND UTILISATION OF ELECTRICITY.*

By A. H. Young.

The tremendous increase in the efficiency of production and utilisation of both gas and electricity in the service of an increased population, in spite of a decrease in the amount of coal mined, is indicated in Table I. This progress has, however, in itself created many problems, among which a shortage of coal and a shortage of generating-plant capacity are important. In the last 50 years there has been a remarkable decline in our coal production for export. In 1913, 73,400,000 tons of coal were exported and 487,000,000 gallons of liquid fuel imported. In 1938, coal exports had fallen to 35,860,000 tons, and oil imports had risen to 2,640,000,000 gallons. By 1950, coal was being imported. It is interesting to note that this is not the only country faced with a decline in coal production. In the United States, coal is playing a diminishing role as a primary source of energy. In the early 1920's it accounted for 70 per cent. of the energy produced from all sources—oil, coal, natural gas and water power—but now it accounts for only 44 per cent.

Table I.

Year.	Coal Mined, Tons.	Gas Sent Out, Cub. Ft.	Electrical Energy Generated, kWh.
	$\times 10^6$	$\times 10^9$	$\times 10^6$
1900 ..	220	57	125
1925 ..	243	284	6,294
1950 ..	200	480	53,700

Unless more coal can be produced in Great Britain, another source of energy must be found. There are in the meantime great opportunities for engineers to apply their skill to assist in solving the more immediate problem of the efficient use of our energy resources. Electrical energy is the most versatile servant that has emerged in the past 50 years. Unfortunately, in some respects the growth of the industry has been so rapid that sufficient regard has not always been paid to its economical utilisation, with the result that many problems have been created. Probably the greatest of these is how to deal with the peak load on the power stations. With the increased need for electricity in industry, and the serious consequences on increased productivity imposed by restrictions on demand, the solution of this problem is urgent. The continuation of load shedding cannot be afforded and resources must be found to supply sufficient energy to meet industrial demands.

Much has been said about the effect of the domestic load on the peak and it is well that this problem should be looked at in its true perspective. The system load factor is now approaching 50 per cent. Industry, with its 44-hour 5-day week, can on average have a load factor of only 20 to 25 per cent. Therefore, the much-maligned domestic load, with its high diversity, helps considerably to achieve the present system load factor of approximately 46 per cent. Industry cannot be economically operated at such a low load factor as 20 to 25 per cent., having regard to its own large capital investment, plus that required for generating stations, transmission and distribution systems, and it appears desirable that steps should be taken to stagger the industrial load. Otherwise it is difficult to see how the gap between capacity and demand can ever be closed. A campaign could, therefore, profitably be undertaken for the purpose of educating users and employees to appreciate that generating stations are only loaded, or overloaded, for comparatively short periods, and that on average they are only carrying less than half-load. If a portion of industry could be persuaded to take its requirements during the lightly-loaded portion of the day there would be no need for load shedding.

Apart from this problem, however, there must be a co-ordinated policy for our fuel resources, and this policy must not restrict development. Generating units installed in industrial premises should be utilised to the fullest capacity in parallel with the public supply, to assist in overcoming the shortage of capacity. To adapt existing British power stations for district heating would be impracticable in most cases, owing to their location, but its possibilities, particularly in new towns and rebuilt areas, should be taken into account when siting new stations. It should also be possible to make greater use of waste heat for industrial purposes. This could be done by siting new factories near existing generating stations, and taking full advantage of the supplies of steam and electricity available, as has been done on the Treforest Estate in South Wales. Alternatively, factories could be encouraged to generate a larger proportion of their electric power requirements, so that heat, which would otherwise be lost in cooling water at a central generating station, could be used for process and space heating in the works.

Great Britain owed her industrial superiority in the past to her initiative in developing her natural resources and the crafts of her people. To regain that position, ever-increasing quantities of electricity must be applied to assist workers to increase productivity, and at the same time our most valuable assets, namely, our brains and initiative, must be used to lead the world in creating new products and commodities which can be exported. Every endeavour should be made to improve our methods and efficiency, so that when free and unrestricted competition returns to world markets, we shall be able to compete with other nations who may be more favoured with natural energy resources. Gone are the days in this country when the price of electricity and other energy sources represented a small percentage of the total works cost. In many industries this is now becoming an important factor. It is essential, therefore, to watch the cost to the consumer, as these costs must ultimately be reflected in the final cost of goods. If industry cannot promptly obtain much-needed electricity to increase its productivity from the public electricity supply sources, then it appears that, as a short-term policy, there is a good case for industrialists installing high-speed Diesel generating sets, operated in parallel with the public supply during peak-load periods. It was stated recently that power cuts last winter cost this country approximately 9*l*. million in industrial production. As this sum represents a national production wastage, some financial outlay made with the object of avoiding future extravagance of this nature would be justified, and some financial allocation towards the provision of private generating sets that could be quickly installed in existing buildings is worthy of consideration. In the past it was feared that if industrialists were encouraged to install their own generating sets there would be a tendency for them to continue using this plant to the exclusion of the public supply. It is doubtful if, in the light of the changed circumstances, this really would happen, as most industrialists would be ready and willing to take their electricity requirements from the public supply provided the terms were reasonable. It is hoped, therefore, that those responsible will encourage the use of private generators to lessen the effects of the serious shortage of public supply plant in the present emergency.

