ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA,

INCORPORATING THE FOUNDRY TRADES' EXHIBITION.

(*Continued from page* 265.)

WE resume below our description of some prominent exhibits at the Engineering, Marine and Welding Exhibition. General views of the Grand Hall and National Hall appear on page 304.

Among the exhibits representative of the work at the various establishments of the Department of Scientific and Industrial Research is a model which demonstrates the operation and control of plant for the recovery of ammonium sulphate and sulphur from power-station flue gases. This plant was developed at the Fuel Research Station, East Greenwich, where an installation capable of dealing with 25,000 cub. ft. of gas per hour is now in operation. Those power stations which, hitherto, have washed their flue gases, have employed a method which yields calcium sulphate as a solution in water or as a sludge. As this product has practically no commercial value in the form in which it is obtained, it has normally been discharged into rivers or dumped in the sea. Scrubbing by the ammonia process, however, yields ammonium sulphate and sulphur, both of which are valuable products at present.

The method being used at the Fuel Research Station is the Simon-Carves process which was tried out in a pilot plant at Fulham power station before the war. A solution containing the sulphate, sulphite, bisulphite, thiosulphate and other compounds of ammonia in concentrated form is used to scrub the flue gases, and ammonia in the form of concentrated gas liquor is added to the solution at a rate depending on the absorption of sulphur dioxide. The concentrations are kept constant by running off liquor from the scrubber when necessary and replacing it by water. The liquor is filtered and heated to 200 deg. C. in an autoclave with a small amount of sulphuric acid and, on decomposing, yields ammonium sulphate and a small amount of sulphur. Other exhibits shown by the Fuel Research Station include a one-third scale model of a vortex combustion chamber for burning pulverised coal in open-cycle gas turbines. This model demonstrates the operation of a full-size combustion chamber of the same kind at the Fuel Research Station. A multi-stage compressor with an output pressure of 1,000 atmospheres, and smoke-eliminating doors for Lancashire boilers, are also on view.

Machines and equipment for the testing of foundry moulding sands are shown on the stand of Ridsdale and Company, Limited, 234, Marton-road, Middlesbrough. An interesting item is a new design of the Ridsdale-Dietert moisture "teller" for the speedy and accurate determination of moisture in foundry sands. It is a cylindrical piece of apparatus arranged for standing on a bench, the height being 20 in., the diameter 13 in. and the weight 19 lb. It consists of a heating element, a blower, a drying pan, and an outer insulated housing. The blower forces air over an electrically-heated resistance coil and down through the sample of sand contained in the drying pan, which has a finely-woven wire-gauze base. The temperature of the drying-air stream is controlled by a thermostat, and an automatic timing device is incorporated for the purpose of switching off the current after a pre-arranged period of time has elapsed. A moisture determination is carried out by weighing a 50-gramme sample of sand and spreading it in a thin layer over the drying pan. The pan is then placed in the apparatus and the drying hot-air draught switched on. The subsequent re-weighing of the drying pan shows the loss in weight, and the percentage moisture is quickly ascertained. The average drying time for a green moulding sand, it is stated, is from 2 to 3 minutes, but, naturally, the time is dependent on the amount of moisture present and the clay content. Usually up to 8 per cent. of moisture can be recovered in 2 minutes.

A wide range of navigational and other equipment is being displayed by Messrs. W. F. Stanley and Company, Limited, New Eltham, London, S.E.9, a large proportion of it being products of their associated company, Messrs. Heath and Company. Sextants, binnacles and compasses are included, and attention is being directed specially to a projector binnacle of which the following are some details. The compass of the instrument, which is of the liquid type with the float incorporating the ring magnets, is housed in a 9⅜ in. diameter bowl and the card is 8 in. in diameter. The inner portion of the card carries a transparent scale which is projected optically on to a screen below the binnacle. The correctors consist of 6 in. diameter spheres with Flinders bar, heeling-error magnets and transverse magnets. Access to the heeling-error magnets may be gained without removing the compass. Sighting is by means of rifle sights on the top cap of the binnacle and a revolving prism azimuth instrument mounted on the bezel. The optical projection equipment is contained in a tubular body, which is completely sealed. All moisture having been removed previously from the container, it is impossible for moisture to condense on the surfaces of the lenses. Light from an electric lamp in the side of the binnacle is concentrated on the surface of the compass card and, by means of an optical system, an enlarged erect image of a portion of the card covering an arc of 40 deg. is produced on a ground glass screen which is viewed in an adjustable plane mirror. No part of the optical projection system is above the compass, so that the view of the card is completely unobstructed and, as all stray light is screened off, the instrument may be used by day or by night. The parent company are showing a range of other instruments including several planimeters as well as theodolites and levels.

British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, are showing a selection of the wide range of cables and conductors they manufacture for all normal requirements on board ship. These cables satisfy the relevant clauses in Lloyd's Register of Shipping Rules for Electrical Equipment and other recognised specifications. The insulation employed includes varnished cambric, impregnated paper, and vulcanised rubber with sheaths of lead alloy or polychloroprene compound. Silicone-rubber insulated cables and "flexibles," which are capable of withstanding extremes of temperature from — 50 deg. to 120 deg. C. under continuous operation, are also being exhibited, as are the tough rubber sheathed flexibles which have been produced for use with welding machines. Mention may also be made of a machine which parts wire ropes so that their ends are left in

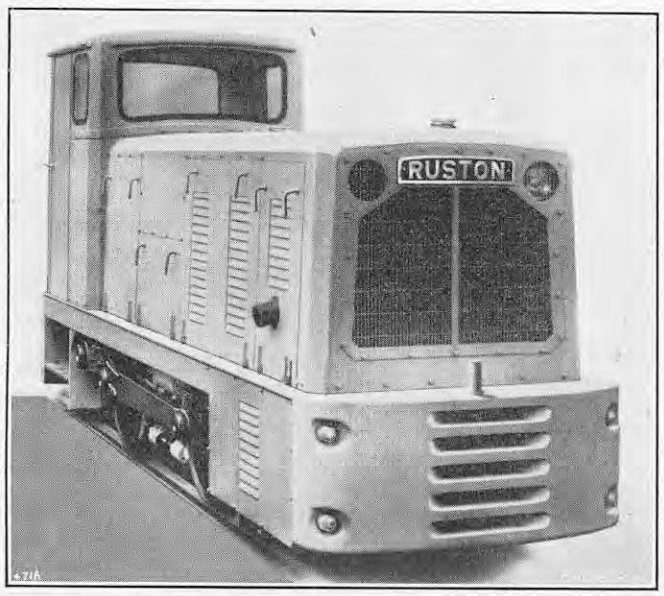

FIG. 32. 75-H.P. NARROW-GAUGE LOCOMOTIVE; RUSTON AND HORNSBY, LIMITED.

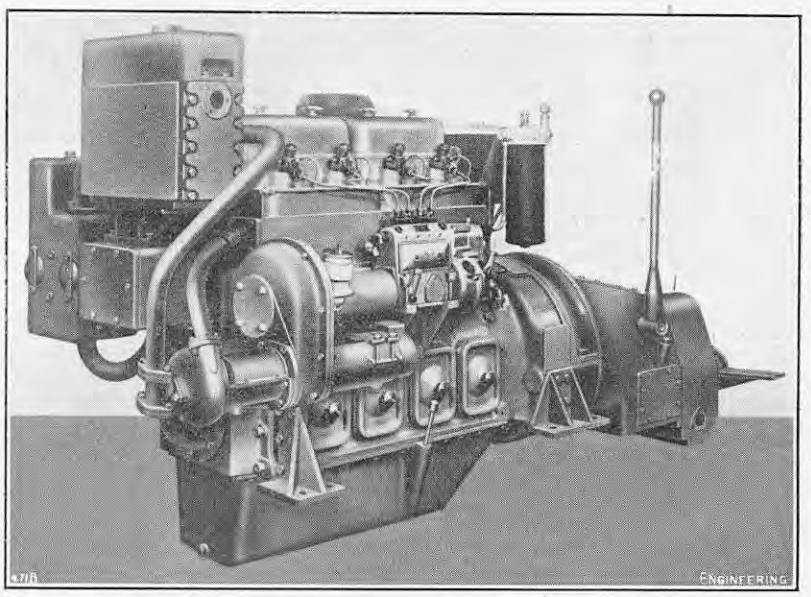

FIG. 33. MARINE OIL ENGINE; RUSTON AND HORNSBY, LIMITED.

tapered form, thus enabling them to be drawn easily through blocks or pulleys and subsequently clamped. It is claimed that by the use of this apparatus the maximum time taken to part a rope can be reduced from 20 to 2 minutes.

The exhibits on the stand of Messrs. Hoover, Limited, Perivale, Greenford, Middlesex, exemplify the range of fractional horse-power motors which they are now manufacturing. The output of these motors extends from $\frac{1}{6}$ to $\frac{1}{2}$ h.p. at 1,425 and 2,850 r.pm. for single-phase and three-phase circuits, and they can be supplied with solid, flange or resilient mountings and an automatic belt-tensioning device. The standard motors conform to British Standard Specification No. 170-1939 for drip-proof motors, but they are also available within a limited range as totally-enclosed motors. The capacitor-start four-pole motors also comply with the requirements of Appendix D of the same specification.

As regards construction, the stator laminations are die-cast into the body, which contains air ducts to ensure adequate cooling. The stator itself is spigoted on to the end frames, thus increasing the robustness. These frames are also die-cast and have been designed to incorporate the air cone and wind shield, thus eliminating the assembly of separate parts. The rotor laminations are stamped from the same high-grade steel as those of the stator; the squirrel-cage, end rings and fan are of die-cast aluminium. The shaft, which is $\frac{7}{8}$ in. in diameter, has been specially designed to ensure rigidity. It is carried in either sleeve or ball bearings.

Messrs. Gilbert Gilkes and Gordon, Limited, Kendal, are exhibiting a model of a hydro-electric power station. It consists of one of their Turgo impulse wheels, which has been designed for working under an artificial head of 90 ft. and develops up to 9 h.p. The turbine is direct-coupled to a 50-cycle alternator the speed of the set being controlled by a shaft governor. The water discharged from the turbine flows over a weir. A miniature switchboard indicates the load distribution, the voltage regulation and the frequency.

The exhibits on the stand of W. T. Henley's Telegraph Works Company, Limited, 51, Hatton-garden, London, E.C.1, include electric wires and cables for ships and shipbuilding purposes. There is a range of rubber-insulated cables with braided, fire-resisting, lead-alloy sheathed and wire-armoured finishes, paper-insulated cables for ring mains and varnished-cambric insulated cables, which are particularly suitable for installation in engine and boiler rooms. In addition, special wires and cables for radio, radar, telecommunication and signal purposes are shown, as are welding and trailing cables. Other exhibits on the stand are service and terminal boxes, a distribution board and a panel on which several electric soldering irons for industrial use are displayed.

Various examples of Fathometer echo-sounding equipment are being exhibited by the Submarine Signal Company (London), Limited, Watford, Hertfordshire. They include a navigational visual indicator with a range of 150 fathoms, which can be calibrated in feet, fathoms or metres and is capable under normal conditions of indicating 150 soundings per minute. It is provided with two concentric scales below which are "on-off" switches for the complete equipment and for controlling the gain of the amplifier. There is also a push-button "range check" switch, which is used to eliminate any ambiguities that may arise when the equipment gives readings from depths greater than 150 fathoms Mention may also be made of the graph recorder, which has been chosen by the Ministry of Transport as the standard equipment for all "Baltic" type coasters. This has a range of 0 to 120 fathoms in two 60-fathom stages and is capable of recording 82 soundings per minute under normal conditions. The recordings are made on dry electrolytic paper, so that there is, it is claimed, no risk of discoloration or shrinking. The chart is marked in 10-minute intervals and in appropriate depths and consists of a roll 50 ft. long, which moves at a speed of 6 in. per hour. The previous hour's soundings are visible without it being necessary to open the instrument case. The two positions are selected by an "on-off" switch and there are also switches for controlling the sensitivity and illuminating the instrument.

Messrs. Broom and Wade, Limited, High Wycombe, Buckinghamshire, are showing a range of pneumatic tools, and stationary and portable air compressors, including a new portable plant designated the SV220. It comprises a steel-framed trailer, with spring axles and pneumatic-tyred wheels, carrying the compressor and power unit. The V-type sleeve-valve water-cooled compressor has four cylinders arranged in two banks of two cylinders; it delivers 210 cub. ft. of free air per minute at a pressure of 100 lb. per sq. in. when running at 1,200 r.p.m. The compressor is driven by a 65-h.p. Gardner five-cylinder Diesel engine.

The Accurate Recording Instrument Company, Aric Works, Garth-road, Lower Morden, Surrey, are showing a wide range of indicating and recording vapour-pressure and liquid-expansion thermometers, a selection of pressure gauges and recorders, and an industrial thermostat which is particularly suitable for operation at low temperatures. The instrument employs liquid as the sensitive medium; standard instruments can be adjusted over a temperature band of 200 deg. F., and can be supplied to operate at temperatures between -240 deg. F. and $+500$ deg. F. They are also showing a pressurestat which can be supplied as an adjustable indicating instrument, or can be pre-set at their works to any desired value. Twin Bourdon tubes are used, one of which is used solely to indicate the pressure in the system. Among the thermometers they are showing is a liquid-expansion indicating instrument developed originally for the brewing industry with a restricted range of 50 deg. to 70 deg. F. and an accuracy within 0·1 deg. F. over this range. Over-range protection up to 212 deg. F. is provided. The instrument is also available as a recording thermometer.

Messrs. Major, Robinson and Company, Limited, Scols Works, Warwick-road South, Manchester, 16, are showing hand- and power-operated tube-bending machines. One of their most recent machines is an electrically-operated machine for handling steam, gas and hydraulic pipes, of internal diameters up to 4 in. From the $\frac{3}{4}$-h.p. motor, the drive is through V-belts to a four-speed gearbox, and thence through a worm and wormwheel drive to the main shaft of the machine. The gearbox and motor are adjustable to allow for taking up stretch in the transmission belting. The motor is controlled by a push-button starter switch coupled with a no-volt and overload release; a reversing switch provides for easy release of the tube after bending. The machine can also be supplied with special formers designed for bending more than one tube at a time.

Messrs. Stratton and Company, Limited, Alvechurch-road, West Heath, Birmingham, 31, are showing a radio receiver which has been specially designed for the use of sailors. It enables programmes on four wavebands—10 to 23·5 m., 23·1 to 51·7 m., 110 to 250 m. and 246 to 575 m.—to be obtained on either a built-in loudspeaker, a pillow-speaker or plugged-in headphones. A seven-valve superheterodyne circuit, using miniature valves, is employed with a selenium rectifier in addition. The radio frequency stage is designed to give good results with long-distance reception or where only a short aerial can be used. The push-pull output stage, in conjunction with negative feed-back and a high-efficiency speaker, gives, it is claimed, adequate volume and quality. All the plugs and sockets are completely insulated and the metal cabinet can be earthed. Owing to this earthing and the internal screening, the direct pick-up of electrical interference and interaction with other receivers on the ship are prevented. A filter unit also reduces mains-borne interference from the ship's motors to a minimum. All the components are of tropical grade. The aerial terminals are arranged to take either a double- or single-wire aerial. Precise re-setting of the tuning to any previously-logged station is possible. The weight of the set is only 32 lb., the overall width and length being $16\frac{3}{4}$ in. and 10 in., respectively, and the height $8\frac{3}{4}$ in.

The diversity of their products is emphasised by the display on the stand of Messrs. Ruston and Hornsby, Limited, Lincoln, the exhibits ranging from a complete Diesel locomotive to a small auxiliary pumping set built to meet the requirements of the Merchant Shipping (Fire Appliances) Rules (1948). The locomotive is illustrated in Fig. 32, on page 289. Basically, it is the surface version of their 10-ton mining locomotive introduced at the beginning of this year and described in ENGINEERING, vol. 171, page 396 (1951). It is driven by a Ruston and Hornsby Mark 4YEL four-cylinder compression-ignition oil engine developing 75 brake horse-power at 1,500 r.p.m., and the drive is transmitted through a Vulcan-Sinclair fluid coupling to a four-speed oil-operated gearbox, the latter being of a new design evolved entirely by the staff of Messrs. Ruston and Hornsby. It is of the fully constant-mesh type and each ratio is selected by a hydraulically-operated cone clutch, all clutches being of the same design and therefore interchangeable with each other. Oil under pressure for operating the clutches is supplied by a gear pump driven from the gearbox primary shaft and arranged in an accessible position on the front casing. The gears on the clutch shaft are, of course, in constant mesh with those on the layshaft and the drive is transmitted to the jackshaft through double-reduction gearing arranged below the layshaft in a separate detachable casing.

The flycranks are of the split type and are secured to the jack-shaft by through bolts. Steel coupling rods of the fabricated type are used and these are fitted with oil-lubricated floating bushes designed so that they can be renewed without dismantling the rods. The locomotive frame is of the plate type and is built up from heavy-section material welded together to form a single unit. Steel castings are used for the wheel centres and these are fitted with rolled-steel tyres shrunk into position. Cast steel is used also for the axleboxes, which are fitted with phosphor-bronze bearings and provided with renewable steel liners on the faces. Straight air brakes of the Westinghouse type are fitted as standard and, in addition, there is a hand-operated parking brake. In working order, the complete locomotive weighs 10 tons and the minimum recommended weight of rail is, therefore, 25 to 30 lb. per yard. The overall length, excluding the buffer beams, is 12 ft. $4\frac{1}{2}$ in., the height, measured to the top of the cab, 6 ft. $9\frac{1}{4}$ in., and the wheelbase, 4 ft. As the locomotive can be supplied for various gauges ranging from a minimum of 1 ft. $11\frac{5}{8}$ in. to a maximum of 3 ft. 6 in., the overall width varies, being 3 ft. 10 in. for the narrowest gauge and 4 ft. 10 in. for the widest. Performance varies, of course, according to the rolling resistances and the conditions of working but, assuming a resistance of 20 lb. per ton in first and second gears and 15 lb. per ton in the remainder, and a factor of adhesion of 4, the locomotive can haul on the level 270 tons in first and second gears, 203 tons in third gear and 109 tons in fourth, or top, gear. When the locomotive is ascending an incline of 1 in 50, these figures are reduced to 76 tons, 44 tons and 20 tons.