The State has now become responsible for our main energy-producing industries—coal, gas and electricity—and the Ministry of Fuel and Power has a major responsibility to provide our needs at an economic price which will enable industry to increase productivity and permit the community to enjoy the amenities and higher standard of living which we have been led to expect over the past 50 years. Electrical engineers, however, have also a responsibility, and still have ample opportunity to develop new techniques, methods and equipment for the utilisation and conservation of all three sources of energy. The State has also taken over responsibility for the operation of our railways and canals, and it is to be hoped that it will proceed with an active programme of electrifying our railways and thereby make a saving in coal which has been estimated at nearly the total amount which is at present required for the production of all the electricity for domestic consumption. Railway electrification offers scope to electrical engineers to improve present methods, and to make available improved equipment for export. It is generally recognised that to cater for possible demands the amount of energy sent out from generating stations will double in ten years or less, and that approximately 50 per cent. of this will be for domestic purposes. At present over 30 million tons of coal are being used at generating stations, so that on this basis 60 million tons annually will be required by 1960. The raising and transporting of this extra coal presents in itself a major problem.

The invention of a means of storing electricity in a light-weight accumulator, which can be charged if necessary at a high rate in a short period, is overdue. Such a device could go a long way towards levelling out the load curve, and could be used extensively in transport to save imported fuel. The recent development of new liquids as heating media for high-temperature operation up to 600 deg. F. without pressure seems to offer a partial solution to storing electrical energy in the form of heat during periods of low demand. Research is proceeding along these lines, but there is ample opportunity for the electrical engineer to co-operate with chemists, physicists and coal-utilisation and mechanical engineers, in an endeavour to store electrical energy for use in industry, commerce and the home.

About one-third of the coal consumed in Great Britain is used directly or indirectly for domestic purposes, principally for space heating, hot-water supply and cooking. Few things could be of more help in liberating women from household drudgery, reducing the electrical industry's peak problem, and increasing the wealth and health of the nation, than a wholesale reduction in the labour and transport involved in the use of this heat. A fundamental difficulty is, of course, immediately apparent in that many of the buildings in this country were designed for the use of low-priced coal as a heating medium. This is no longer available and probably never will be again. Property owners and occupiers should therefore be encouraged to make greater use of thermal insulation and to install modern efficient apparatus, whether their selection is ultimately electricity, gas or solid fuel.

It is frequently stated that the domestic and commercial heating load is the main cause of our peak problem. It is doubtful, however, if the user of the portable electric fire realises that when it is used during peak-load periods the cost in capital charges to the electricity authority for a 2-kW model is over 200*l*. It is difficult to suggest what can be done with the millions of existing fires, except to appeal to the users—as has already been done—to "keep off the peak." Considering the solution that has been found for low-temperature problems by the use of dry ice, it is suggested that the solution to the electrical space-heating problem does not lie in restriction by load limiting or other devices, but in the development of a heating medium which can be used with low-wattage elements as a base load in conjunction or alternating with modern efficient slow-combustion anthracite stoves. Investigation in the use of one or other of the new chemicals appears worth-while. Before this could be used for domestic purposes, however, many problems would have to be solved, and suitable apparatus for cooking, space heating, water heating, etc., developed.

During the past 50 years spectacular progress has been made in improving the thermal efficiency of generating plant, and the average for the country is now about 21·5 per cent., while the best power stations reach 28 to 29 per cent. Sir Henry Self recently pointed out that an increase of only 0·1 per cent. in thermal efficiency represents a reduction in coal consumption of roughly 140,000 tons, or an annual saving of some 350,000*l*. Such economies are, however, frequently dissipated after the electricity leaves the power station, either by way of excessive losses in distribution or by faulty utilisation. In 1949 the energy lost in distribution and transmission amounted to 5,211 million kWh, or 13 per cent. of the total sales to consumers. This is equivalent to the startling figure of 412 kWh per consumer. It is suggested that many economies could be effected in order to save our national resources and support the economies made in generation.

It is probable that most of the new consumers in the future will be isolated and in rural areas, requiring high-voltage extensions and small single-phase transformers. From the point of view of iron losses it is desirable that the smallest unit suitable for the job should be selected. Losses can be saved by serving as many consumers as possible from one transformer; loading transformers for individual consumers so as to take advantage of the overload rating of the unit; and endeavouring to improve the load factor and keep the maximum demand to a minimum.

It is regrettable that shortage of capital is preventing a more rapid expansion of electrical facilities into rural areas. The economic problem involved in giving public electricity supply to isolated premises is very considerable. Even if the would-be consumer pays for the entire cost of the extension, the scheme can still be uneconomic because of the high rate of depreciation and the losses on a transformer serving only one consumer. In the smallest size of transformer normally used the iron losses amount to the figure of 630 kWh per annum. Many rural dwellers scarcely use this amount in a year, so that for every unit used two have to be supplied to the transformer. In such circumstances it may be desirable to install small wind-power generators or engine-driven sets, coupled with improved methods of storing electricity.

Electricity used by agriculture in this country at present amounts only to about 1 per cent. of the total output. Although progress has been made in recent years in the design and development of specia electrical apparatus for the use of farmers—for example, the small hammer-mill, the low-loaded sterilising unit and the milk cooler—much has still to be done, and the problem of comprehensive rural electrification on progressive lines offers great opportunities to those interested. Electricity can contribute greatly to increased agricultural production and efficiency, and will indirectly stimulate an expanding market for a wide range of machinery, goods and services. It should be remembered that 1 kWh of electricity, properly applied, can replace ten hours of human energy. In terms of money, therefore, one pennyworth of electricity can give results equal to something between 20 and 30 shillings-worth of human effort.

* Chairman's address to the Utilization Section of the Institution of Electrical Engineers on Thursday, October 25. Abridged.

MOBILE TELEVISION STATION FOR CANADA.

The accompanying illustration shows the interior of one of the two outside television broadcasting vehicles which have been designed and equipped by Marconi's Wireless Telegraph Company, Limited, Chelmsford, for use on the Canadian television service. From left to right, the units shown in the illustration are as follows: the power-regulating unit, the broadcast distribution box, three camera control monitors and a master control monitor. Above the monitors are sound and vision receivers. The producers' desk is on the extreme right. The three cameras, with which the vehicle is equipped, are carried in fitted cupboards, as are the electronic view-finders and sets of lenses. The cable is on reels at the rear of the vehicle and the receiving aerial is mounted on outriggers. The facilities provided allow all the members of the crew to hear both programmes and instructions through their earphones, while the camera operators can speak to the camera control personnel and to the producer, and the producer and technical director to the crew. The equipment can be operated either from the mains or from a generator on a trailer, and a micro-wave sound channel can be used to replace the telephone lines, thus eliminating all external connections. The vision micro-wave link is permanently stowed on the roof, access to it being obtained by an internal ladder for the erection and orientation of the parabola. The vehicle can be lighted either from the mains or from a battery, the latter being provided with a mains-operated charger. Heating can be effected by oil when the vehicle is parked away from the mains.

With these vehicles it will be possible to drive from and to any place within micro-wave range of the main station and be "on the air" within 45 minutes. The vehicle is driven by a 105-h.p. Chevrolet "Roadmaster" engine, but the body work, fittings and equipment are British made. An interesting point is that there are special front and rear exterior lights to conform with the Canadian traffic laws and a swivel working light at the rear.

TRADE PUBLICATIONS.

Terminal Boxes for Auxiliary Circuits.—Details of the boxes manufactured by them for terminating, jointing and sub-dividing telephone circuits and auxiliary wiring generally, are given in a pamphlet issued by British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2.

High-Duty Refractories.—The Morgan M.R.1 "super-duty" refractory, containing from 95 to 97 per cent. of silica and alumina together and stated to give a brick which remains rigid at a temperature of 1,600 deg. C., is described in a folder issued by the Morgan Crucible Co., Ltd., Battersea Church-road, London, S.W.11.

Spray-Painting Equipment.—B.E.N. Patents Ltd., High Wycombe, Buckinghamshire, have sent us their catalogue CB 94 dealing with the firm's spray-painting equipment. Portable and stationary air-compressor units for spray-painting purposes, spray guns, containers and other accessories are described and illustrated.

Dust Control in Foundries.—Air Control Installations Ltd., Ruislip, Middlesex, have sent us a copy of their publication, No. G.513, dealing with foundry dust control. In this are set out succinct descriptions and illustrations of several types of the firm's Rotoclones. These are combined fans and dust collectors built as a single unit.

Television Cables.—One criterion for the successful operation of a television receiver is a properly-designed aerial arrangement. Particulars of the three types of the downlead cables manufactured by them for this purpose are given in a pamphlet which has been issued by British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2.

Creep-Resisting Alloys.—A publication, entitled "The Nimonic Alloys," issued by Henry Wiggin & Co., Ltd., Wiggin-street, Birmingham, 16, presents in convenient form much information concerning the physical and mechanical properties of these nickel-chromium alloys, at various temperatures, and also contains data on typical applications and other matters of interest.

High-Vacuum Equipment.—W. Edwards & Co. (London), Ltd., Worsley Bridge-road, London, S.E.26, have sent us a 16-page booklet, Digest 1/50, which gives details of high-vacuum equipment manufactured by them for use in industry, research, and educational establishments. Rotary and diffusion pumps, vacuum pipe-line outfits, water-jet pumps, high-vacuum gauges, vacuum coating-equipment, freeze-drying and vacuum sublimation plant, and various accessories, are among the items mentioned.

MOBILE TELEVISION STATION.

MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, CHELMSFORD.

HIGH-VOLTAGE RESEARCH AT THE NATIONAL PHYSICAL LABORATORY.*

By R. Davis, M.Sc.

High-voltage research is mainly concerned with the property of electric strength. This property is possessed by dielectrics, which occur in the solid, liquid or gaseous state. Data are required concerning the electric strength of the dielectric itself, and the insulation strength of complete equipments which may incorporate one or more dielectrics in one or more physical states in the insulation path; it is this latter requirement which usually calls for the highest voltages. Imperfections in dielectrics give rise to energy loss and to internal discharges which can lead to gradual loss of electric strength; these properties are of interest in the high-voltage laboratory. Experience gained in the utilisation of dielectrics to withstand high voltages has enabled some laboratories to make useful contributions to the design of specialised equipment, such as Van der Graaf generators and electron microscopes. Since lightning provides the main test of electric strength, workers have been stimulated to study this phenomenon, and to collect and analyse statistics relating to it.

With the high-voltage test transformer, over-voltages can be applied to electrical equipment with the aim of providing guidance concerning its performance over long periods and under adverse weather conditions. Hitherto, two types of transformer, the oil-filled and the air-insulated, have been used. The advantage claimed for the air type is that large numbers of voltage tappings are simultaneously available, but in practice little use has been made of this feature. The disadvantages of poor regulation and large space requirements are likely to render the type obsolete. The maximum voltage usually provided is 1,000 kV (root mean square), and it is doubtful whether there is likely to be any demand for voltages in excess of this because of the development of surge testing. For the highest system voltages contemplated, this upper limit should be adequate for testing equipment such as overhead-line insulation, which requires a large safety factor to combat the effects of inclement weather and atmospheric pollution.