In April of this year, Messrs. Ruston and Hornsby introduced a new range of four-stroke Diesel engines designed to meet the demand for heavy-duty units having a lower power-weight ratio. The range was described in ENGINEERING, vol. 171, page 463 (1951), but since this time, units have been adapted for use on board ship. Two such units are being shown, namely, the four-cylinder propulsion engine illustrated in Fig. 33, on page 289, and the auxiliary generating set illustrated in Fig. 34, Plate XX. In general, the construction of the engine in each case follows closely that for the industrial units described previously. The crankcase and cylinder block are of monobloc construction and the cylinder bores are fitted with renewable wet-type liners. The cylinder heads are detachable, being cast in blocks of two, and each is fitted with the overhead valve gear and injectors, the valves being operated from the camshaft through push rods and rocking levers in the normal manner. An underslung crankshaft is fitted, bearings of the steel-backed copper-lead type being provided between each crank-throw. Pistons of low-expansion silicon-aluminium alloy are used and these are coupled to the crankshaft by H-section connecting rods fitted with steel-backed copper-lead big-end bearings split at an angle to facilitate withdrawal through the cylinder bores. Lubrication of all

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(*For Description, see Page* 290.)

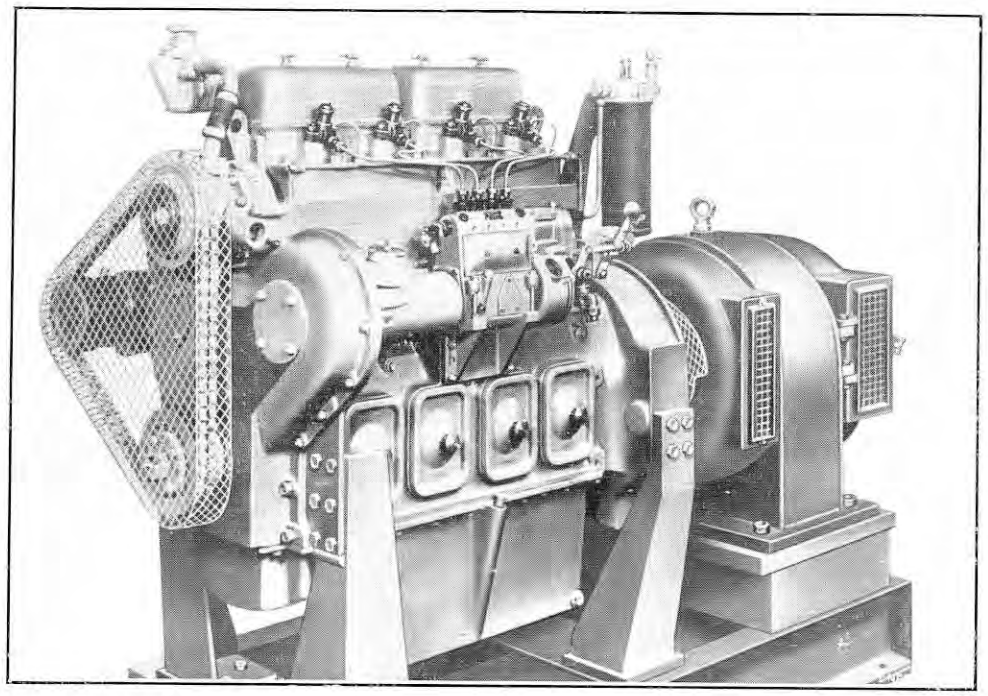

FIG. 34. MARINE AUXILIARY GENERATING SET; RUSTON AND HORNSBY, LIMITED.

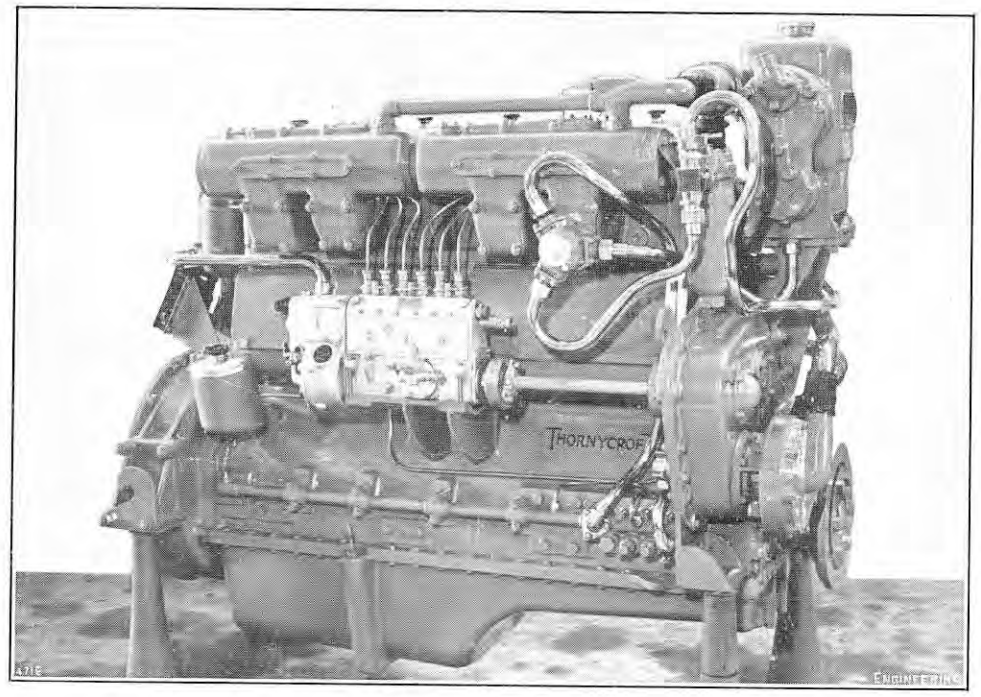

FIG. 36. 125-B.H.P. INDUSTRIAL DIESEL ENGINE; JOHN I. THORNYCROFT AND COMPANY, LIMITED.

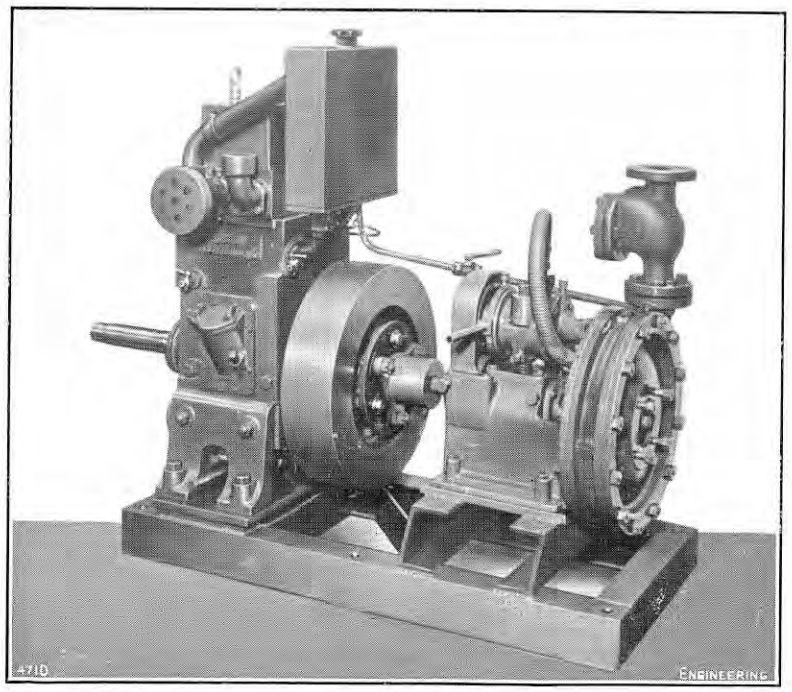

FIG. 35. MARINE FIRE PUMPING SET; RUSTON AND HORNSBY, LIMITED.

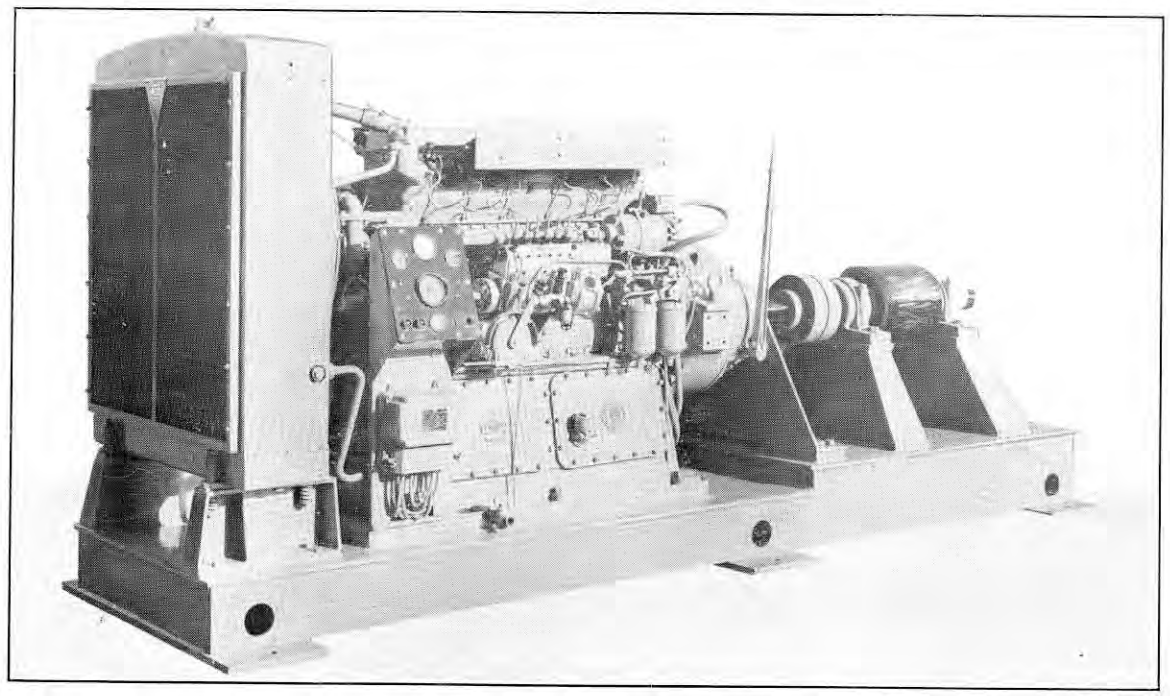

FIG. 37. A.E.C. 100-B.H.P. DIESEL ENGINE; A.C.V. SALES, LIMITED.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

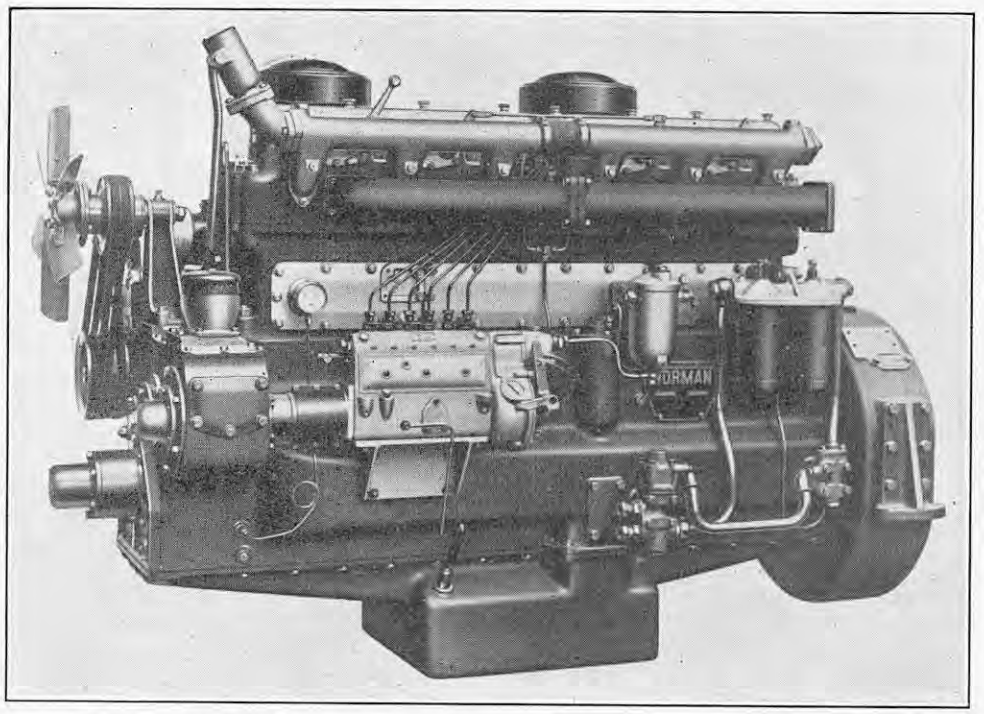

FIG. 38. 160-B.H.P. DIESEL ENGINE; W. H. DORMAN AND COMPANY, LIMITED.

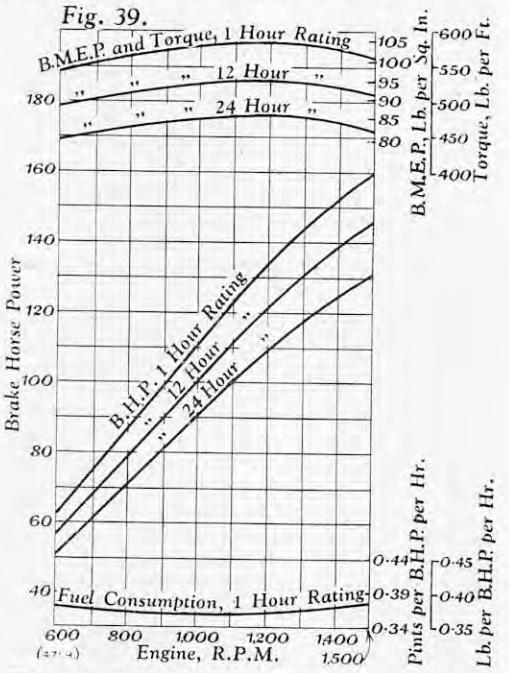

FIG. 39. PERFORMANCE CURVES FOR DORMAN DIESEL ENGINE.

moving parts except the gudgeon pins and pistons is by pressure, a gear pump being installed in the lowest part of the sump.

The propulsion unit illustrated in Fig. 33 is fitted with double-acting piston-type sea-water circulating and bilge pumps driven through suitable gearing from the forward end of the crankshaft. A self-contained fresh-water cooling system can be supplied as an alternative, the equipment including a heat exchanger and oil cooler mounted at the forward end of the engine, together with a centrifugal-type fresh-water pump; the engine illustrated is provided with this extra equipment. The propulsion unit is also fitted with a mechanically-operated reverse-reduction gear, the ahead clutch being of multi-plate design while the reverse gear is of the bevel differential type operated by a Ferodo-lined brake band. The reduction gear is of the double-helical type and the gear casing is arranged for sea-water cooling. It should, perhaps, be mentioned that the reduction gear is an optional extra, the makers recommending its use on heavier craft. The engine used to drive the generator illustrated in Fig. 34 is the same as that used for propulsive purposes, but is not fitted with the extra cooling equipment. As will be seen from the illustration, the engine and generator are mounted on a single baseplate, the whole forming a compact unit. Four-cylinder engines are illustrated in both cases, but five-cylinder and six-cylinder engines are also available for the two applications. When used for propulsion purposes the service ratings of the four, five and six-cylinder engines at 1,500 r.p.m. are 67·5 h.p., 84·5 h.p., and 100·75 h.p., respectively, and for the generator sets, 48 kW, 62 kW and 74 kW, respectively.

The emergency fire pump referred to earlier is illustrated in Fig. 35, Plate XX; as previously mentioned, it has been designed to meet the requirements of the Merchant Shipping (Fire Appliances) Rules (1948). The power unit is a standard Ruston and Hornsby IVSHZ single-cylinder Diesel engine running at 1,500 r.p.m., at which speed it develops 11 brake horse-power. It is bolted to a common baseplate of welded-steel construction and is equipped with a circulating-water tank, fuel tank and all associated piping. The pump is of the centrifugal type with a 3-in. suction branch and a 2-in. discharge branch, the output being 45 tons an hour against a head of 120 ft., 27 tons an hour against a head of 170 ft., and 22 tons an hour against a head of 180 ft. Means are incorporated in the pump to enable initial priming to be accomplished, the device being arranged for hand engagement and disengagement. The fuel tank is of sufficient capacity to ensure an uninterrupted run of from 4 to 6 hours but a larger tank can be provided if required. As will be seen from the illustration, the common baseplate is of girder construction and carries the engine, pump and all ancillary equipment, the whole making a neat and compact unit of moderate weight.

Many of the exhibits on the stand of Messrs. John I. Thornycroft and Company, Limited, Smith-square, London, S.W.1, consist of models, this, of course, being the only practical method of displaying their larger products, such as boilers, anti-smoking funnels and complete vessels. Some actual examples of their products, however, are being shown and these include their latest and largest industrial Diesel engine, namely, the type RZ6, a photograph of which is reproduced in Fig. 36, on Plate XX. This is one of a number being supplied to Messrs. Merryweather and Son, Limited, for coupling directly to centrifugal pumps. It is equally suitable, however, for other duties, such as for driving earth-moving machinery and is available also as a marine engine. As the type designation infers, there are six cylinders; these have a bore of $4\frac{3}{4}$ in. and a stroke of $6\frac{1}{2}$ in., the maximum output being 125 brake horse-power at 1,600 r.p.m. Direct injection is employed, the combustion chambers being formed in the piston crowns; the manufacturers claim that the detailed design of the combustion chambers is such that easy cold starting without recourse to heater plugs or other aids is ensured.

In general, the arrangement of the engine follows accepted practice. The crankcase is machined from a deep-section iron casting and the cylinder block, also an iron casting, is secured to the crankcase by long bolts which also serve to hold the main-bearing caps in position. Aluminium pistons are used and these are joined to the crankshaft by H-section connecting rods machined from nickel-chromium steel stampings and fitted with steel-backed copper-lead big-end bearings. There are two separate cylinder heads, each of which covers three bores, and these are fitted with the inlet and exhaust valves operated in the usual manner through push rods and rocking levers. The marine version of the engine is fitted with a reverse gear or, when required, a reverse-reduction gear. The ahead clutch, which is of the multi-plate type, and the epicyclic gearing for astern are operated by oil pressure, the oil being supplied by a pump embodied in the gearbox. Instead of the more usual large reversing lever requiring considerable manual effort for operation, the clutches giving ahead and astern motion are controlled by moving a small control valve, the linkage of which is also connected to the fuel-injection pump so that the clutches cannot be engaged or disengaged when the engine is running at full speed. When incorporated, the reduction gear is integral with the reverse gear and is no longer a separate unit as on some of the earlier models. Helical gearwheels are used and are hardened and ground to ensure quiet running. They are fitted with ball and roller bearings and the cast-iron casing is provided with a water jacket through which the cooling water passes on its way to the engine.