For high-voltage power-frequency measurements the most valuable tool is the capacitor. It can be used as a standard of phase angle for dielectric-loss measurements, for peak-voltage measurements in conjunction with a rectifier and measuring instrument, and for root mean square voltage measurements as the high-voltage arm of a divider. Three types have been used, incorporating air at atmospheric pressure, compressed nitrogen or carbon dioxide, and paper in oil, respectively as dielectric. Parallel plates or uniform-field electrodes are used with air dielectric. For voltages of 1,000 kV, large electrodes with considerable clearances are required. The electric field between the high-voltage electrode and external objects is likely to vary with atmospheric conditions and corona. These may lead to variability in the flashover values to external objects and in the working capacitance. The compressed-gas capacitor with a completely shielded electrode-system has many attractive features, which include reasonable size and independence of capacitance on external conditions, but it is at present only available for voltages up to 500 kV. Standard capacitors with a paper-in-oil dielectric are in common use for surge-voltage measurements, but for power-frequency measurements they appear to be uncommon. Their disadvantages, apart from unsuitability as a standard of phase angle, are possible changes of capacitance with changing stray capacitance, temperature, voltage and time.

The accuracy of high-voltage measurements depends ultimately on a comparison with a standard cell, so that a chain of processes is involved, including the verification of the voltage divider, the measuring instrument and the alternating/direct-current comparison. It is desirable, therefore, to have facilities for direct high-voltage absolute measurements, and for this purpose the attracted-disc electrometer of Kelvin is admirably suited. The attractive force between two electrodes in an electric field is proportional to the square of the field strength, and, by balancing this force against weights, an absolute method of measuring voltage in a uniform field is available. An absolute voltmeter for 100 kV with atmospheric air as dielectric has been constructed at the Bureau of Standards, the maximum field strength of which is about 5 kV per centimetre. By the use of higher fields a smaller instrument results in which a greater force can be obtained. This permits of more robust control; it is also easier to secure a uniform field. At the National Physical Laboratory a project is well advanced for constructing a voltmeter to operate in compressed nitrogen at 200 lb. per square inch (gauge pressure), with an anticipated working stress of 100 kV per centimetre. Similar stresses can be achieved with a high vacuum as dielectric, and a vacuum construction is being undertaken elsewhere.

The most severe test of electric strength imposed on equipment is provided by the transient voltages reaching overhead lines through the agency of lightning. Most of the research effort of the High-Voltage Laboratory in the last decade has been directed to studying the behaviour of dielectrics and equipment under voltages of similar form to those resulting from lightning. The surge generator for supplying these voltages is now a well-engineered piece of equipment, which is finding a place in all high-voltage laboratories. Briefly its characteristics can be specified by the stored energy and the open-circuit voltage. Desirable features are small internal inductance in the capacitor bank, and facilities for utilising the total stored energy at different voltages by simple series-paralleling arrangements.

* Chairman's Address to the Supply Section of the Institution of Electrical Engineers, delivered on Wednesday, October 31, 1951. Abridged.

To accommodate generators for two or more million volts, high buildings are required so that the voltage delivered per unit height becomes an important factor in the cost of an installation. One of the greatest simplifications in surge-testing technique achieved in recent years has been the introduction of modern cathode-ray tubes and lenses which permit the use of single-sweep recordings having a duration of a fraction of a microsecond. The time appears to be past when a laboratory fitted only with a surge generator and sphere-gaps for measuring purposes can be regarded as equipped for surge testing. Selected oscillograph tubes can give a performance in every way comparable with that obtained with the continuously-pumped high-voltage oscillograph.

For quantitative measurements there are, associated with the oscillograph, voltage dividers and, for the comparatively rare occasions when deflectional sensitivity is lacking, amplifiers. The main features of the different arrangements of dividers for use with standard waves of shape 1/50 microseconds have been established, and agreement in amplitude to better than 2 per cent. is readily obtained with resistor, capacitor, and resistor-capacitor dividers. The effects of small residuals in the arms of the divider on the response to rapidly changing phenomena are now being examined at the National Physical Laboratory. One effect is to introduce disturbances into the wave during the first microsecond or so, and the distortion in wave-shape can appreciably affect the amplitude recorded when breakdown takes place on the front of a steep wave. In addition to the recording of high-voltage phenomena with the aid of dividers, the problem has arisen of recording high-speed phenomena of low voltage amplitude. This requirement is being met by using oscillographs with post-deflection acceleration, and distributed amplifiers which can deal with rise times in the milli-microsecond range.

In the realms of electricity supply and the manufacturing industry, the merits of high-voltage direct-current transmission are being actively considered. It behoves the High-Voltage Laboratory to take cognisance of such developments, and to be ready to provide answers to some of the questions likely to be posed. These include the maximum working stress with direct-current, and the problem of pollution. The availability of a high-voltage direct-current supply would enable studies to be made of the breakdown of gases with high voltages as distinct from high stresses, and the study could be extended to compressed gases, complex gases, and high vacuum. At the National Physical Laboratory plans are well advanced for the provision of a metal rectifier for use in a simple half-wave rectifying circuit and utilising the high-voltage transformers to provide a direct-current at 1,000 kV with an output of the order of 30 milliamperes. The rectifiers will be housed in ten oil-filled insulating cylinders, and the cylinders will be supported in pairs by strings of insulators from the roof of the laboratory. The cylinders will hang at an angle to the vertical, the ends of each pair being drawn apart at the bottom, so that in elevation the system of cylinders will form a zigzag pattern. By reversing the direction of slope of the cylinders to the vertical the polarity will be readily reversible. The proposed generator is highly experimental, and experiments will be required to determine the effect of series and parallel capacitance on the voltage distribution throughout the rectifier and the output to be obtained from the use of rectifier discs of a given size.

It has been established experimentally that many dielectrics have, for a considerable range of thickness and time of application, an intrinsic electric strength; in a uniform field there is a maximum stress which can be applied without loss of insulating properties. Many of the earlier experiments gave lower values than those now generally accepted, and these could be explained by a failure to determine the breakdown stress from the voltage and the geometry of the electrode system—a failure often due to the occurrence of discharge in the medium in which the dielectric was immersed. The experimental conditions for satisfactory measurements are now well established; the use of surge voltages ensures the avoidance of complications associated with time of stressing. Some typical approximate values of intrinsic electric strength are 14,000 kV per centimetre for mica, 2,000 kV per centimetre for glass and oil-impregnated paper (if a composite material can be regarded as having such a property) and 500 kV per centimetre for porcelain.

There are a number of obstacles in the way of the full utilisation of the electric strength of dielectrics to provide high-voltage equipment of small bulk. It is not practicable, for example, to insulate an electrode at a voltage of 1,000 kV from an earthed electrode by a 1-cm. slab of dielectric of intrinsic electric strength of, say, 1,100 kV per centimetre to give a 10 per cent. margin of safety. Among the factors are the difficulty of securing uniform fields with practical electrodes, and the unavoidable presence in the field of other dielectrics of different strength and different permitivity. In equipment such as transformers the insulation path between high- and low-voltage electrodes is usually made up of solid and liquid dielectrics in series, and for high voltages the path must be large and the whole equipment somewhat bulky. In cables, on the other hand, the field distribution is nearly ideal and a single (composite) dielectric is employed. In consequence, the path between electrodes can be short and the cable can be subjected to a stress approaching the breakdown value of the dielectric.

With the ultimate aim of securing a better utilisation of the dielectrics in the insulation path of transformers, the National Physical Laboratory has undertaken, on behalf of the British Electrical and Allied Industries Research Association, an investigation into the surge breakdown characteristics of liquid and solid dielectrics in series. The materials at present being studied are pressboard, resin-bonded paper, paper-covered conductors and transformer oil. The immediate aim of the work is to arrive at generalisations concerning the performance of typical combinations which may be of use to the designer. The puncture voltage of single sheets of the solid dielectric with different electrode arrangements is being observed to determine the effect of barrier thickness and the significance of electrode shape, and similar measurements are being made on series combinations involving different numbers of solid and liquid layers. In examining the behaviour of covered conductors immersed in oil, the variables are conductor size and shape, thickness of paper covering, and the type of lapping of the paper. For all this work an experimental impregnating plant is available for investigating different impregnating procedures.

The electrical properties of gases, in particular of air, are of considerable practical interest to the electrical engineer. Insulator strings, bushing insulators, cable sealing-ends, etc., have an air path between the electrodes which for satisfactory working must withstand the voltages applied between the electrodes. The provision of data on flashover characteristics is a straightforward operation with the measuring techniques already described. Other and more fundamental knowledge of gaseous discharge phenomena is required for an understanding of corona phenomena, the mechanism of dielectric failure by internal discharges, and the whole range of gaseous discharge devices. The corona discharge is a special aspect of the general phenomenon of gas discharge; it is associated with divergent electric fields, and the breakdown is restricted to a part of the field space. It is of interest for two main reasons, first for the corona losses which occur on overhead lines, and secondly for the attenuation it produces in travelling waves on overhead lines. Corona losses on supply lines become a factor of greater importance with each upward step in the transmitting voltage, and the research laboratories of the British Electricity Authority are studying this problem in the field. Investigation has also been made of the corona attenuation of travelling waves on overhead lines, and the National Physical Laboratory are making a study of the corona discharge associated with surge voltages as a contribution to the study of the gas discharge and to aid in the interpretation of corona field studies.

A corona discharge produces light, causes current to flow in an external circuit and abstracts energy from the voltage source. All three of these manifestations require investigation, but up to the present efforts have been restricted to the current and the energy. For the first experiment a point-sphere electrode system was used with the sphere at high voltage, and the current was derived from the voltage drop across a resistor placed between the point electrode and earth. With surge voltages of sufficient amplitude a corona current was recorded which lasted about 0·5 microsecond and had a very steep front. This shape was little affected by the waveshape or amplitude of the applied voltage. Because of the times involved there can be little doubt that the current was due almost entirely to electron movement and was the outcome of one or more avalanches. The advantages of a point-sphere or point-plane electrode system for corona studies are that the current can be directly recorded and that the location of the discharge region is known, but the disadvantage for quantitative study is the difficulty in calculating the applied field.