The many uses to which their A.E.C. oil engines can be put are well illustrated by the display on the stand of Messrs. A.C.V. Sales, Limited, Southall, Middlesex, the exhibits including a Diesel-driven generator for use on board ship, a propulsion unit, a stationary power unit and a Diesel-electric locomotive traction unit. The generating set is fitted with an A.E.C. type-A 212 six-cylinder ship's auxiliary oil engine of 120 mm. bore and 142 mm. stroke and having continuously-rated outputs of 65 brake horse-power at 1,000 r.p.m. and 100 brake horse-power at 1,500 r.p.m. The engine is complete with a fresh-water cooling system incorporating a positive-lift sea-water pump, a heat exchanger, an oil cooler and a centrifugal fresh-water pump. It is coupled directly through a flexible coupling to a marine-type generator designed to have an output of 45 kW at 220 volts, when operating at 1,000 r.p.m., the two units being mounted on a common fabricated-steel bedplate. The engine for the propulsion unit is similar to that employed on the generating set, having the same bore and stroke and the same output at 1,500 r.p.m., namely, 100 brake horse-power. Similarly, it is provided with the same form of fresh-water cooling system but has an all-speed governor and a fully-equipped instrument panel. A reverse-reduction gear is provided, the reduction ratio being 1·96 to 1. The gearbox casing is water-cooled in accordance with usual practice.

Like the two marine units just referred to, the stationary power unit is fitted with a six-cylinder Diesel engine having a bore and stroke of 120 mm. and 142 mm., respectively, and a continuously-rated output of 100 brake horse-power at 1,500 r.p.m. It is provided with a radiator cooling system and is complete with a toggle-action clutch arranged to drive a flat pulley. As will be seen from the photograph of the unit reproduced in Fig. 37, Plate XX, the engine, clutch and pulley are mounted

on a fabricated-steel bedplate, thereby rendering the unit entirely self-contained. The Diesel-electric rail-traction unit is fitted with the same engine as the power unit just described, but in this case it is coupled directly to a B.T.H. direct-current generator, the two units being mounted on a common bedplate of fabricated-steel construction. The complete unit is entirely self-contained and includes special electrical control gear designed for traction duties. All the engines referred to in the foregoing summary are fitted with the A.E.C.-Ricardo Comet Mark III combustion system and the remaining exhibits on the stand include a sectioned cylinder head and block cut away to show the principles of this system.

The exhibits on the stand of Messrs. W. H. Dorman and Company, Limited, Stafford, include a new six-cylinder Diesel engine on view to the public for the first time. A photograph of the new engine is reproduced in Fig. 38, and performance curves in Fig. 39, on page 291. It will be noted from the latter that the engine develops a maximum of 160 brake horse-power at 1,500 r.p.m. It is a four-cycle unit having a bore and stroke of 135 mm. and 160 mm., respectively, the piston displacement, as a consequence, being 13,741 c.c. Direct injection is employed, the fuel being sprayed into toroidal-shaped combustion chambers formed in the piston crowns. The compression ratio is 15·2 to 1 and the compression pressure is between 520 lb. and 530 lb. per square inch, while the maximum pressure developed is approximately 1,035 lb. per square inch. Aluminium-alloy pistons, each fitted with three compression rings and two scraper rings, are used; they are arranged to work in wet liners of the detachable type with chromium-hardened bores. The gudgeon pins are fully-floating but located endwise by circlips, and are provided with lead-bronze-lined bearings. The same material is used to line the big-end and main bearings, the diame er of the former being 3·68 in. and the latter, 4 in.

Standard C.A.V. components are used in the injection system which, in addition to the injection pump and injectors, incorporates a feed pump, a priming device and a pre-filter. A C.A.V. centrifugal governor is also fitted; it is usually of the idling-maximum speed type, but an all-speed governor can be installed if required. With the exception of the gudgeon pins, the timing gears, and the drive to the auxiliaries, lubrication throughout is effected by oil under pressure, the system incorporating a Vokes twin-element filter of the full-flow type. Accessories provided with the engine include a 24-volt C.A.V. starter motor and associated dynamo, an oil-bath air filter, fuel filters and the usual form of decompression gear for assisting starting. Those engines governed in excess of 1,350 r.p.m., and in cases where the drive is taken from the front of the engine, are provided with a torsional-vibration damper. The dry weight of the unit, complete with flywheel housing and electrical equipment, but without the flywheel, is 2,850 lb. The length, measured from the fan to the flywheel face, is 5 ft. 11 in., the overall width, 2 ft. 7 in., and the height 4 ft. 4 in.

For the first time since the formation earlier this year of the David Brown Corporation, Limited, a representative selection of exhibits from the organisation's gear, tractor and foundry groups is being shown together on one stand. One of the main exhibits, a David Brown MD4 Diesel marine engine coupled to a reverse-reduction gearbox, serves to illustrate the close collaboration between the companies within the group, as the engine is a product of David Brown Tractors, Limited, Meltham, near Huddersfield, while the transmission unit was made by David Brown Gears (London), Limited. The marine engine, a photograph of which is reproduced in Fig. 40, on this page, was first introduced in the spring of last year and was described in detail in ENGINEERING, vol. 169, page 565 (1950). As will be seen from the illustration, the engine is of compact and clean design. It has four cylinders with a bore and stroke of 3½ in. and 4 in., respectively, and develops 25·5 brake horse-power at 1,600 r.p.m. continuous rating. The design is quite straightforward. The cylinder block and crankcase are a monobloc casting of

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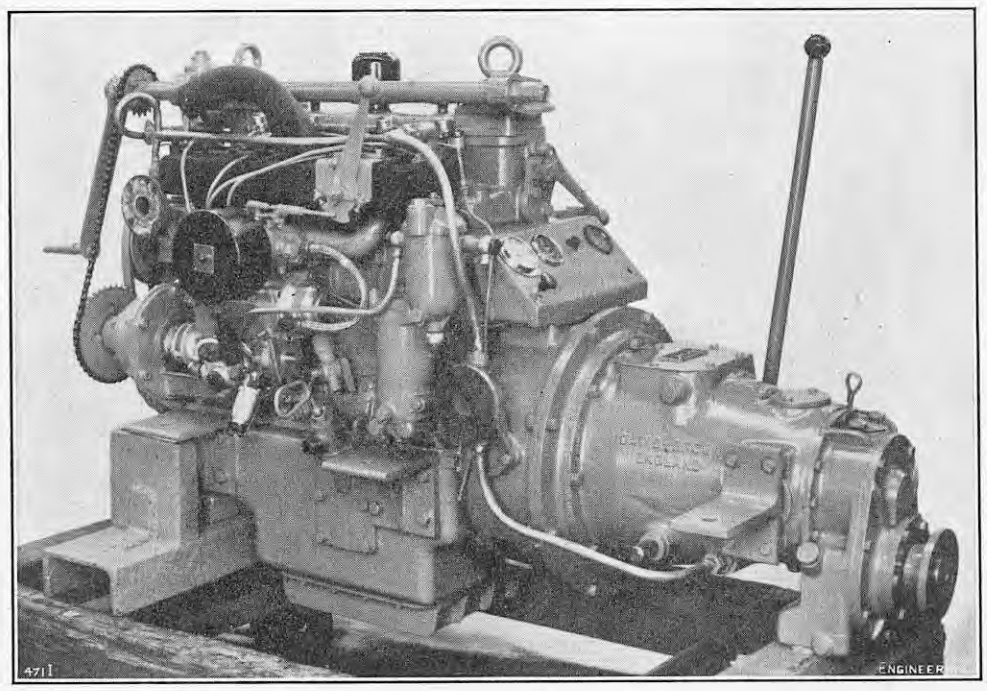

FIG. 40. 25·5-B.H.P. MARINE DIESEL ENGINE; DAVID BROWN CORPORATION, LIMITED.

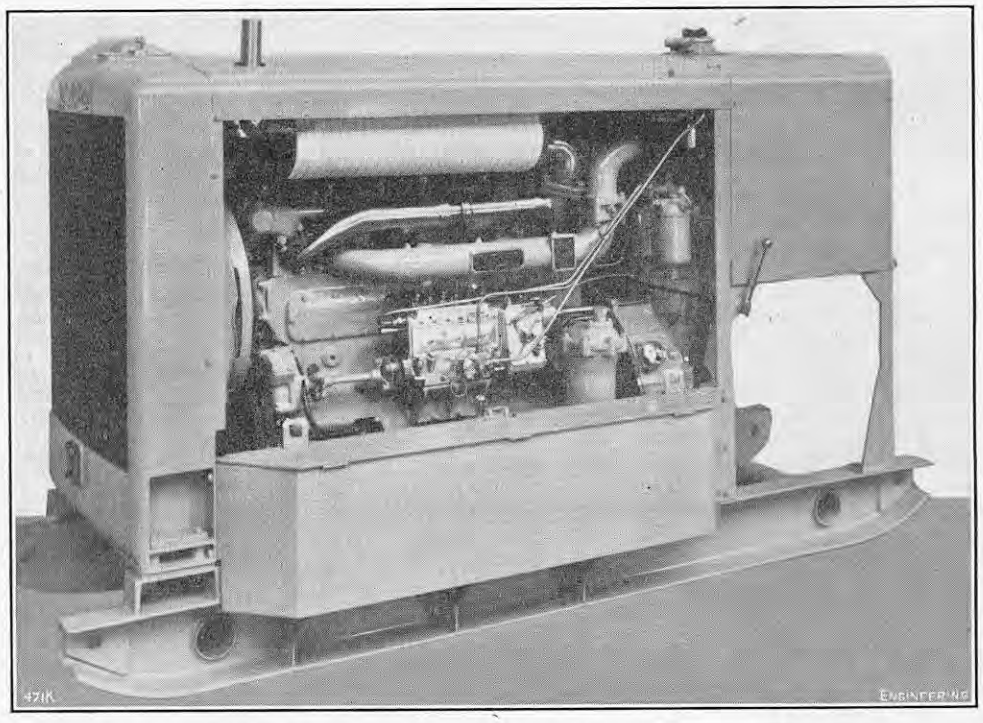

FIG. 41. 95/125-B.H.P. INDUSTRIAL DIESEL-ENGINE UNIT; LEYLAND MOTORS, LIMITED.

nickel-chromium iron. Cast silicon-alloy pistons are used, each fitted with three pressure rings and an oil-control ring, and they operate within replaceable wet-type liners of close-grained cast iron. There are three main bearings of the replaceable steel-backed type, the top halves of which are lined with whitemetal and the lower halves with copper-lead, the centre main bearing being designed to take the thrust. The cylinder head is an iron casting and is fitted with the usual form of overhead valve gear. Direct-injection is employed, the fuel being injected into toroidal-shaped combustion chambers, formed in the piston crowns, by means of a C.A.V. monobloc fuel-injection pump working in conjunction with four-hole injection nozzles. A pneumatic governor is installed on the injection pump and an excess-fuel device is provided for starting purposes.

As previously mentioned, the engine is shown complete with a reverse-reduction gearbox; it should be pointed out, however, that the reduction gearing is an optional extra and does not form an integral part of the unit. The reverse gearbox is of the planetary bevel-gear type with fixed planet carriers, a single lever controlling the toggle mechanism which engages the Ferodo-lined ahead and astern clutch plates. Dry clutch plates are fitted but the gears run in an oil bath. Plain spur gears are used in the reduction gearbox, the shafts being provided with ball bearings; the assembly is lubricated by splash from an oil-well formed in the bottom of the casing; the latter is water-cooled.

Other exhibits on the stand of the David Brown Group include the steel casting for the bottom half of a high-pressure turbine casing and a turbine gear-reduction unit. The steel casting, which was produced by the David Brown Foundries Company, weighs approximately 3 tons and forms part of an order for electrical-generating plant being supplied to the Orlando power station, Johannesburg, for use in conjunction with a 30,000-kW turbo-alternator. The gear-reduction unit was made by David Brown

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

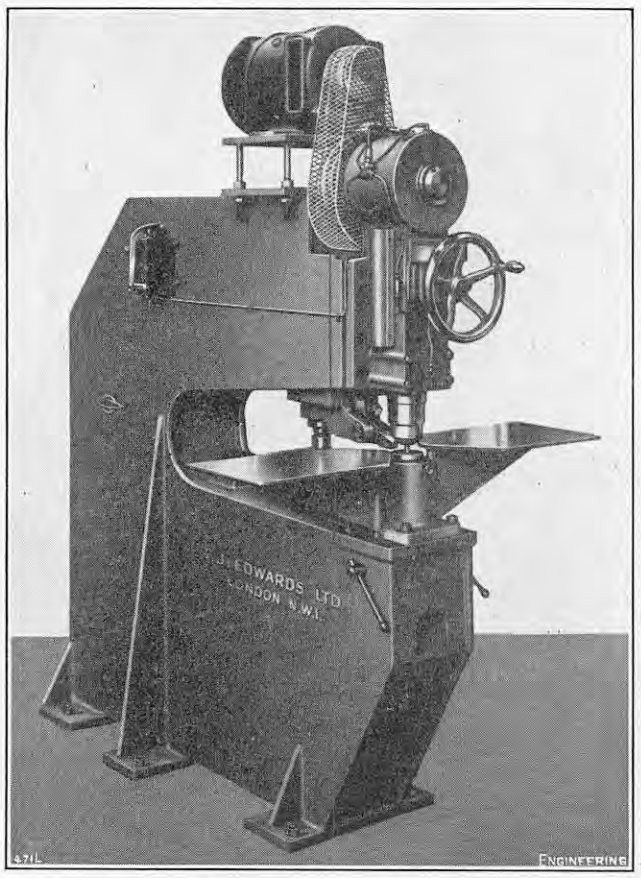

FIG. 42. HIGH-SPEED NIBBLING MACHINE; F. J. EDWARDS, LIMITED.

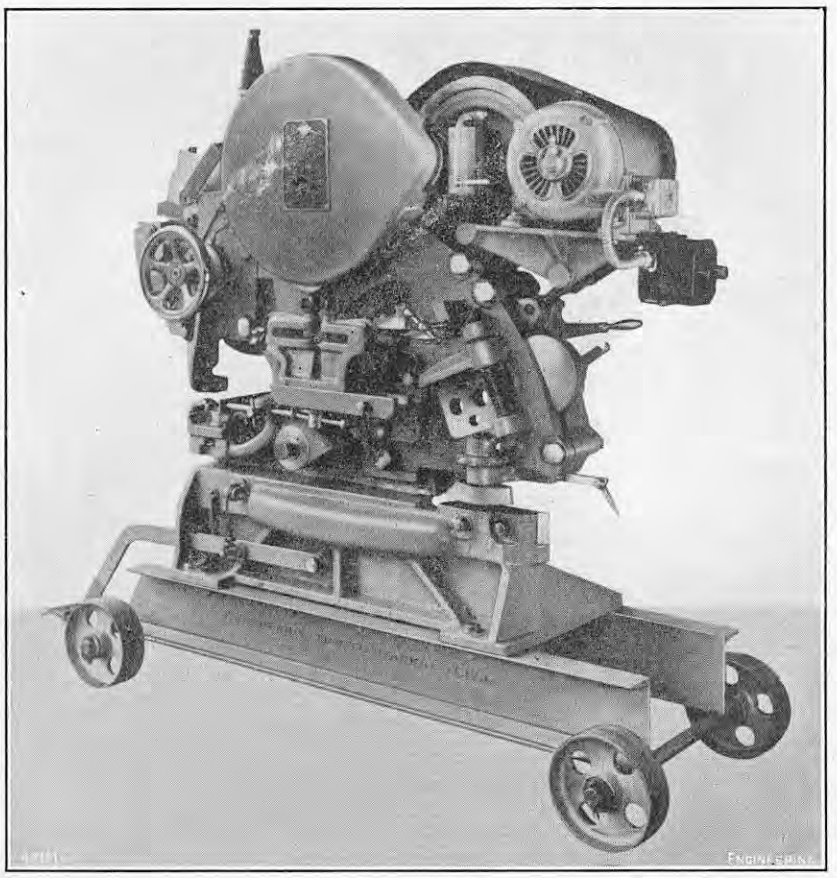

FIG. 43. PUNCHING, SHEARING AND NOTCHING MACHINE; F. J. EDWARDS, LIMITED.

and Sons (Huddersfield), Limited, and, like the casting, is intended for use in conjunction with a turbo-alternator. It is a 17-in. unit and has been designed to transmit 1,250 kW at an output speed of 1,500 r.p.m., the turbine speed being 6,000 r.p.m. The Group's interest in the development of gear-cutting machinery is shown by a representative selection of gear cutting and finishing tools, together with measuring instruments, manufactured by the David Brown Tool Company.

Six different types of industrial Diesel units are being shown by Leyland Motors, Limited, Leyland, Lancashire. One of these, which has been designated the PU600, is illustrated in Fig. 41, opposite. It is 95/125-h.p. unit, the engine having a bore and stroke of 4·8 in. and 5·5 in., respectively, and for continuous running has a maximum rating of 95 brake horse-power at 1,600 r.p.m. A thermostatically-controlled cooling system is incorporated, the water being circulated by a belt-driven pump and cooling assisted by an engine-driven fan. The radiator is arranged for both engine-oil and water cooling and is fitted with an exceptionally large filler cap. A 39-gallon fuel tank is installed and the fuel system is provided with a C.A.V. type "D" twin-filter assembly designed so that one filter element can be cleaned at a time with the engine still running. The single-plate clutch and rear drive are designed to S.A.E. standard No. 1 with a plain taper shaft of 2 in. nominal diameter, sufficient to transmit the full engine power. The whole unit is mounted on a rolled-steel sub-frame and is totally enclosed by a quickly-detachable canopy and side covers, which can be locked in position; when locked, the battery and tool lockers, which extend along both sides of the unit, cannot be opened. An instrument panel is mounted at the rear of the unit and this also can be enclosed by a hinged lid which locks in position. The electrical equipment includes an axial starter motor, a belt-driven dynamo provided with compensated voltage control and a 135-ampere-hour battery; a starting-circuit switch, a starter button, an ammeter, and sockets for an inspection lamp are mounted on the instrument panel.

An unusually wide range of metal-working machinery is being shown on the stand of Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1, several of the machines being displayed for the first time. One of these, a high-speed nibbling machine, is illustrated in Fig. 42, on this page. It is of entirely new design and has a cutting capacity up to $\frac{3}{16}$-in. mild steel. It is arranged for mounting directly on the floor, has a throat gap of 32 in. and is provided with two large supporting tables. The ram is of the balanced-piston type and runs in long phosphor-bronze bearings at a speed of from 720 to 1,000 strokes per minute. It is adjustable for height, thereby allowing cutting to be commenced on the inside edge of the blank after pre-punching, the adjustment being effected by means of mitre gears operated through a handwheel conveniently placed on the head. The punch and die are made from hardened tool steel and the punch is held in a collet-type chuck which can be turned to cut in any direction. A stripper for clearing work from the punch is mounted on a slide in the throat of the machine and is combined with a circle-cutting device capable of cutting discs or rings up to 30 in. diameter from blanks from which the corners have been removed. With a square blank, the maximum size of circle that can be cut is 22 in. diameter and the minimum 7 in. diameter. A counter-balanced flywheel regulates the movement of the eccentric shaft, the latter being mounted in Timken roller bearings, and the machine is arranged for a two-speed V-rope drive from a 2-h.p. motor mounted on a movable platform to permit adjustment in the tension of the ropes.

The exhibits on the stand of Messrs. F. J. Edwards also include the universal punching, shearing, section-cropping and notching machine illustrated in Fig. 43, on this page. Four sizes of this machine are availabe, but that on show, namely, the KS15, is the heaviest that is suitable for portable use. It is a strongly built unit, the body being constructed from heavy cast-steel sections and fitted with high-grade alloy-steel shearing blades capable of cutting steel plate up to $\frac{5}{8}$ in. thickness of any length or width in successive cuts. Accuracy is ensured by a cutting-line indicator and an adjustable hold-down clamp. Situated above the plate shears are two "slip-in" blades supplied as standard equipment for cutting up to $1\frac{9}{16}$-in. round or $1\frac{3}{8}$-in. square bars, but other shaped sections may be cut if the blades are provided with suitable apertures. The angle and "T" cropping mechanism is situated centrally in the machine and is capable of cropping sections up to 4 in. by 4 in. by $\frac{3}{8}$ in. at right angles, and 3 in. by 3 in. by $\frac{3}{8}$ in. sections at 45 deg., self-adjusting clamps holding the work as it passes through the aperture. The punch and notching head are arranged at the opposite end of the machine and both tools are controlled by the same clutch. Normally, a rectangular notching tool is supplied and this will also make mitre notches in angles, T-pieces, joists, channels and plates. Location of the punching tool is effected by means of a handwheel, and a stripper, together with an adjustable guide for punching holes in the edges of steel sheets, is provided. The machine is driven by a 3-h.p. electric motor running at 2,800 r.p.m. and giving 40 strokes a minute, the motor being situated at the top of the machine and the drive transmitted by multiple V-belts. All gearing is adequately covered and the working parts are lubricated by means of the Tecalemit one-shot system.

The exhibits on the stand of the Hamworthy Engineering Company, Limited, Poole, Dorsetshire, are representative of their wide range of pumps and compressors, the emphasis being, possibly, on the marine side. The compressors on view include their type 3TM8E two-crank three-stage machine developed for main starting duties. This machine, a photograph of which is reproduced in Fig. 44, on page 294, has a continuous rating of 246 cub. ft. free air per minute delivered against a pressure of 600 lb. per square inch when operating at 500 r.p.m. First-stage compression occurs in annular spaces, while the second and third stages are effected on the buffer portions of the pistons. The cylinder walls are temperature-controlled and are lubricated by splash in the first stage and by mechanical lubricators in the second and third stages. The inter-

coolers have extractable elements and are bolted pannier-wise to the main frame in such a way that they can be removed readily for cleaning. A Burgess combined air filter and silencer is fitted to the air inlet, and the valves, which are of the low-lift pattern, have plates of chromium-vanadium steel. Air cooling is employed for the cylinders but the first-stage valve pockets, intercoolers, second- and third-stage cylinder heads and the aftercooler are water-cooled, the jackets being fed from the mains supply or by a positive-displacement pump driven from the crankshaft. The machine is of robust construction, the crankcase, cylinder blocks and cylinders being of close-grained cast iron and the crankshaft and H-section connecting rods machined from steel forgings. The pistons also are of close-grained cast iron and are fitted with an adequate number of pressure rings, the first-stage pistons having, in addition, scraper rings to prevent an excessive quantity of oil entering the cylinders. The main and big-end bearings are of gunmetal lined with whitemetal and they are lubricated under pressure, the oil being supplied by a gear pump driven from the crankshaft.

The principal exhibits of Messrs. Mechans, Limited, Scotstoun Iron Works, Glasgow, W.4, are an aluminium-alloy class-B motor lifeboat and a set of twin-engine reply telegraphs which are electrically operated. The lifeboat, which is illustrated in Fig. 45, on Plate XXI, is 24 ft. long and has a moulded depth of 3 ft. 4 in. and a breadth of 8 ft. It is built in accordance with Ministry of Transport requirements and is suitable for 38 persons. It is fitted with a Morris 6/12-brake horse-power marine petrol engine, loose buoyancy tanks and Binmore patent release gear. The specification for the construction is as follows. The keel consists of 7-in. by $\frac{5}{16}$-in. aluminium-alloy extrusions (B.S.N.E.5), of bulb-plate section, riveted to the shell by $\frac{1}{4}$-in. rivets spaced four diameters apart. The gunwale is a 3-in. by $2\frac{1}{2}$-in. by 0·30-in. extrusion (B.S.N.E.5) riveted to the shell by $\frac{1}{4}$-in. countersunk rivets spaced eight diameters apart. The shell plating, 12-s.w.g. thick, is on independent angle frames, and is plated longitudinally; it is of B.S.N.E.5 aluminium alloy. The shell seams are $\frac{3}{4}$-in. wide, with $\frac{3}{16}$-in. rivets spaced four diameters apart. The shell butts are $1\frac{1}{2}$ in. wide, double-riveted with $\frac{3}{16}$-in. rivets, and the shell is fixed to the keel, stern and stem by $\frac{1}{4}$-in. rivets. The frames are of $1\frac{1}{4}$-in. by $1\frac{1}{4}$-in. by $\frac{1}{8}$-in. extrusions B.S.N.E.5 aluminium alloy. The shell seams are The floors are of 14-s.w.g. aluminium alloy (B.S.N.S.5), riveted to the frames by $\frac{3}{16}$-in. rivets. The stern frame consists of two $\frac{3}{16}$-in. mild-steel bottom plates and one $\frac{5}{16}$-in. mild-steel top plate with a mild-steel tubular boss welded thereto; the whole is zinc-coated after assembly.

The most notable exhibit on the stand of Modern Wheel Drive, Limited, Stanley-avenue, Chesham, Buckinghamshire, is a large working model of their S.L.M. oil-operated reverse-reduction gearbox designed for coupling to four marine engines. By simplifying the layout of this gearbox, the number of gearwheels has been reduced from 23 to 13. The principle on which the clutches work is well known and has been proved by many years of service; the drive is transmitted when oil under pressure is admitted between two bronze members which thereupon move slightly away from each other and engage frictionally with the gear. Each engine may be isolated from the transmission at will, by the movement of a small handle on the master control cock which is on top of the transmission. Manœuvring is accomplished simply, quickly and smoothly by remote control, and ahead, astern and neutral conditions are provided for.

The advantages of multi-engine propulsion, which these gearboxes make possible, are as follows. When only reduced power is needed one or more engines may be shut off, thus economising in fuel and lubricating oil, and reducing wear and tear when a vessel is on light or ballast voyages. In the event of trouble with one engine, it can be shut off and the ship can proceed without a substantial loss of speed. Spare engines can be carried and a system of regular overhauls by the ship's staff instituted. At terminal ports an engine can be replaced by a spare, and then overhauled during the voyage. Fig. 46, Plate XXI, shows an S.L.M. twin-engine reversion-reduction gearbox for main propulsion. One such gearbox is being shown at Olympia. S.L.M. gearboxes are now being made for four engines, transmitting a total of 8,000 brake horse-power at 400 r.p.m. of the engine shaft. The gear ratio may be up to 6 to 1, as required.

The Alfa-Laval Company, Limited, Great West-road, Brentford, Middlesex, are showing a representative range of centrifugal separators, including the following: one for treating low and high-viscosity fuel oil (boiler oil) for use as a Diesel fuel; a hermetic clarifier for liquids with no air contact, or for clarifying liquids containing gas when no gas loss is permissible; a general-purpose laboratory centrifuge; and the "P.S.E." equipment shown in Fig. 47, Plate XXI, which has been designed for turbine lubricating oil in power stations. It is self-contained and incorporates devices for preventing loss of oil and reducing the amount of attention required. The drive is taken from the motor to the centrifuge through a centrifugal friction clutch, which gives a smooth acceleration and reduces the starting current. The transfer pumps (one or more can be fitted) are integral parts of the machine and are driven through gears from a cross-shaft. The oil inlet and discharge pipes are permanently connected to the lower stationary parts of the separator so that no joints have to be broken when the covers are opened.

The baseplate serves as a clean-oil de-aerating tank of approximately 22 gallons capacity; a float-controlled valve ensures that the clean oil remains in the tank for a predetermined period before being discharged. Separated water is delivered to another compartment in the bedplate. In the tank top immediately above this chamber is a large drain hole with a gauze strainer through which any surplus oil collecting on the tank top drains. The contents of the tank are emptied into this tank before the cleaning operation. The water tank is fitted with an oil-level pipe through which a continuous discharge of the water occurs, while any oil floating on the water is periodically taken through the separator and thus recovered. The baseplate is extended at one end to take an oil heater of the indirect type. In the event of the driving motor failing, current to the heater is automatically cut off, though the temperature of the water jacket can be raised before starting up the separator. A supply of hot water from the heater jacket can be fed into the dirty-oil piping for sealing or washing out the bowl.

The P.S.E. unit is invaluable for continuously maintaining turbine oil in first-class condition. It is impossible entirely to prevent moisture finding its way into the lubricating system, through the glands, etc., and small particles of solid impurities find their way into the oil stream, even if the system is of the enclosed type. A centrifuge is particularly suitable for this duty as it separates the constituents according to their specific gravities; it does not, like an ordinary filter, depend on the physical dimensions of the particles, and, in par-

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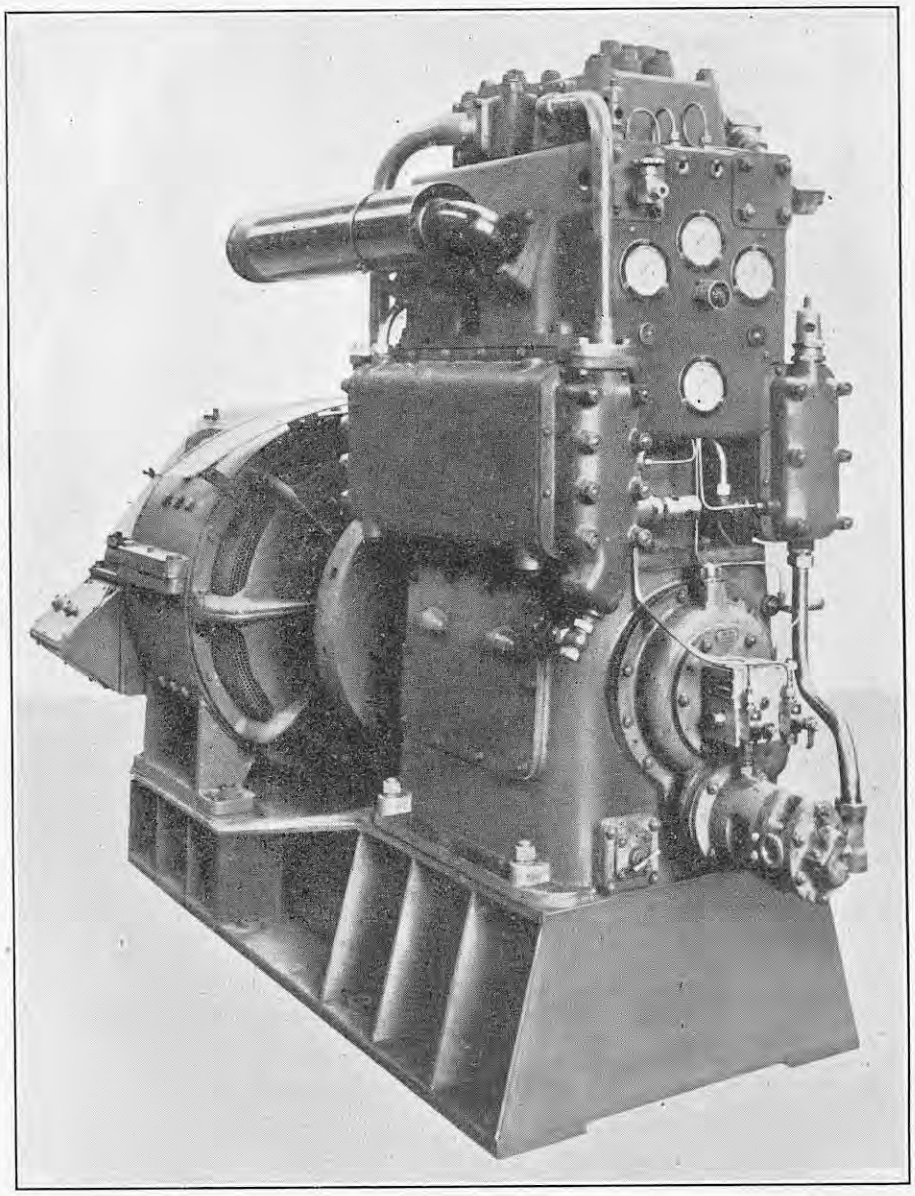

FIG. 44. THREE-STAGE COMPRESSOR FOR ENGINE-STARTING; HAMWORTHY ENGINEERING COMPANY, LIMITED.

(To face page 294.)

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(*For Description, see Page* 294.)

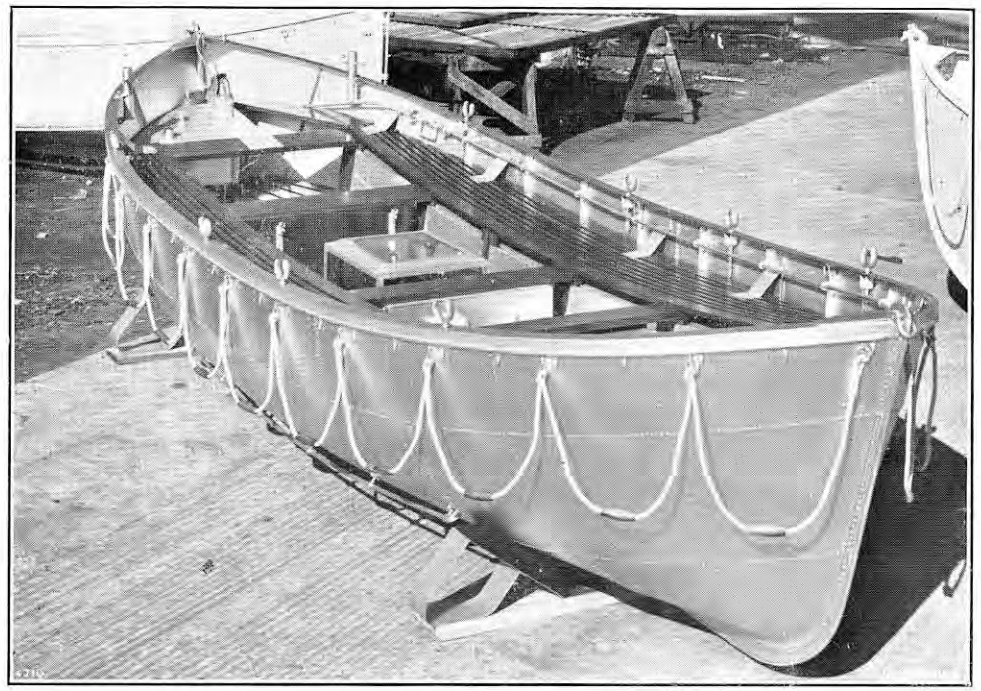

FIG. 45. ALUMINIUM-ALLOY LIFEBOAT; MECHANS, LIMITED.

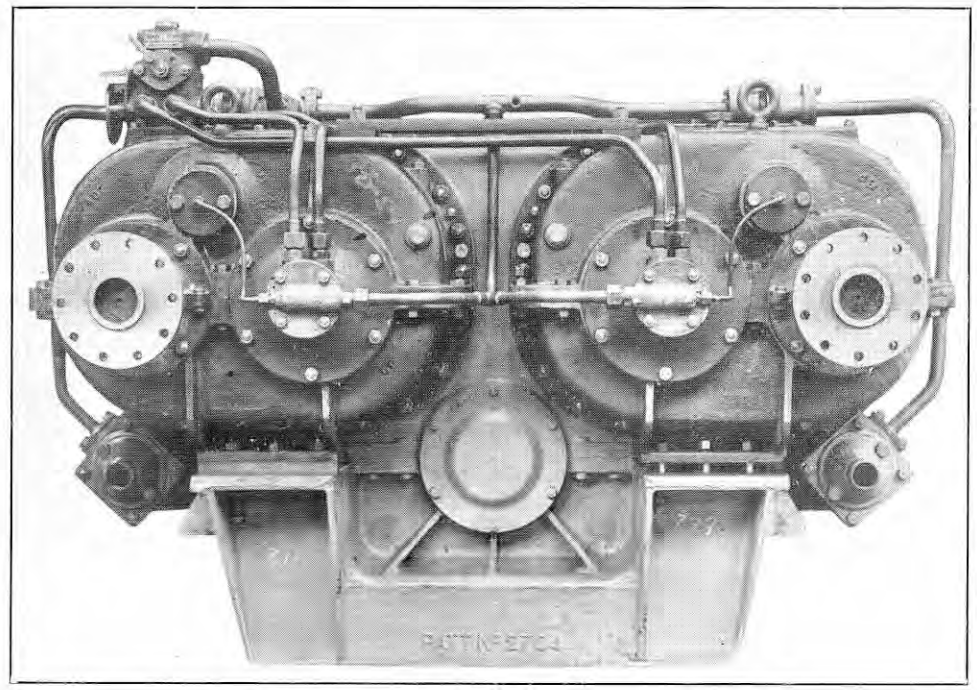

FIG. 46. S.L.M. TWIN-ENGINE MARINE GEARBOX; MODERN WHEEL DRIVE, LIMITED.