Experiments were also made with an electrode system of concentric cylinders where the applied field was radial. Here the corona current could not be recorded directly because it was masked by the capacitance current. The charge-flow in the circuit was derived from the voltage across a capacitor placed between the low-voltage electrode and earth; this voltage was applied to the Y-plates of an oscillograph, and a fraction of the electrode voltage to the X-plates. From these charge/voltage curves, the corona current and the energy dissipated by the corona discharge were derived. If W is the energy dissipated and v and i the applied voltage and the current at time t, then

$$W = \int v\,i\,dt = \int v\,dq,$$

which is the area bounded by the charge/voltage curve and the charge axis. To derive the corona current, the charge Cv due to capacitance current is subtracted from the observed charge to give the charge q due to corona, and the differential $\frac{dq}{dv}$ multiplied by the known $\frac{dv}{dt}$ gives the corona current.

The corona-current pulse with concentric cylindrical electrodes consists of an initial high-amplitude short-duration portion, corresponding presumably to electron movement, followed by a relatively long-duration low-amplitude portion, which passes through zero while the applied field is still appreciable and remains reversed for a period before falling to zero. This long-duration low-amplitude portion is to be attributed to ionic movement; the reversal of sign of the current suggests that space charge has considerably modified the field. It has been possible with relatively crude assumptions to provide an explanation for the shape of the current wave in terms of electron and ionic mobilities. The experiments to date suggest that with radial-field electrodes the shape of the corona-current wave should depend on voltage amplitude and wave-shape, and that the direct corona current could be derived from surge corona measurements. These questions, the effect of polarity, and the information to be derived from corona light measurements are being or will be examined.

Recent work has confirmed that the surge electric strength of cables with impregnated-paper dielectric is about 1,000 kV per centimetre. With positive polarity the strength is between 5 and 10 per cent. higher than with negative. The strength is also affected slightly by conductor size; the puncture stress for a cable with a 0·5 sq. in. conductor is some 7 per cent. lower than for a 0·15-sq. in. conductor. This value is based on the puncture voltage and the assumption of a smooth inner conductor, but the trend is maintained if allowance is made for the effect of stranding on the maximum stress. In cables proper as distinct from joints and sealing ends, the effect of polarity reversals is small. In cable joints, where there is an appreciable amount of hand-applied paper, and where, in general, there is a component of stress along the surface of the paper laminæ, Brazier claims that there is a significant reduction in puncture voltage effected by polarity reversals. This conclusion was based on few observations and requires further investigation to establish the magnitude of the effect. No evidence for a fatigue effect in cables had been obtained. If it could be established that, with joints and sealing ends also, the effect of repeated surges of amplitude a few per cent. below the puncture value is small, there would be a good case for providing cable lengths on exposed systems with voltage-limiting protective devices.

Joints and sealing ends present the most difficult design problems in cable installations. The design usually involves a departure from the simple radial field existing in the cable, with the consequent introduction of a longitudinal stress. The strength of the dielectric along the laminæ is approximately one-fiftieth of that through them, so, ideally, the joints and sealing ends should be designed so that the longitudinal component of stress is negligible. This means, in the case of the joint, that the cross-section should be the same as that of the cable, and the paper tapes in the joint indistinguishable from those in the body of the cable. With sealing ends, the required condition is probably best achieved with a construction similar to that used for condenser bushings. Polythene, with its low power factor, has been widely used as the dielectric for radio-frequency cables, and its application to power-frequency cables is being considered. Its intrinsic electric strength is about 7,000 kV per centimetre, i.e., 3½ times that of cable-paper dielectric, and direct breakdown voltages corresponding to a stress of 3,000 kV per centimetre have been measured on finished cable. The life of cables at a given voltage stress, however, is very dependent on the discharge characteristics and operating frequency. It is doubtful at present whether polythene cables can be operated at as high stresses as pressure cables and give long life. The discharges, which so seriously affect working life, occur in gaseous inclusions in the dielectric or at the conductor surface which are formed during manufacture, partly because of the large coefficient of expansion of polythene. Softening of polythene occurs around 80 deg. C. and this limits the working temperature of the cable conductor.

Surge tests of transformers, although of fairly recent origin, are being increasingly applied, but there are still outstanding questions of technique and interpretation. In spite of this, their superiority over power-frequency tests in indicating shortcomings in design and manufacture, which would limit life in service, are becoming generally accepted. Surge tests have been devised to prove the suitability of the insulation of the transformer to withstand the most severe electrical stressing to which the equipment is likely to be subjected in service.

This insulation consists of the major, between winding and tank and core, and the minor, between turns and coils of the winding. Detection of failure during tests of the major insulation usually presents no difficulties; in addition to the evidence provided by oscillograms, such failure is likely to be accompanied by noise in the transformer and the formation of smoke bubbles, which can be observed if the tank lid is removed. Faults in minor insulation are more difficult to detect, the only evidence usually being that provided by oscillograms. In chopped-wave tests, which are designed to provide the most severe test of the minor insulation, oscillograms may provide no information of failure unless the fault is made apparent by the subsequent application of a full wave. The basis of the oscillographic method of fault detection is the change in some recorded parameter when the test voltage is applied from that recorded with an applied voltage of lower amplitude. The parameters available are the applied voltage, the current at the low-voltage end of the winding under test, and the voltage developed across a winding coupled to the test winding, and it is desirable to record two of these parameters simultaneously. The applied voltage is usually required in order to verify compliance with the test conditions. In using the record for fault detection, care must be taken to ensure that irrelevant distortions, introduced by corona discharges in the external circuit, are avoided or discounted, and to ensure that the measuring circuit is made as responsive as practicable to small changes in the surge impedance of the test winding caused by local breakdown of minor insulation. Of the two remaining sources of information, the record of current at the end of the winding is the more easily and generally available. Two schools of thought exist concerning the best way of recording the current for fault detection. One school believes that slow variations are introduced by minor insulation faults which can be observed with relatively insensitive equipment, while the other claims that such faults introduce significant changes in the fine structure of the current wave which can be detected by sensitive equipment. The claim is also made that the fine-structure changes can be interpreted to give an indication of the location of the fault producing them. The final solution of the controversy may be provided by the current Electrical Research Association theoretical studies of transient response of transformer windings. Other difficulties in interpretation of oscillograms may result from the use of non-linear resistance material on tap-changing equipment. In spite of what has been said about the immaturity of the technique and uncertainties in interpretation, some users have sufficient confidence in methods of detection to call for surge tests on transformers immediately prior to their installation on site.