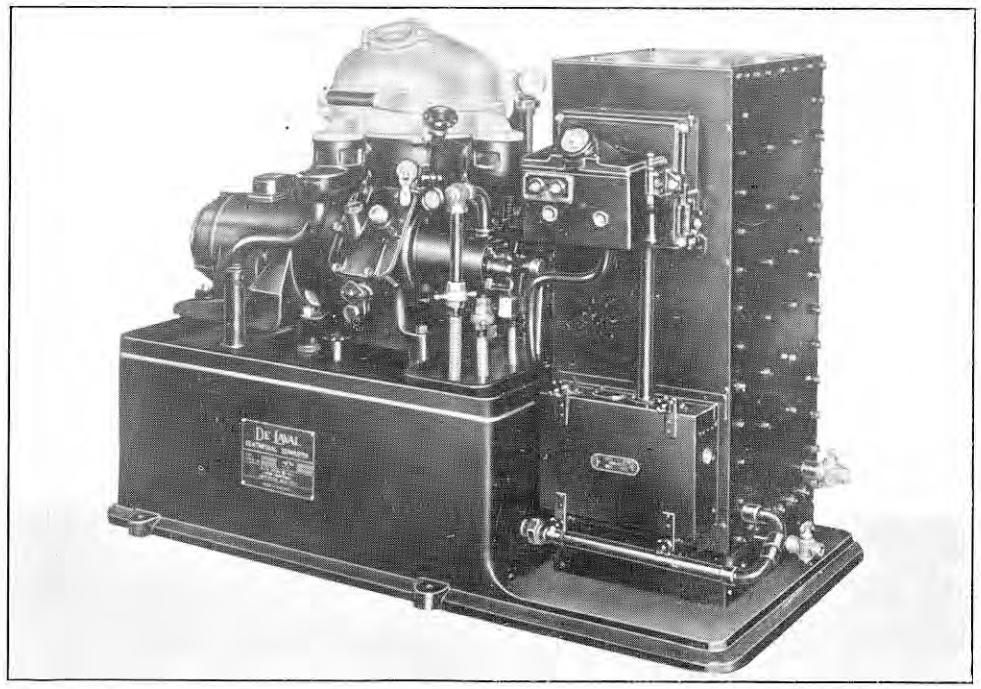

FIG. 47. CENTRIFUGAL SEPARATOR FOR TURBINE LUBRICATING OIL; ALFA-LAVAL COMPANY, LIMITED.

FIG. 48. 250-KV INDUSTRIAL X-RAY EQUIPMENT; NEWTON VICTOR, LIMITED.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

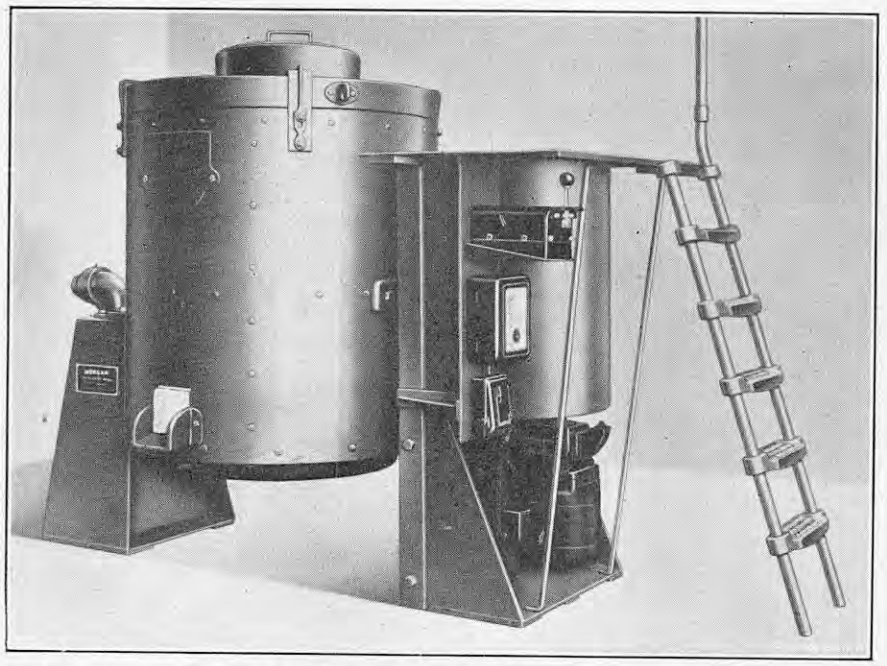

FIG. 49. POWER-TILTED CENTRAL-AXIS CRUCIBLE FURNACE; MORGAN CRUCIBLE COMPANY, LIMITED.

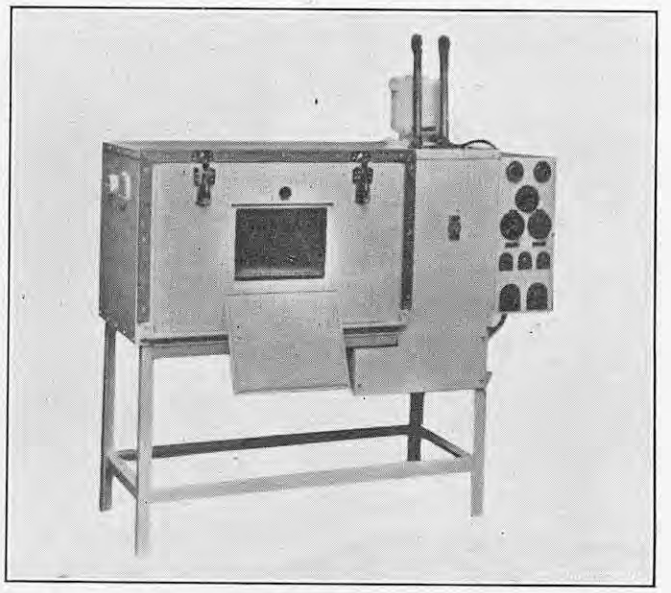

FIG. 50. HUMIDITY-TEST CABINET; BARLOW-WHITNEY, LIMITED.

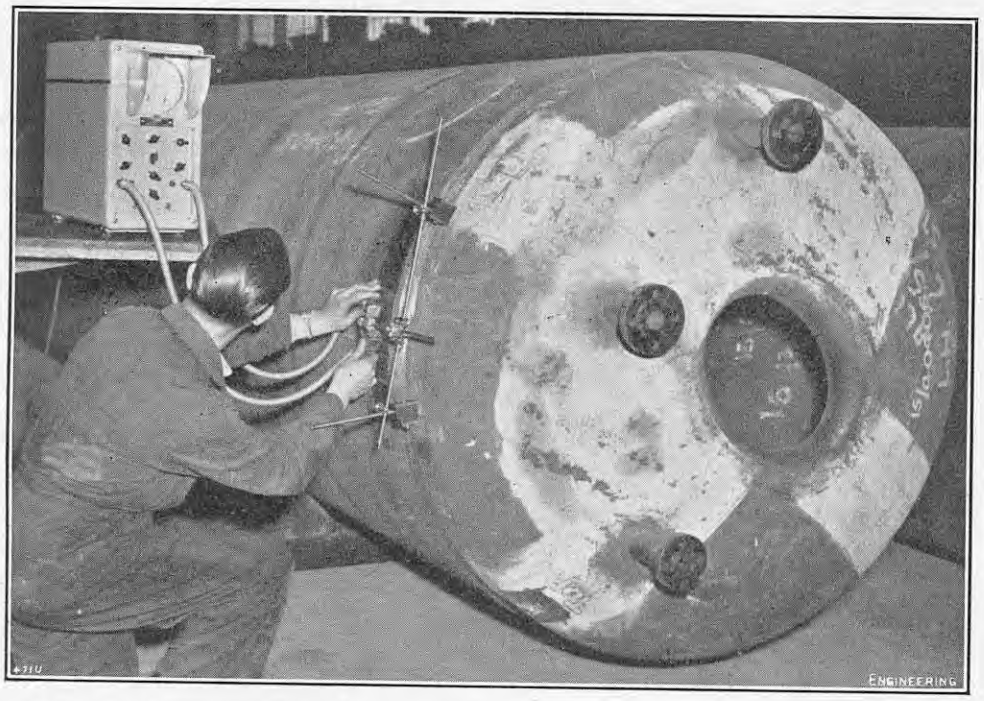

FIG. 51. SUPERSONIC FLAW DETECTOR; KELVIN AND HUGHES (INDUSTRIAL), LIMITED.

ticular, it removes water where a filter is ineffective, Furthermore, it will remove non-ferrous particles, whereas of course a magnetic filter will not.

Messrs. Newton Victor, Limited, 15, Cavendish-place, London, W.1, are exhibiting the 250-kV industrial X-ray unit illustrated in Fig. 48, Plate XXI. This has been designed for the examination of castings, welded joints and fabricated parts up to a thickness corresponding to 3 in. of steel. All the components, including the generator, X-ray tube and control panel, are, as will be seen, mounted on a rubber-tyred chassis, so that the unit can be used wherever electric power is available. The makers draw attention to the fact that a particular feature of this equipment is that both the X-ray tube and the high-voltage generator are enclosed in a single dust-proof and damp-proof tank containing oil, so that the use of trailing cables is avoided. Efficient cooling is effected by circulating the oil through a heat exchanger on the chassis. Water cooling is therefore unnecessary and the tube can be operated continuously at a peak voltage of 250 kV, with a current of 10 milliamperes.

To provide freedom of movement of the X-ray beam, the head is mounted on a motor-driven jib having a vertical travel of 6 ft.; it can also be given a horizontal movement of 4 ft. by hand. In addition, the jib can be rotated about its horizontal axis and about the vertical stanchion of the crane. The radiographic examination of large specimens and intricate castings is thereby facilitated. The control panel from which all the electrical and radiation equipment, including the automatic timing of the X-ray exposures, are regulated, is mounted at the rear of the chassis in a lead-lined cab, so that the operator is completely protected. Apparatus of this type was used for examining the welded structure supporting the main flight deck of H.M.S. Ark Royal.

The stand of the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, is devoted mainly to a display of crucibles, foundry accessories and crucible furnaces. Of particular interest to foundrymen is the new Salamander Suprex crucible, which is exhibited for the first time. It has been developed for use in specially arduous conditions and is intended to satisfy the needs of melters who, for technical reasons, are unable to obtain complete satisfaction from the standard type of crucible. Although the makers do not recommend such practice, they state that the new crucibles can be plunged into hot furnaces without preheating and will resist the resultant thermal shock. The crucibles can also be brought up to a maximum temperature rapidly, or chilled quickly between heats, and another advantage claimed for the new crucible is that it offers exceptional resistance to erosive slag. Among the crucible furnaces shown by the company is their recently-developed power-tilted central-axis furnace which is also on exhibition for the first time. The furnace, which is the firm's type CA/MECH., is similar to their type CA hand-tilted central axis furnace. As may be seen in Fig. 49, herewith, which gives a general view of the new furnace, the tilting gear is operated by an electric motor and the fixed speed of pouring is controlled by means of the selector handle shown. Special attention has been paid to the design of the tilting gear, which is of simple design yet of extremely robust construction. The furnaces are available in sizes ranging from a melting capacity of 400 lb. of brass to one for melting 10 cwt. of aluminium, and may be either gas- or oil-fired.

Messrs. Barlow-Whitney, Limited, Coombe-road, Neasden-lane, London, N.W.10, are showing examples of their high-vacuum and pressure impregnating plants, industrial ovens, furnaces, heating baths, etc. The humidity-test cabinet illustrated in Fig. 50, which is one of their most recent products, is also on view. It has been developed for testing electrical components in accordance with the Defence Departments Inter-Service specifications, and for research work on materials, finishes and equipment designed for tropical and sub-tropical use. It consists of two compartments thermally-insulated and enclosed in a sheet-steel casing, a working chamber 2 ft. 6 in. long by 1 ft. 6 in. deep by 1 ft. 6 in. high, and a humidifying and heating compartment in which the wet and dry air streams are thoroughly mixed before being circulated around the working chamber. Humidity is produced by an electrically-heated low-capacity boiler, the 1-kW heating circuit being controlled by a wet-bulb mercury-in-glass adjustable-contact thermometer. A similar dry-bulb thermometer controls a separate dry-air heating circuit. The mixed wet and dry air streams are circulated through the working space by a fan. Water which condenses in the working chamber drains through a hole in the bottom and is led to a sump.

Inside the working chamber are two removable wire-mesh working trays; bushed holes, 1 in. and 3 in. in diameter, with removable covers, are provided

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

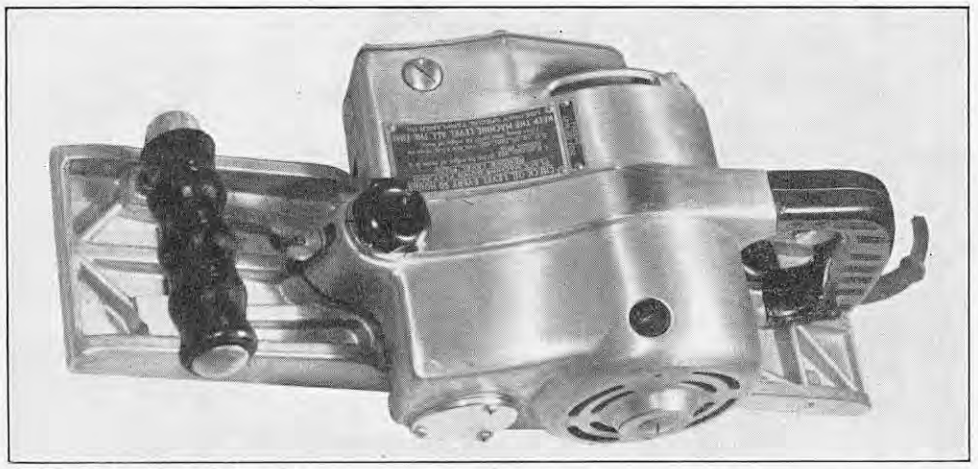

FIG. 52. PORTABLE PLANER; BRITISH EQUIPMENT COMPANY, LIMITED.

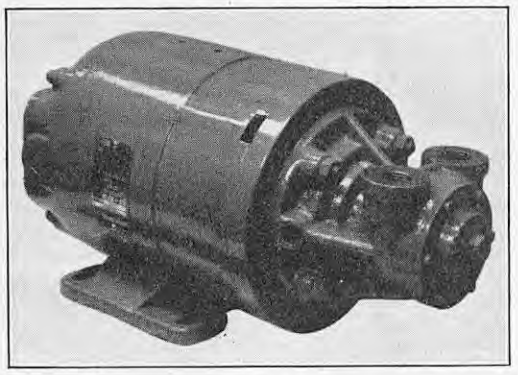

FIG. 53. "ROTOMOT" PUMP; ROTOPLUNGE PUMP COMPANY, LIMITED.

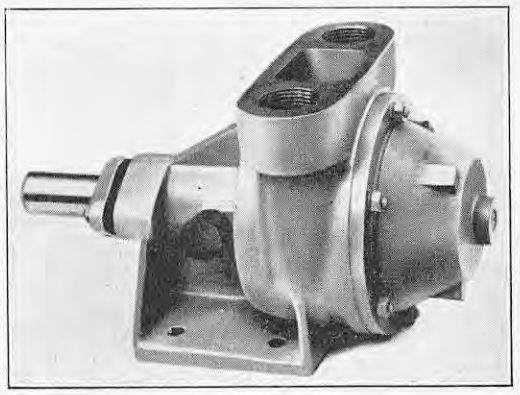

FIG. 54. AUTOMATIC REVERSING PUMP; ROTOPLUNGE PUMP COMPANY, LIMITED.

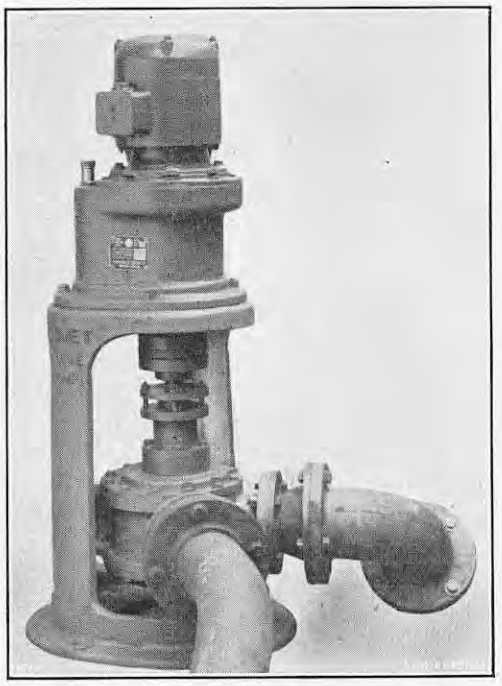

FIG. 55. PUMP FOR RAW MASSECUITE; COMET PUMP AND ENGINEERING COMPANY, LIMITED.

in one end of the cabinet for passing test leads into the chamber. The door of the chamber is fitted with an inspection window and a light is provided inside to view the work. The control gear, apart from the contact thermometers at the top of the cabinet, is housed in a steel compartment at the end of the cabinet, and comprises energy regulators and three heat switches in each circuit, which enable the heating and cooling rates to be regulated. A cyclic control is fitted to allow a cyclic temperature variation of $\pm$ 1 deg. to $\pm$ 2 deg. C. for 5 to 10 cycles per hour for certain tests. A time switch is available which automatically switches on a saturating spray during the cooling periods. The standard models have a temperature range up to 110 deg. C. with dry heat only and up to 60 deg. C. with wet heat only. Temperature control by means of the contact thermometers is accurate to $\pm \frac{1}{2}$ deg. C. The relative humidity obtainable ranges between 40 and 100 per cent., according to the dry-heat temperature, and the wet-bulb depression can be maintained within $\pm \frac{1}{2}$ deg. C.

The ability of ultrasonic compression waves to reveal internal flaws in solid materials and in welded joints is well known. Whenever such waves reach a surface of discontinuity, where the density or elastic constants of the material traversed change abruptly, reflection takes place and the reflected wave reveals the presence of the discontinuity. The photograph reproduced in Fig. 51, on page 295, shows the application of an ultrasonic flaw detector developed by Messrs. Kelvin and Hughes (Industrial), Limited, 2, Caxton-street, London, S.W.1, to the examination of a boiler in the works of Messrs. Babcock and Wilcox, Limited, Renfrew. Equipment of this kind and its mode of employment are being demonstrated on Messrs. Kelvin and Hughes' stand. It has been established that such equipment, independently of any X-ray apparatus, can detect flaws of many kinds, and is particularly suitable for detecting fine cracks. It is also possible to differentiate between the various types of flaws, provided certain supplementary tests are made.

Butt welds in steel and light alloys, where the plate thickness is $\frac{1}{8}$ in. or more, present no difficulty from the point of view of ultrasonic examination, although certain austenitic steels cause some scattering of the waves and necessitate the use of lower frequencies than would normally be employed. Special techniques, moreover, must be adopted in the examination of welds with backing strips and those involving changes in plate section. Simple techniques have also been devised for the inspection of flash-butt welds and may be employed in testing chain links, rings, drills, etc., being readily applicable also to production testing. Demonstrations of the techniques and of methods suitable for the examination of fillet welds are being given. Ultrasonic methods may be employed also to find the thickness of a plate. In the range from $\frac{1}{4}$ in. to 4 in., thickness may be determined accurately to within $\pm$ 0·01 in. without difficulty. An ultrasonic flaw detector is particularly useful for detecting laminations in plates used for pressure vessels and for revealing piping and segregation in billets, bars, etc., which not only cause trouble during welding but also result in structural weaknesses.

Ultrasonic waves are also being employed in a demonstration of an entirely different character on Messrs. Kelvin and Hughes' stand. Prominent among the marine instruments exhibited by the company is a radar installation with a scanner and auxiliary display unit. The scanner is a new design which has a greater range and better resolution than earlier models. To enable the equipment to be demonstrated at the exhibition, radar-simulating equipment has been devised and is being used in conjunction with a model of Weymouth Bay having a number of vessels moving in the area. The simulator is a quartz crystal which is mounted in a tank of water and rotates in sympathy with the radar scanner. Electrical impulses applied to the crystal generate ultrasonic waves in the water which travel out from the crystal and are reflected back by the shore or by the moving models. The reflected pulses are fed to the P.P.I. (plan position indicator) display and produce a continually changing picture of the bay on the fluorescent screen. The simulator is so sensitive that a pencil point dipped in the water shows up immediately on the screen. Messrs. Kelvin and Hughes (Marine), Limited, are also showing four types of echo-sounding depth recorder. The range covered by the company's recorders is from 3 in. to 5 miles, and the models shown have been designed for use in hydrographic surveys. They may also be used for the location and identification of fish. Another model has been devised to meet the special requirements of inshore fishing craft. It is available for use on 12-volt batteries and has a maximum range of 120 fathoms. Several models of sextants and a variety of equipment for other purposes are also being shown.

The British Equipment Company, Limited, Ixworth-place, London, S.W.3, are showing portable woodworking tools, among which are two circular saws, the Swifsure Model 8 and Model 12, and a planer. The Model 8 Swifsure saw has an 8-in. diameter blade which is driven directly by a $\frac{1}{2}$-h.p. universal motor, and has a free speed of 4,000 r.p.m. It is suitable for use on prepared timber less than 2 in. thick, the baseplate being adjustable for depth of cut, grooving or kerfing. The blade is protected by an automatic telescopic guard. The frame of the machine is of die-cast aluminium; the shaft runs in sealed bearings which are packed with lubricant before leaving the works. The main features of the Model 12 saw, which is a heavy-duty machine particularly suited to the building trades, are similar to those of the 8-in. saw, but the 12$\frac{1}{4}$-in. diameter blade is driven by a $\frac{3}{4}$-h.p. universal motor, and the machine is fitted with a tilting base which gives a depth of cut of 4 in. at 90 deg., or 3 in. at 45 deg.

The portable hand planer shown by the British Equipment Company, known as the Tarplaner, is illustrated in Fig. 52, above. This machine, which was shown at the 1949 Engineering and Marine Exhibition, has been modified in several respects. The life of the blades has been increased by making them in cobalt-chromium steel; a more powerful helical gear train has been fitted, and oil lubrication has been provided for the gears. The machine is driven by a $\frac{5}{8}$-h.p. universal motor. A lapping tool is available for maintaining the cutting edge of the blade at the correct angle, and an adjustable fence can be supplied for attaching to the backplate of the planer for planing narrow surfaces such as window frames and door edges.

The Rotoplunge Pump Company, Limited, Flaxley-road, Birmingham, 9, are showing several

ENGINEERING, MARINE AND WELDING EXHIBITION

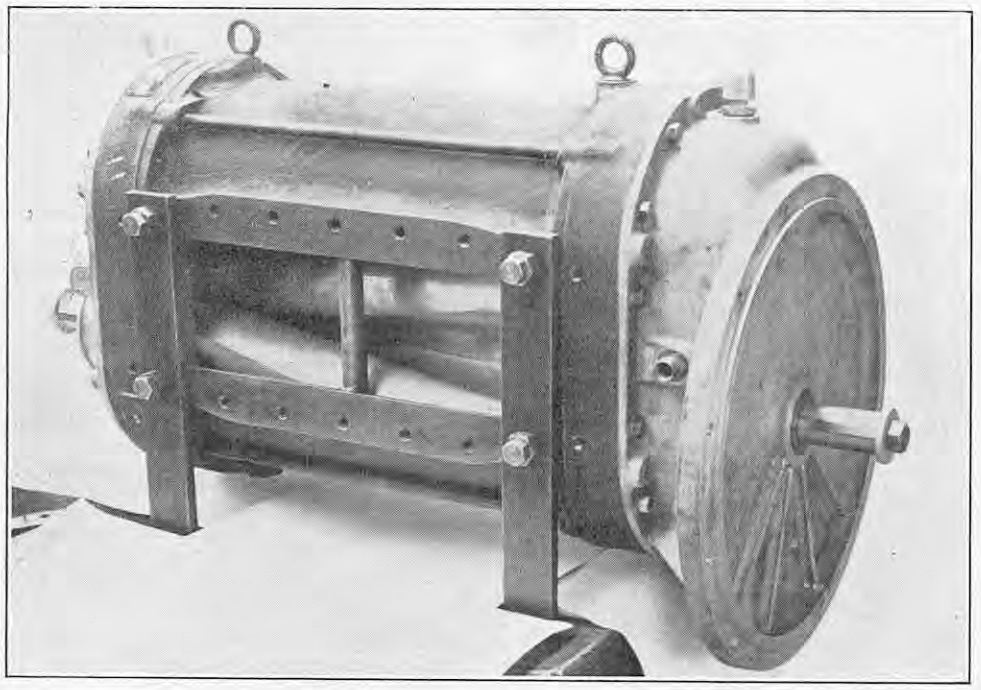

FIG. 56. INDUSTRIAL BLOWER; SIR GEORGE GODFREY AND PARTNERS (INDUSTRIAL), LIMITED.

versions of their valveless rotary plunger pumps, which are particularly suitable for handling oil. They are recommended by the manufacturers as lubricating-oil pumps for the gears and bearings of machinery, as transfer pumps for serving oil-storage tanks, and as fuel pumps supplying oil to the burners in heating installations. The standard pump is constructed in cast and malleable iron, the eccentric pin being of ground steel. The pump illustrated in Fig. 54, opposite, is an automatically reversible S-model pump, with a capacity of 240 gallons per hour; it is self-priming for suction lifts up to 25 ft. and can work continuously at a pressure of 30 lb. per square inch. It is fitted with a reversible cover, which carries a peg holding the eccentric pin in one of two positions. To reverse the direction of flow, the cover is removed, turned through 180 deg., and replaced; the operation can be carried out while the pump is running. Other standard pumps are available in capacities ranging from 8 gallons to 4,500 gallons per hour, with suction lifts up to 25 ft. and working continuously at pressures up to 50 lb. per square inch. They can be supplied as pumps only, or as motorised units mounted on a cast-iron bedplate, or mounted directly on the end shield of an electric motor; Fig. 53, opposite, shows a Rotomot pump of the latter type.

The Comet Pump and Engineering Company, Limited, Johnson-road, West Croydon, Surrey, specialise in designing rotary vane-type pumps for unusual and difficult applications. They are demonstrating a pump handling a heavy grease supplied by the Shell Petroleum Company, Limited. The pump illustrated in Fig. 55, opposite, is a low-speed reversible 6-in. marine pump handling heavy machine oil; it can also be used for handling raw sugar massecuite, i.e., the treacly, semi-crystalline sugar as extracted from the cane. The firm are demonstrating the pumping of massecuite with another pump—a reversible 3-in. pump with 6-in. inlet and outlet pipelines; it is used for loading and unloading sugar cargoes at a rate of about 20 tons per hour, at 65 r.p.m. At the exhibition, a 3-h.p. single-speed motor is used to drive this pump. The Comet company recommend, however, the use of variable-speed motors, and have built some 10-in. pumps, for loading and unloading molasses tankers, with a speed range of 50 to 80 r.p.m. To withstand the slightly abrasive action of the sugar crystals, the vane is hardened to a Rockwell C value of 62 to 64. It should be mentioned, however, that pumps for really severe abrasive applications, such as handling iron filings and other solid matter, are supplied with alloy-iron vanes with a Brinell hardness number of 550. To avoid damage to the sugar crystals, the pump rotor has scavenging ducts on each side of the vane, which accept any solid or semi-solid matter that has not passed out with the main stream, and carry it round for another cycle. Another Comet development on view at the exhibition are their "total ball-race" pumps for heavy loadings, in which the loads both on the spindle and the vane are carried on ball bearings.

Sir George Godfrey and Partners (Industrial), Limited, Hanworth, Middlesex, are well known as makers of industrial blowers, vacuum pumps, gas booster and superchargers, to meet varied requirements for the blowing and exhausting of air and gas. The trade name "Marshall" is applied to their units, the standard range of which extends in capacity from 10 to 6,000 cub. ft. per minute at pressures up to 10 lb. per square inch. The exhibits on the firm's stand include the M2000 industrial blower, described below and illustrated in Fig. 56, herewith; an L450 supercharger developed for Messrs. Rolls-Royce, Limited; and a K325 supercharger for Messrs. Marshall, Sons and Company, Limited, Gainsborough.

The L450 supercharger is made for the Rolls-Royce Diesel engine that is fitted to the new Vickers tractor. Owing to the exacting requirements of the specification, in respect of size and performance, the design of the supercharger differs from that of the standard range. The principle of positive rotary displacement has been retained, but the inlet and outlet ports have been disposed to suit axial-flow delivery.

The M2000 industrial blower (Fig. 56) is taken from the Godfrey air-conditioning trolley which was designed and made by Sir George Godfrey and Partners in collaboration with the British Overseas Airways Corporation. With this equipment, air under pressure, hot or cold, is supplied for air-conditioning standing aircraft. The compressor is of the positive-displacement Roots' type and supplies 1,500 cub. ft. of air a minute at pressures up to 12 lb. per square inch; this pressure, which is higher than the standard figure, has been provided to suit tropical conditions. The delivered air is entirely uncontaminated by oil, as oil is not required in the rotor chamber. In addition to supplying air for the cooling, heating and pressurising systems, the blower also drives an axial cooling fan and a pulley is fitted on the rear-end shaft for this purpose. The drive to the blower is through a flexible coupling from the crankshaft of a Rolls-Royce standard B80 four-stroke petrol engine. The involute blades of the rotor are of helical form.

(To be continued.)

THE ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

THE opening of the third Anglo-American Aeronautical Conference, organised by the Royal Aeronautical Society and held in Brighton from September 3 to 7, is recorded on page 307. During the technical sessions, 20 papers were read on various aspects of aerodynamics, hydrodynamics, structures and materials, thermodynamics and propulsion, air-transport operation and air safety. Many of the papers contained valuable information of a specialised nature; others reviewed developments which may be of considerable interest to engineers generally. We give below summaries of papers falling into the second category. A complete list of the lectures was given on page 179, *ante*.

AIRCRAFT STRUCTURAL DESIGN.

The first paper was read on Tuesday, September 4, by Professor G. T. R. Hill, on "Advances in Aircraft Structural Design." He reviewed structural design over the past 100 years, from the models of Henson and Stringfellow to the first successful powered flights by the Wright brothers. The series of monoplane disasters just before the first World War, which affected for many years the trend of British aircraft design, might well have been due, he said, to aero-elastic effects. He traced the development of metal aircraft from the tubular steel structure to the skin-covered structure, showing that the trend was towards thicker skins, possibly of sandwich construction or of extruded form with integral stiffeners. Discussing structure weight as a percentage of all-up weight, he showed that there were limitations to the application of the "square-cube" law for predicting aircraft structure weight. Little was yet known about clear-air gusts which might occur at the cruising altitude, 30,000 ft. to 40,000 ft., of jet-propelled aircraft; the successful development of gust alleviators could, however, solve the problem of severe gust accelerations. The development of the swept-back wing of thin section had increased the problems of aero-elasticity—loss of control at high speed, divergence, and flutter; the stiffer delta wing promised to be better from the structural point of view. Other possibilities were the "aero-isoclinic" swept-back wing in which the tip incidence remained unchanged under load, and a wing in which the sweep-back could be varied in flight.

The new problems in structural design and analysis arising from the attainment of supersonic speed were discussed by Professor N. J. Hoff on Tuesday afternoon in a paper entitled "Structural Problems of Future Aircraft." The thin wing sections for supersonic aircraft, he said, required thicker wing skins; they might take the form of sandwich construction with a balsa-wood or corrugated-sheet core, heavier-gauge sheet with closely-spaced stringers, or rolling integral stiffeners into the sheet. New methods of stress analysis were required for highly-swept and delta wings. Aerodynamic heating at supersonic speeds gave rise to thermal stresses which might exceed the yield strength of the material. New criteria of safety were required, and, he suggested, airworthiness requirements should be based on calculations of the probability of failure, taking into account stress concentrations, plastic deformation, etc. For piloted aircraft, a new "semi-expendable" category of airworthiness would be required; it would not be possible to design aircraft for operating at Mach numbers of 3 to 4 for indefinitely long periods as creep was bound to occur.

PLASTIC STRUCTURES.

In a paper on "Plastics and Plastic Structures," given on Wednesday morning, Mr. J. E. Gordon described methods of using plastics for the primary structures of aircraft, which had been developed at the Royal Aircraft Establishment. The basis of structural plastics, the author said, was fibres which were stiffer and stronger than any metal; the resins bonding them, however, were relatively weak. In plastic structures, therefore, the directional properties had to be matched as far as possible to the direction of the applied stresses. The materials were easily moulded into complex shapes. There were

two categories of plastic materials suitable for structural use—the glass-fibre polyester-resin type which had been developed in the United States, and the asbestos-fibre phenolic-resin type. The former were stronger and tougher, and were more simply manufactured; the asbestos-phenolic materials were weaker and more brittle, but were considerably stiffer for their weight. Glass-fibre polyester materials were well suited to applications where rigidity was not too critical, but for the main structure of fast aircraft it appeared to be essential to use a material of relatively high stiffness.

The Royal Aircraft Establishment had carried out experiments on Durestos, an asbestos phenolic resin, consisting of a thin felt of asbestos fibres impregnated with phenolic resin; its mechanical properties, weight for weight, were not so good as those of the better light alloys, but in fatigue resistance it was much less sensitive to stress raisers, and it withstood extreme temperatures better. A resin-impregnated paper-honeycomb material, or corrugated Durestos sheet, could be used for the cores in sandwich construction.

Two methods of fabricating Durestos had been developed—the "pressureless" method, suitable only for simple shells, in which the material, saturated with water, was hand-rolled against a simple former and then set and cured; and vacuum moulding, which gave better properties and a more accurate contour. In vacuum moulding, the water evolved during setting was removed by a vacuum pump through a porous pad placed against the material. On the other side of the porous pad was a flexible impermeable bag; the space between the bag and the mould face was evacuated so that the bag pressed the material against the mould face and thus formed the moulding. Sandwich structures could be moulded in one operation. Heat was applied by electric-resistance elements embedded in the mould body. Since the moulds defined only the outside shape of a component, it was possible to produce the shell before the thickness or the position of the internal structure had been determined.

Parallel wings had been made and tested satisfactorily and the production of delta wings for flight trials, on an aircraft of otherwise metal construction, was now well advanced. The forward part of the wing comprised an integral fuel tank, and a thick single skin was used. Since Durestos was porous, it had to be impregnated by a special resin. Over the rear part of the wing, which provided large compartments to house various mechanisms, sandwich construction was used. The shell was continuous over the leading edge, which formed a shear member, right back to the metal elevons, thus eliminating all skin joints. The rear boundary member of the fuel tank was curved and ran roughly spanwise, and a system of spanwise reinforcing webs, butting on to the leading edge, was used in the tank area; the elimination of chordwise ribs here imposed additional shear loads on the skin. The webs were of double-Y form with their stems joined. Aft of the fuel tank, ordinary flat ribs were employed. The internal-structure members were moulded by the pressureless method, the attachment flanges being left soft, and inserted in the shell on an expanding jig. The shell was then replaced in the main mould and the assembly was hardened. The steel root-end fittings had a broad fish-tail plan form, and excellent adhesion between the steel and the Durestos had been obtained. The root rib, a plain vacuum-moulded Durestos sheet, was added at a late stage in manufacture. The dull porous surface of the wing was finished by sanding and rubbing to a special finish by a technique similar to French polishing.

Materials for High-Altitude Aircraft.

"Some Material Problems of High Altitude Aircraft" were described in a paper by Mr. H. W. Hall and Dr. T. P. Hughes on Thursday, September 6. Temperature gradients arising from rapid changes of height could, they said, cause high thermal stresses in thick sections of low conductivity, such as glass windscreens. Ultra-violet radiation incident on an aircraft surface at heights of 30,000 ft. to 50,000 ft. could cause serious photo-chemical degradation of certain organic protective coatings; this could be overcome by including flaked aluminium, which had a high reflective power, in the paint. At high altitudes, it was believed that the rising content of ozone contributed to the deterioration of rubber; in selecting rubbers for high-altitude aircraft, a compromise had to be made between low-temperature flexibility and a low degree of interaction with the liquids—fuels, lubricants, hydraulic fluids—with which they were in contact.

The problem of vapour locking of fuel systems during rapid climb had been overcome by the modern fuel booster pump. The loss of volatile fuel by boiling at high altitude could be overcome by cooling the fuel before or during flight or by applying pressure to the fuel tank. Aviation kerosene, in current use in gas turbines, was not likely to encounter boiling, but at low temperatures the dissolved water content might freeze out and block certain filters, or wax could separate out at the freezing point of the fuel. Thermal insulation provided by rubber-bag tanks could help to keep the heat loss through the tank wall low. Solid deposition at low temperatures might also affect stagnant lubricating oil or hydraulic-fluid lines.