Extension of Main Runway at Manchester (Ringway) Airport.—On Tuesday, November 6, the extended main runway of Manchester (Ringway) Airport, which has been lengthened from 4,200 ft. to 5,900 ft., was officially opened by the Permanent Secretary to the Ministry of Civil Aviation, Sir Arnold Overton, K.C.B., K.C.M.G., M.C. The opening of the extension marks the first stage in the development of the airport for use by modern transport aircraft operating on scheduled services. The taxying tracks and the terminal apron are also being extended. Ringway Airport is already equipped with standard beam approach, and ground-controlled approach; the instrument-landing system will be introduced in the near future, and improved high-intensity lighting is being installed. These improvements are being carried out by the Ministry of Civil Aviation in agreement with the Manchester Corporation, the owners and managers of the airport.

The Chemistry of Cement.—An international symposium on the chemistry of cement is to be held in London next year from September 15 to 20. It is being organised jointly by the Building Research Station and the Cement and Concrete Association, and will be the third symposium on this subject. The first, organised by the Faraday Society, took place in London in 1919, and the second was held in Stockholm in 1938. Next year's symposium will be presided over by Sir Ben Lockspeiser, F.R.S., Secretary of the Department of Scientific and Industrial Research; the vice-president will be Sir Francis Meynell, R.D.I., Director of the Cement and Concrete Association. The first day's session, to be held at the Royal Institution, will be devoted to the reception of delegates and to papers of general interests. The remaining four sessions, to be held at the Royal Society of Arts, will deal with the constitution of Portland cement, the mixing, setting and hardening of cement, special cements, and the application of research. There will also be visits to cement works, the research station of the Association, the Building Research Station, etc. The address of the Cement and Concrete Association is 52, Grosvenor-gardens, London, S.W.1.

NOTES ON NEW BOOKS.

Elektrische Maschinen.

By Professor Rudolf Richter. Vol. I. Allgemeine Berechnungselemente. Die Gleichstrommaschinen. Second edition. Verlag Birkhäusen, Basle. [Price 49.40 Swiss francs in cloth, or 45.25 fr. in paper covers.]

This book is the second edition of a work by a well-known German professor of electrical engineering, which was first published in 1924. It has been reproduced from the earlier edition by a photographic process, corrections being inserted in the text where that is possible. Otherwise, they are contained in a list which is included directly after the contents. After dealing with general principles of all electrical machines and transformers, the book covers the design and performance of direct-current electrical machinery in detail. It will be found particularly useful for reference on special problems connected with the design and behaviour of this class of plant. Theory predominates and the application of actual designs is entirely omitted. The problems of commutation are naturally given an important place and the procedure that should be followed in designing a direct-current machine is set out at length. A useful feature is a complete list of the meanings of all the letters used in formulæ, together with references to the pages on which they are first introduced. There is also a long bibliography; unfortunately, the value of this is much reduced by the fact that all the references are over 25 years old.

Applied Electricity.

By Professor H. Cotton, M.B.E., D.Sc., M.I.E.E. Cleaver-Hume Press, Limited, 42a, South Audley Street, London, W.1. [Price 17s. 6d. net.]

The objects of this book, it is stated, are to provide a sound and comprehensive account of the fundamental principles upon which the edifice of electrical practice is built; and to cover adequately the most recent requirements of certain important examinations, especially that of applied electricity for Part I of the B.Sc. (Engineering) degree in the University of London. The first 100 pages are devoted to the electric circuit, magnetism, electrostatics, conduction in electrolytes and thermoelectricity. Rather less than 50 pages are then occupied with direct-current machinery and about 150 with alternating current plant, an indication, perhaps, of the relative importance of the two classes at the present time. Electronics are, however, dismissed in 20 pages and measuring instruments in nearly the same space, while a final chapter of ten pages deals with units and dimensions. Principles rather than practice are the keynote, which perhaps explains the absence of any reference to switchgear and the related problem of protection, as well as to the numerous applications of electrically-produced heat. The application of electricity to communications is entirely omitted. The treatment is inevitably concise, although the style is clear and the arguments are well illustrated, both mathematically and by numerous diagrams. The work should form a useful text-book for those for whom it is intended, but whether it will, as is claimed, provide the student in one volume with all the knowledge he requires for his particular purpose, is open to question; the painstaking student may desire to delve more deeply into a particular branch of the subject. The book would be improved, therefore, by the inclusion of a bibliography; and the index, too, is so brief as not to be of any great utility.

The Great Western Railway: An Appreciation.

By O. S. Nock, B.Sc. (Eng.), A.M.I.C.E., M.I.Mech.E. W. Heffer and Sons, Limited, Cambridge, England. [Price 18s. net.]