The main part of the lecture was devoted to a discussion of the mechanism of the "crazing" of transparent acrylic-resin canopy materials. It was believed to arise from local tension failure near the surface, resulting in numerous fissures, which affected the transparency of the material and reduced its mechanical strength. As cast, the plastic material retained a variable amount of solvent and also contained random residual stress. An increase in either could cause crazing; attack by solvent alone produced random crazing, whereas the application of stress caused directional fissures. Heat treatment tended to release both solvent and internal stresses. Strains could, however, be re-introduced into heat-treated material by local heating and chilling; moreover, by stretching heat-treated flat sheet to form curved shapes, the solvent absorption at highly curved parts was enhanced. It was necessary, therefore, to heat-treat after shaping.

The differential contraction between the canopy edges and the metal surround could be reduced by reinforcing the plastic with a fibrous material of high elastic modulus, e.g., laminated sheets of glass-fibre cloth impregnated with acrylic resin; this improved the mechanical properties and reduced the overall coefficient of expansion. To overcome the tendency for a pressurised canopy to break up completely if failure occurred at any point in it, a sandwich construction of a tough transparent rubbery material, such as polyvinyl butyrate, between two sheets of acrylic resin could be used; the impact strength, however, dropped sharply at a temperature of about 0 deg. C.

(To be continued.)

HIGHER TECHNICAL AND SCIENTIFIC MANPOWER.*

By The Rt. Hon. Lord Hankey.

High authorities claim that the foundations of the modern university system were laid long before the Christian era, at Athens and Alexandria. Athens came first with Plato's Academy, Aristotle's Lyceum, Zeno's Stoa and the Garden of Epicurus. Next came the Mouseion of Alexandria, which was founded by Soter, the first of the Egyptian Ptolemies (323-283 B.C.) on the model of the Athenian Mouseion, a philosophic establishment that had housed the library of Aristotle. Although the Mouseion of Alexandria did not neglect the humanities its pre-eminence was in science.

On the science side of Alexandria, Euclid composed his *Elements* and founded a mathematical school that lasted 700 years; Apollonius wrote on conic sections; and Eratosthenes the geographer measured the earth and came within 50 miles of the correct diameter. In astronomy, the calendar we now use was worked out; and in medicine, anatomy was taught and vivisection practised on animals and even on condemned criminals. It was to the Mouseion of Alexandria, with its famous scientists, lecture halls, laboratories, huge and well organised library, zoological gardens, park and dining hall that the youth of the ancient world (after primary and sometimes secondary education in Government-supported schools) flocked for scientific and technical training and education.

From that fascinating episode there is one important lesson to be drawn. Unlike the Athenian schools whose income was derived from private sources, the Mouseion of Alexandria was supported by the State, the funds being administered by a priest who was appointed by the King—a prototype, we can imagine, of the chairman of the University Grants Committee. But "he who pays the piper calls the tune" and, under control of the palace, which included both the Court and the Government Offices, the university experienced both the advantages and the disadvantages of Government control.

In less than a hundred years from its foundation, the scientific energy of Alexandria had lapsed. To-day when Governments are, quite rightly, spending large sums on science in their own establishments and in universities, technical colleges and the like, there is a latent danger that pure science, the basis of applied science, may be starved, and that insistence may be too great on immediate and practical results. I do not suggest that it has happened or is likely to happen here in the near future under the present enlightened system, but, on a long view, universities are right to be on their guard against the risk. As was well said by Mr. Gladstone in the first Romanes Lecture, delivered in 1892, with specific reference to our own universities: "The chief dangers before them are probably two: one that in research, considered as apart from their teaching office, they should relax and consequently dwindle; the other that, under pressure from without, they should lean, if ever so little, to that theory of education which would have it to construct machines of so many horse-power, rather than to form character, and to rear into true excellence the marvellous creature we call man; which gloats upon success in life, instead of studying to secure that the man shall ever be greater than his work, and never bounded by it, but that his eye shall boldly run (in the language of Wordsworth) 'Along the line of limitless desires.'"

Some of the mediæval universities were founded by the State, notably the University of Naples, by the Emperor Frederick II in 1222 B.C.; others, like Bologna, by the Popes, and many were associated with monastic orders. The contribution of these early universities to science was limited to a few, like Salerno, which specialised in medicine. Three that tower above the rest are Paris, Oxford and Cambridge, all founded in the Twelfth Century A.D. It was not until after the Restoration that, through the agency of societies in London and Oxford, the Royal Society for the promotion of Natural Science was founded (in 1662) and that, through the earlier stimulus of men like Lord Bacon (1561-1626) and Newton (1642-1727) science began to come into its own. In Great Britain, after Oxford and Cambridge the oldest universities are in Scotland—St. Andrews (1411), Glasgow (1451), Aberdeen (1494) and Edinburgh (1583). Glasgow and Aberdeen were established by Papal Bulls, in Glasgow's case on the model of Bologna, to which university Scotch students had been wont to resort.

The other British Universities are of modern origin. They comprise Durham (1832), London (1836), Manchester (1880), Wales (1893), Birmingham (1900), Liverpool (1903), Leeds (1904), Sheffield (1905), Bristol (1909), Reading (1926), Nottingham (1948) and a number of important university colleges. The remarkable features are, firstly, the extent to which university development in England has advanced since the Great Exhibition of 1851; secondly, the important place that the newer universities occupy in British scientific prestige; and thirdly, the reassuring fact that the older universities whose world-wide reputation was built on the "humanities," while retaining their status in that respect, have also achieved high distinction in science and technology.

The origins of the technical colleges are attributed partly to a welfare movement by working men and partly to the initiative of a few private individuals, notably Dr. George Birkbeck and Professor John Anderson. At the end of the Eighteenth Century two groups of voluntary societies emerged—mechanics' institutes, and literary and scientific societies. The first mechanics' institute was almost certainly in Birmingham, with Glasgow a close second; others developed in Liverpool, Manchester, Huddersfield and London. There were also unions of mechanics' institutes in Yorkshire, Lancashire, Cheshire and London, and by 1851 there were 55 mechanics' institutes in England and Wales. There are now, in 1951, over 500 major establishments for instruction in technology and commerce and almost 10,000 evening institutes. Over two million students attend these institutions.

The 1851 Exhibition, the writings of authors such as Tyndall, Huxley and Darwin, and the many discoveries in science and technology during the Nineteenth Century, produced a climate of opinion favourable to the application of State funds to education. Evening

* Lecture delivered at the Home Office Industrial Museum, London, S.W.1, under the auspices of the Ministry of Labour and National Service, on August 29, 1951. Abridged.

classes were so aided, grants being paid to responsible bodies which arranged courses in science and the arts. Examinations were set by officials of the Science and Art Department of the Board of Trade, established in 1853. At the end of the Nineteenth Century, by voluntary effort very largely, the mechanics' institutes, or other similar organisations, were converted into technical colleges. Also, with supplementary State aid, many important colleges were established, such as Regent-street Polytechnic in 1881, followed closely by six others in London and similar colleges in about 20 other important towns. Those who studied at these colleges cheerfully accepted heavy programmes of evening study after a full day's labour. The system meant the survival of the fittest, for only the strongest and most resolute could stand the strain.

The Education Act of 1902 placed the control of technical education under the county and borough councils, and the first quarter of the Twentieth Century saw a steady development of the original system; more colleges, the provision of course rather than subject instruction, a broader treatment of subjects. The financial arrangements, very broadly, were that half the cost fell on the rates and half on the Exchequer. The system of external examinations then current was replaced, in 1921 and onwards, and for certain types of students only, by a typically British system of examinations, partly external, partly internal, and with many special and admirable features. The awards are known as National Certificates and have a truly national currency. At the present time, the number of entrants for National Certificate examinations in Mechanical Engineering alone exceeds 20,000; the total for all branches of technology is much more than this. A spurt was made in 1936, when the Board of Education announced an intended capital expenditure on technical education up to 12*l.* million, with a similar sum to be provided by the Local Authorities. The response was very satisfactory, but World War II impeded the full implementation of the programme.

To complete the tale of scientific and technical development, the important professional institutions that came into existence during the industrial expansion of the Nineteenth and Twentieth Centuries must be mentioned. As an illustration, I take the three major Institutions of Civil Engineers, founded and incorporated by Royal Charter in 1828; Mechanical Engineers, founded in 1847, and incorporated in 1929; and Electrical Engineers, founded in 1871 and incorporated in 1921. The first had, on July 1, 1951, about 18,500 members, the second 36,000, and the third 37,000. The total membership of the three is of the order of 90,000 members (corporate and non-corporate). The institutions keep their members abreast of engineering developments by lectures, discussions and monthly journals of high quality. They concern themselves with standards of professional competence and education, and co-operate with the Education Departments, and technical colleges, particularly on the standard of National Certificates which are taken into account in the highly-valued qualifications for membership of the respective institutions. Their mutual co-operation *inter se* is very close. There are, of course, corresponding institutions for many other branches of science and technology with similar attributes. Collectively, these institutions make an invaluable contribution to British science and technology. The venerable Royal Society, the doyen and ancestor of the institutions, pursues its ever-expanding task of promoting natural science with vigour and efficiency.

Between the two world wars, the Manpower Sub-committee of the Committee of Imperial Defence had recommended as the pivot of man-power defensive plans the setting up of a Ministry of National Service in the event of war. In August, 1939, the Ministry of Labour, the parent department of the scheme, assumed the obligations and duties of the proposed Ministry, which it discharged with conspicuous success throughout the war. The pre-war preparations included a schedule of reserved occupations, compiled during 1937 and 1938, to provide against the mistake in World War I of enlisting into the fighting Forces skilled men essential for the construction of war material: a Central Register of volunteers for war service by persons with technical, professional and higher administrative qualifications, brought into existence with the aid of the Royal Society, the universities and the principal technical and professional institutions: a General Purposes Committee to control the general conduct of the Register in war time, and, through committee representatives of the various professions, to advise and assist in its use: joint recruiting boards at universities on the outbreak of war, to interview undergraduates and resident university graduates under the age of 25 and to assess their suitability for training as officers and for other forms of national service. Those were the key features of the Ministry of Labour's scheme for higher technical personnel, and I can testify to its essential soundness, for the fates had decreed that I should be associated with it up to this very day.

The story begins at 10.30 a.m. on September 3, 1940, when Air Marshal Sir Philip Joubert, who was responsible in the Air Ministry for radar organisation, came into my office to say that radio-location, or R.D.F. as we then called it, which had been brought to light in 1935 and applied with success in a limited field, had, so to speak, "come round the corner" and that startling new developments were at hand. There were insufficient personnel within the Services to supply prospective requirements and these would have to be obtained from civil life and sufficiently trained. Unless immediate drastic steps were taken, the three fighting Services were threatened with a critical situation. The responsible Minister, Mr. Ernest Bevin, the Minister of Labour and National Service, whom I consulted, at once asked me to take over the job, and placed at my disposal the invaluable services of the Central (Technical and Scientific) Register.

There were two problems; the immediate deficit and the future supply of trained personnel. The first was met apart from the Central Register, by raiding universities, professional institutions, the B.B.C. (including television), the Post Office, and the Dominions, especially Canada. About industry, we had to be careful lest we should "kill the goose that laid the golden eggs"—namely, the priceless radar apparatus. Nevertheless, the Radio Manufacturers' Association rendered invaluable help, e.g., by giving us the names and units of men who had enlisted in the forces, which, as the result of several combings, yielded considerable numbers. By these measures, and with some invaluable help from the United States, we just managed to fill the gap in the critical first year.

The long-range problem was solved, with prompt assistance from the Education Departments, the Committee of Vice-Chancellors of Universities, the universities themselves, and the technical colleges, by the establishment of special courses to which a large proportion of the scientific students was diverted. Eventually, over 50,000 men and women were selected for basic scientific instruction and passed to the fighting Services, research and industry. The supervision of the scheme was undertaken by a Wireless Personnel Committee under the chairmanship of Sir Clement Jones, which overcame innumerable difficulties. Thus the threatened shortage of university students was met by a system of State Bursaries to attract to the course qualified persons who became known as "Hankey Bursars." A tough struggle was to induce the fighting Services to accept women recruits, who in the event proved invaluable. The difficulties in finding competent instructors and technical apparatus for 19 universities and university colleges, and 93 technical colleges were very great. For the instructors (who did a wonderful job in this new science) summer schools were held, twice in London, and once at St. Andrews University.

Scarcely was the radio personnel problem in hand before Mr. Bevin consulted me about extending to the whole range of higher technical personnel the methods that had succeeded in radar, and, in August, 1941, the Technical Personnel Committee was set up, with myself as chairman and Sir Clement Jones as deputy chairman, "to consider questions relating to the demand and supply of technical personnel and to increase the supply of certain types of scientists and engineers needed for the war effort." This time, to meet the urgent demands of the Services, which were mechanising themselves at a staggering rate as apparatus poured out of the factories, we had to ask industry to release hundreds of engineers at the risk of reducing output. Industrialists took the big line. They saw that their apparatus would be useless without skilled personnel for operation and maintenance, and, with assistance from the Institutions of Civil, Mechanical and Electrical Engineers, we managed to meet all needs.

I was, however, always anxious about what would happen in the event of a very long war, and in October, 1942, we introduced a scheme of engineering cadetships for youths aged 16 to 19, leading to technical commissions in the Services so as to enable the future needs of industry to be met without adversely affecting their capacity to equip the armed Forces. Training was again carried out largely at technical colleges, and about 3,000 youths had been trained or accepted for training under the scheme when, in 1944, owing to the improvement in the military situation, it was suspended.

It is important to note that a high proportion of those who took the courses proved acceptable to the fighting Services on technical grounds. The educationalists had done their job well. What disturbed us was the number rejected by the Services—especially the Army—for want of what was termed "officer qualities," notwithstanding that the original Boards which "vetted" the candidates before their selection had taken that factor into account. It was extremely irritating to all concerned, and I never got to the bottom of it; but, in my experience in peace and war, the qualities of "leadership" and "character" are harder to find and even more important than technical capacity.

(*To be continued.*)

BOILER AND TURBINE TESTING.*

By CAPTAIN (E) L. F. INGRAM, R.N., and CAPTAIN (E) L. A. B. PEILE, D.S.O., M.V.O., R.N.

(*Continued from page* 287.)

THE other feature that was not entirely satisfactory was boiler-casing lagging. The use of economisers usually results in fitting fewer rows of generating tubes in the tube bank and, therefore, in higher gas temperatures over a considerable area of boiler casing; this, coupled with increasing congestion in the boiler room, has led to complaints from sea of hot pockets and high firing-space temperatures. With so much thought and effort being devoted to weight-saving, it seemed desirable not to adopt an overall increase in lagging scantlings, but rather to await shore trials experience. From a habitability stand-point, conditions in the boiler room are worse at low powers, when the general air velocities in the stokehold are low and heat radiated from hot surfaces is not carried away. Trials were therefore carried out at one-tenth and three-tenths power and it was apparent that working conditions would be unpleasant in tropical climates. The average metal temperature of the boiler casings was 200 deg. F. at three-tenths power, which resulted in temperatures being recorded on the floor plates some 30 deg. F. above the outside air temperature. The boiler-casing lagging comprised 1-in. thickness of Newall's "Newtempheit" high-temperature insulating block. The associated gas temperature inside the boiler casing during this trial was 700 deg. F.

On a weight basis, the most economical method of improving habitability was to build a light metal air-casing external to the boiler, arranged so as to lead the air supply to the registers. This was estimated to impose an additional resistance on the discharge side of the forced-draught fans of 0·6 in. w.g., and the stokehold air pressure of 15·6 in. w.g. was already considered high enough. Again the register design was referred to the Admiralty Fuel Experimental Station, to see if the draught loss across the register could be reduced. This was achieved by increasing the area for flow of primary air at the entrance to the register. While new boiler fronts were being fitted to accommodate the revised register arrangement with the larger sprayers, opportunity was taken to remove some 30 superheater tubes. Although, on the initial trial, the superheater performance conformed with expectations, the fitting of baffles below the superheater tubes had increased the gas flow through the superheater and this raised the superheat temperature. Removal of these superheater tubes restored the balance of the design and subsequent trial proved that the additional steam pressure drop through the superheater was acceptable.

Trials were then resumed. The re-designed registers effected the necessary saving in draught loss, and the effect of the increased distance of the registers from the heating surfaces, resulting from fitting larger sprayer caps, eliminated all flame impingement. As a result a clear funnel was obtained with a CO_2 value of 13 per cent., corresponding to an air : fuel ratio of 17 : 1. With the elimination of burning in the tube bank, the mean gas temperature below the economiser at full power was further reduced from 860 deg. F. to 790 deg. F. The "habitability casing" built round the boiler resulted in satisfactory floor-plate temperatures at 3/10 full power, the surface temperature of this casing being 130 deg. F.

A series of trials was now conducted up to 6/5 power, which constitutes the performance record of the boiler. During these trials, calorimeter readings had shown figures of 2 and 3 per cent. wetness at high output, and it was decided that a further series of trials was required to investigate and rectify this trouble. Some difficulty had been experienced with the throttling calorimeters, due largely to the awkwardness of the main steam-pipe leads and to the cooling air flow caused by the habitability casing; some time was also occupied in trying different designs of sampling nozzles, but it was not found practicable to obtain an accuracy greater than $\pm \frac{1}{4}$ per cent. Several schemes for internal drying were tested, and, in addition, an external helix dryer of the Superheater Company's design was fitted in the saturated pipe between the steam drum and the superheater.

The different designs of internal gear produced results varying from 1 per cent. to 5 per cent. wetness at full power. With a good design of internal steam separator, the additional use of an internal dry pipe reduced the wetness from about 1 per cent. to about 0·8 to 0·9 per cent. In the trials arranged particularly to test the helix dryer, varying degrees of wetness were produced artificially by raising the water-level and by overdosing the water with boiler compound to give figures of 0·5 to 5 per cent. at two or three powers.

* Paper presented to the International Conference of Naval Architects and Marine Engineers at a meeting held in London on June 27, 1951. Abridged.

ELECTRICAL MEASUREMENT OF MECHANICAL QUANTITIES.

FIG. 1. CONVERTER.