Those whose interest in the Great Western Railway has been aroused or re-stimulated by reading Mr. A. S. Quartermaine's presidential address to the Institution of Civil Engineers, our reprint of which is concluded in the present issue, will find in Mr. Nock's latest book plenty of material for study. It does not compete in any way with the classic work of E. T. MacDermot, to which all students of G.W.R. history must turn sooner or later—preferably sooner; but it supplements MacDermot's book in several valuable particulars and of course brings the story down to a considerably later date. Mr. Nock writes skilfully as well as accurately, and, without descending into hyperbole, can be colourful in his choice of words when the occasion requires—as, for example in his brief description of the testing of a series of bridges by running over them, at high speed, two pairs of engines of the "King", class. The style is frankly "popular" and here and there are a few traces of hasty writing (as on page 81, where the present and past tenses are rather curiously mixed), but we should suppose that few readers, not actually employed on the Great Western Railway, could peruse it without learning something of that unique system.

LAUNCHES AND TRIAL TRIPS.

M.S. "Aureol."—Twin-screw liner, to carry a total of 353 first-class and cabin-class passengers and cargo, built and engined by Alexander Stephen & Sons, Ltd., Glasgow, for the United Kingdom/West Coast of Africa service of Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 537 ft. by 70 ft. by 36 ft. 6 in.; deadweight capacity, 7,400 tons on a draught of 25 ft. The two Stephen-Doxford four-cylinder opposed-piston oil engines together develop 9,400 b.h.p. at 118 r.p.m., giving a speed on service of 16 knots. Trial trip, October 11.

M.S. "Malekula."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for Burns, Philp & Co., Ltd., Sydney. Seventh vessel constructed for these owners. Main dimensions: 336 ft. by 47 ft. by 27 ft. 6 in. to shelter deck; gross tonnage, 3,750. Burmeister & Wain-Harland & Wolff-Kincaid eight-cylinder trunk-piston oil engine, developing 2,200 b.h.p. at 150 r.p.m., constructed by John G. Kincaid & Co., Ltd., Greenock. Launch, October 22.

M.S. "Arbitrator."—Single-screw cargo vessel, built and engined by William Doxford & Sons, Ltd., Sunderland, for Thos. and Jas. Harrison, Ltd., Liverpool. Last vessel of an order for four. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 37 ft. 8 in.; deadweight capacity, 10,000 tons on a draught of 26 ft. 6 in. Doxford four-cylinder opposed-piston oil engine, to develop 3,300 b.h.p. at 108 r.p.m. Speed in service, about 12½ knots. Delivered, October 29.

M.S. "Caltex Tanganyika."—Single-screw oil tanker, built and engined by William Doxford & Sons, Ltd., Sunderland, for the Overseas Tankship (U.K.), Ltd., London, W.1. Second vessel of an order for four. Main dimensions: 490 ft. overall by 61 ft. 9 in. by 36 ft. 3 in.; deadweight capacity, about 12,000 tons on a draught of 28 ft. 2¼ in. Doxford five-cylinder opposed-piston balanced oil engine, developing 5,150 b.h.p. at 108 r.p.m. Speed, 13¾ knots, fully loaded. Launch, October 31.

S.S. "Velletia."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Anglo-Saxon Petroleum Co., Ltd., London, E.C.3. Main dimensions: 610 ft. between perpendiculars by 80 ft. 6 in. by 45 ft. to upper deck; deadweight capacity, about 28,000 tons on a draught of 34 ft.; cargo-tank capacity, about 26,000 tons; gross tonnage, about 18,600. Impulse-reaction steam turbines with double-reduction double-helical gearing, to develop a maximum of 13,000 s.h.p. at 106 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne, and three oil-fired Babcock and Wilcox boilers. Service speed, fully loaded, about 15 knots. Launch, October 31.

BOOKS RECEIVED.

Proceedings of the Third British Electrical Power Convention. Brighton, 18th to 22nd June, 1951. Offices of the Convention, 16, Stratford-place, London, W.1.

All-Purpose Diesels. By J. Malcolm Robson. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 50s. net.]

Werkstattbücher. No. 40. *Das Sägen der Metalle.* By Dipl.-Ing. Joh. Hollaender. Second revised edition. [Price 3.60 D.M.] No. 54. *Der elektrische Antrieb von Werkzeugmaschinen.* By Dipl.-Ing. H. Birett. Second revised edition. [Price 3.60 D.M.] Springer-Verlag, Reichpietschufer 20, Berlin W.35, Germany.

Department of Scientific and Industrial Research. Forest Products Research. Hardwoods for Building and General Purposes. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 3d. net.]

Structural Theory and Design. By J. McHardy Young. Vol. II. Crosby, Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 25s.]

Building and Civil Engineering Plant: Its Purchase, Application and Operation. By Spence Geddes. Crosby, Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 30s.]

Productivity Report. Saving Scarce Materials. Report of a Specialist Team which visited the United States of America in June and July, 1951. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 2s., post free.]

Strength of Materials. By Professor Gerner A. Olsen. George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.1. [Price 32s. 6d. net.]

Sydney County Council: Annual Report of the General Manager for the Year 1950. Offices of the Council, 457-479, George-street, Sydney, Australia.

Practical Mathematics. Vol. I. By Louis Toft and A. D. D. McKay. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 20s. net.]

Facts from Figures. By M. J. Moroney. Penguin Books, Harmondsworth, Middlesex. [Price 5s.]