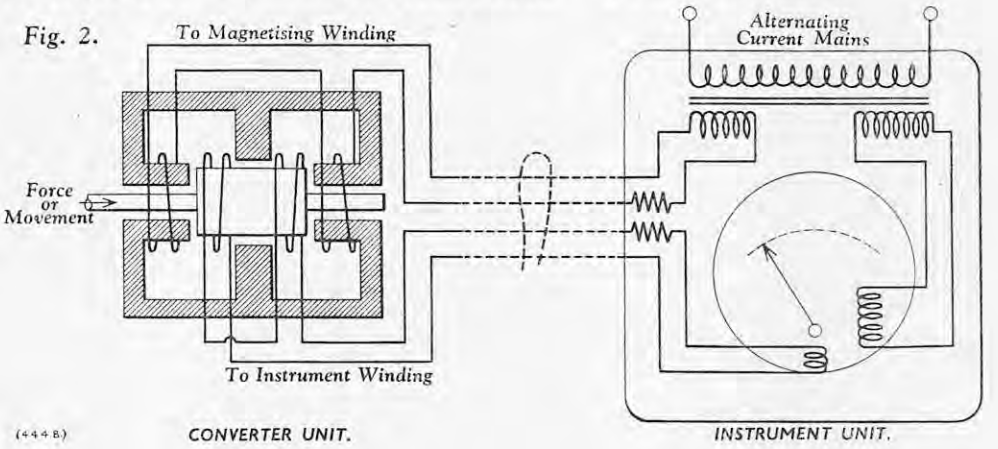

Fig. 2.

The trials showed the helix dryer capable of removing, on average, four-fifths of the moisture, irrespective of the wetness before the dryer.

As a result of these trials, it became clear that the main cause of wetness was the use of an internal feed pipe which sprayed water into the steam space. By feeding below the water level, a maximum wetness figure of 0·5 per cent. at full power was obtained with a relatively simple arrangement of internal gear, and without having recourse to an external dryer. The immediate effect of drowning the feed was to cause hunting of the water-level, but the addition of a steam-flow component to the feed-water regulator steadied up the rate of feed and the water-level hunting ceased.

Having settled the dryness problem, this prototype boiler test was concluded by a final series of performance trials to check previous results. Throughout these trials, various incidental tests were made on safety valves, and brick and casing temperatures, some of which were necessarily of long duration. Apart from the collection of data on performance, valuable to the designer as a check on his technique and methods, and valuable to the Admiralty for present use and also in the identification of possible troubles in service, these trials gave timely indication of the necessity to modify superheaters, combustion equipment—both from the efficiency and handling aspects—and the internal drying gear.

The above notes on the Daring boiler trials give some indication of the work done at A.F.E.S. on the development of oil-burning registers. Thirteen per cent. CO_2 is considered the standard to be achieved for combustion efficiency, with 15 per cent. as the aim, though this latter figure represents only 10 per cent. excess air. In these tests, CO_2 readings are taken with an infra-red recorder, an electrical conductivity recorder, and two chemical-type recorders drawing samples from single and multiple nozzles above the economiser. With a draught loss of 6½ in. across the register, 2,000 lb. per hour sprayers have been burned to give a compact flame 8 ft. to 9 ft. in length. In a normal design of furnace, this will give a heat-release rate of about a quarter of a million B.Th.U. per cubic foot of combustion volume per hour. To improve upon this, a higher draught loss across the register will be necessary, which brings many problems in its train; for a register draught loss of 15 in. w.g. would mean a total drop across the boiler of around 50 in. w.g.

Tests which have been carried out with many different burner caps, with fuel-oil pressures varying from 100 to 1,500 lb. per square inch, show that combustion is best when the droplet mean diameter is between 80 and 110 microns. For a given output, the higher the viscosity the larger the droplets, while increase of fuel-oil pressure decreases the droplet size. Because of the need for sufficiently small droplets at minimum output, it was found necessary in one naval design to use an oil pressure for full output of 600 lb. per square inch; at that pressure, a viscosity between 40 and 75 seconds Redwood I gave the best results.

Extensive tests are being made of wide-range burners, and various commercial types are being tested from absolute and comparative aspects. The objective is to develop a fully reliable burner with a maximum output between 3,000 lb. and 5,000 lb. of oil per hour, and having a 20 : 1 turn down, as compared with 1·4 : 1 for the type used in the Daring trials. It appears desirable that the spray angle shall be as nearly as possible 90 ± 5 deg. over the full range. Constant attention is given to the installation and user aspects, in that the simplest possible arrangement of plant, piping and control is the objective, and also that the burner shall require the minimum attention for cleaning or adjustment. The types of burner under test are the centre spill, outside spill and air or steam-assisted atomisers.

To give more scope and facility for burner and register tests, the present test boiler, which delivers 80,000 lb. of steam per hour at 400 lb. per square inch and 700 deg. F., is being superseded by a specially-designed combustion-test boiler with a rear wall which can be adjusted to give a furnace length from 7 ft. 6 in. down to 3 ft., and fitted for any degree of air preheat and for very high air pressures. Modern boiler designs tend to use more furnace cooling surface; good combustion at low boiler outputs is therefore more difficult to achieve. The combustion-test boiler will have an all-cooled furnace.

Another field of activity of the A.F.E.S. is the testing of refractories. Here the effort has been directed to the production of material specifications which will ensure the greatest resistance to spalling and slagging of firebricks, avoid the use of materials not available in this country, and provide a serviceable and light design of furnace lining as a whole. During this study, it has become apparent that firebrick temperatures are not as high as had been generally supposed, even with quite high furnace heat-release rates. Typical figures for a furnace having three refractory and three tube walls, at a heat-release rate of $0·2 \times 10^6$ B.Th.U. per cubic foot per hour, show a furnace temperature of 2,600 deg. F. and a firebrick hot-face temperature of 2,430 deg. F.; with the higher heat-release rates produced during experimental trials, furnace and hot-face temperatures of 2,850 deg. F. and 2,730 deg. F., respectively, have been recorded. The brick temperatures quoted are those of the hottest bricks in the furnace; those adjacent to tube walls would be about 100 deg. F. cooler. The direct effect of excess air has been shown to reduce furnace and firebrick temperatures by about 70 deg. F. for every 10 per cent. excess air.

Firebricks are refractories, not insulants. The temperature drop across the whole thickness of a 4½-in. brick is of the order of 300 deg. F., leaving a drop of some 2,000 deg. F. to be absorbed by the insulating bricks and the slabs of insulating material which are arranged behind the firebricks. If the thickness of the firebrick is reduced to 2½ in., the additional temperature drop of 130 deg. F. is accommodated almost entirely by the insulants, and the resulting increase in hot-face temperature of the firebrick is less than 10 deg. F. In these trials, brick temperature measurements were taken both by the temperature-gradient method and by direct surface measurement, using platinum : platinum-rhodium thermocouples; furnace temperatures were measured with aspirating thermocouples.

The minimum limit of alumina specified for firebricks for naval use has been progressively raised to give a higher refractoriness, but, quite recently, study at A.F.E.S. has led to the conclusion that an increase in alumina over 43 per cent. nearly always leads to a lower sea-salt slagging resistance. This, together with the knowledge that firebrick temperatures are lower than was supposed, has led to the pyrometric cone equivalent being fixed at No. 33 (3,145 deg. F.), which can be met with a 43 per cent. alumina content. The alumina limit is therefore omitted from the latest refractory specification, and clauses covering porosity and contained fluxes have been tightened up. Spalling and slagging call for some opposing qualities; spalling resistance generally increases with coarse grain and porosity, while slagging resistance is lowered. Trials are therefore in hand to test coatings resistant to the slagging mechanism on a firebrick highly resistant to spalling.

Of great significance is the question of fuel-oil quality and, in particular, contamination of oil by salt water in the form of an emulsion. This contamination arises chiefly in ships in which empty fuel-oil tanks have to be ballasted with sea water to preserve stability. In such ships, emulsions containing 15 to 20 per cent. of sea water have been encountered; 76 per cent. sea water in emulsion is the maximum physically obtainable, and in one exceptional case an emulsion containing 50 per cent. sea water was recorded in one of H.M. ships. With emulsions containing 15 per cent. or more of sea water, the fuel-oil sprayers commence spluttering and the presence of water is apparent, but emulsions containing 11 to 13 per cent. have been burnt without any evidence of contaminated fuel at the sprayer.

It must be remembered that a one per cent. sea water in fuel-oil emulsion will throw into the furnaces 700 lb. of fluxing agent per 1,000 tons of fuel oil burnt. The results of burning these emulsions are the slagging of furnace brickwork and the formation of bonded deposits in the economisers and tube banks. Diagnosis of these troubles, together with a solution of the problem of how to break these emulsions, has been the result of trials at A.F.E.S., and this work has already been reported in a paper "Sea Water Contamination of Boiler Oil Fuel and its Effects," by C. J. Gray and W. Kilner, *Trans. I.Mar.E.*, vol. 60, page 43, 1948.

(To be continued.)

THE ELECTRICAL MEASUREMENT OF MECHANICAL QUANTITIES.

AN electrical method of measuring mechanical quantities has recently been devised by Salford Electrical Instruments, Limited, Silk-street, Salford, in association with the Research Laboratories of the General Electric Company, Limited. It consists essentially of a "converter," which converts a mechanical displacement, such as is set up by pressure, tension, weight or temperature in springs, levers, bellows or capsules, into an electric current; and an instrument which indicates this current and thus allows the displacement to be ascertained either directly, or indirectly in conjunction with a conversion table or curve.

The converter (shown in Fig. 1, on this page), is housed in a cylindrical aluminium casting, 3½ in. in diameter and 5 in. long, which has a flange 5 in. in diameter at one end. It is protected from external magnetic leakage and temperature errors and can be installed near masses of metal without the calibration having to be altered. Its robustness ensures that a minimum of maintenance and attention will be necessary. A rod, which is not shown in the illustration, projects from the centre of the flange and in its end there is a hole tapped with a No. 2 B.A. thread to which the mechanical conversion equipment is connected. The converter is also connected by a four-core cable to an instrument unit, as shown in Fig. 2. The standard length of this cable is 10 ft. but longer lengths can be used if the setting of a self-contained resistor is altered. The instrument unit, too, is of all-metal construction and is 12½ in. square by 8 in. deep. It contains an instrument, 8 in. in diameter, which is provided with a 100-deg. scale calibrated in thousandths of an inch, as well as a switch and indicating lamp. It also contains a transformer, although this can, if desired, be mounted separately. Further, it can be provided with a ten-way switch, so that a number of converters can be connected to it in turn. Arrange-

HEAVY MOTOR LORRY WITH LOADING WINCH.

TRANSPORT EQUIPMENT (THORNYCROFT), LIMITED, LONDON.

FIG. 1.

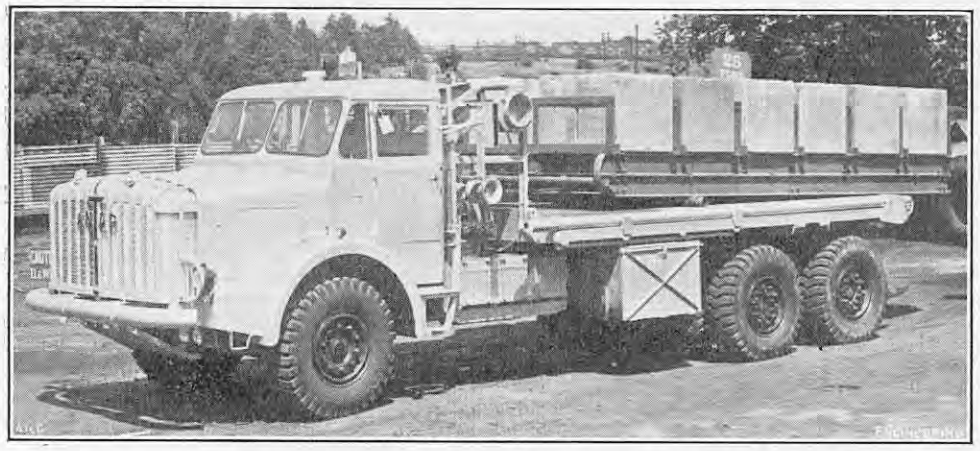

FIG. 2.

ments can be made for automatic operation of alarms, recorders and relays.

The converter consists of fixed and moving cores made of an insulated magnetic powder, Gecalloy PL, which is compressed to accurate dimensions by moulding. This process also imparts adequate permeability, high stability and nearly linear magnetising characteristics to the moving core, so that its response to the output current is also approximately linear. This linearity is maintained even when the moving core approaches the fixed core, thus providing a great improvement over the use of stampings. The low magnetising current, which is supplied from the transformer in the instrument unit, also results in the attraction between the fixed and moving coils being small, thus avoiding magnetic instability. In addition, the cores can be made cylindrical with the windings inside them and the air gap at the physical centre, as is essential if the external leakage field is to be negligible.

The material of which the core is made is self-supporting, so that clamps or spacers are not required. The actuating rod from the mechanical system passes through holes in the centre of the moving core and is located by beryllium-copper spiders, the mechanical hysteresis of which is negligible. It is claimed that the conversion of mechanical movement into electric current takes place without appreciable loss or temperature rise and without interference from external circuits or adjacent metal. The primary winding of the converter, which may be regarded as a variable-ratio transformer, is supplied from the mains, while the secondaries, as can be seen in Fig. 2, are connected in opposition, so that no voltage is induced in the connections to the instrument when the moving core is in its zero position. Variations in the moving core, which is placed centrally in the electromagnetic circuit of the converter, result, however, in changes in the effective mutual inductance; but these changes are dependent solely on the position of the core and are not affected by variations in the supply voltage or frequency.

The indicating instrument is of the moving-coil type, although the usual permanent magnet is replaced by an electromagnet supplied from the transformer secondary, as shown in Fig. 2. The conventional control spring is also replaced by ligaments, so that the torque is produced solely by the alternating current magnetic fluxes of the electromagnet and the output of the converter which flows through the moving coil. The instrument can also be incorporated in a recorder circuit.

As a result of tests extending over a year, it has, we understand, been found that a high degree of stability can be obtained at widely varying temperatures and that the electrical system will maintain an accuracy of at least 2 per cent. over most practical operating conditions. The applications of such a system are numerous, among the most important being the measurement of displacements up to $\frac{1}{10}$ in. with full-scale deflection on the instrument. The latter can, however, be modified to give about one-tenth of this value. Weights from a few ounces to many tons can also be ascertained by measuring the deflection of a beam or beam system of known mechanical characteristics, and by employing a calibrated spring the tension of ropes, ties or cables can be measured. It would appear possible that converter units can also be built into a bridge or other structure to register the variation of load continuously. Gas pressures can be measured by utilising bellows, diaphragms or capsules as the transmitting medium.

MANUAL OF RADIO VALVES.—*The Valve Manual*, Part I, which has recently been published by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, at the price of 5*s.*, is intended as a guide for radio engineers engaged in the maintenance or design of broadcast receivers. Full characteristics, operating data and curves are given of the many types of amplifying and rectifying valves, cathode-ray tubes, photoelectric cells, current and voltage-regulator tubes, neon indicators, Geiger-Müller tubes, gas-filled arresters, and crystal valves, including silicon and germanium diodes. All this useful information is accompanied by a short historical retrospect, which indicates the progress that has been made in this class of electrical apparatus since 1918, and by some notes on manufacture, which will be studied with interest. There are a number of useful diagrams and an index.

25-TON MOTOR LORRY WITH LOADING WINCH.

TRANSPORT EQUIPMENT (THORNYCROFT), LIMITED, Smith-square, London, S.W.1, introduced last year a heavy tractor, known as the Mighty Antar and designed for transporting abnormally heavy loads over rough ground. The first of these to be produced were designed for use in conjunction with Crane trailers on a pipe-laying project in the Middle East and an illustrated description of both the tractors and the trailers was given in ENGINEERING, vol. 169, page 341 (1950). Recently, the company completed three further vehicles of this type for the Shell Petroleum Company, Limited, St. Helen's-court, Great St. Helen's, London, E.C.3, two of which will be shipped to Sarawak and the other to Venezuela for use in the oilfields of those two countries. One of the vehicles is illustrated in Figs. 1 and 2, on this page, from which it will be seen that it is equipped with a platform body instead of the turntable described in connection with the earlier models. The body, which was designed and constructed by Messrs. R. A. Dyson and Company, Limited, Liverpool, is of all-steel construction and has been made to transport loads up to 25 tons. Basically, the chassis is a standard "Mighty Antar" six-wheeled unit with a mean wheelbase of 21 ft. but fitted with rear-bogie beams in place of the rear springs and provided with a power take-off on the auxiliary gearbox arranged to drive a Tulsa "70" 50,000-lb. winch mounted behind the driver's cab.

A notable feature of the vehicles is their self-loading characteristic, it being possible to load skid-mounted rigs up to the full load of 25 tons merely by using the winch and a heavy-duty roller fitted to the tail of the platform body. This self-loading operation, it is claimed, can be completed in a matter of minutes by the driver and his assistant without any extra help or equipment; similarly, unloading can be accomplished by using the reverse procedure. When loading, the winch cable is attached to the forward end of the load, which subsequently is drawn towards the tail of the vehicle by means of the winch; alternatively, the vehicle can be reversed up to the load. When the point of attachment of the winch cable is vertically below the tail roller, it draws the forward end of the skid on which the load is mounted upwards until it makes contact with the tail roller on the body. During the next stage, the bottom surfaces of the skid "runners" ride over the roller and the load, still with its rear end on the ground, is hauled forward over the body of the vehicle. Eventually the load reaches a state of balance on the axis of the roller, the tail, as a consequence, rising from the ground and its nose descending towards the platform. It may be noted that, at this point, the front wheels of the vehicle rise from the ground by approximately 2 ft. for a few moments, as shown in Fig. 1. Further winching lowers the load on to the platform and, at the same instant, the front wheels descend gently to the ground.

If a long journey is contemplated, the load is winched well forward on to the body. On the other hand, if it is only a short trip to the off-loading point the forward end of the skid is lowered on to a roller and winched forward just far enough for stability to be obtained as shown in Fig. 2. By adopting this method, it is only necessary to accelerate the vehicle with the winch cable slack to bring the load back to the point of balance.

REGISTER OF LIGHTING ENGINEERS.—The Illuminating Engineering Society, 32, Victoria-street, London, S.W.1, have issued a Register of Lighting Engineers. It consists of the names of those members who have applied for inclusion, have been a member in some class in the Society for not less than one year, are in the possession of certain educational and technical qualifications, and have been engaged in the practice of illuminating engineering for not less than five years. Only those included in the Register will be entitled to adopt the description of "Registered Lighting Engineer," but registration will not be regarded as a condition either of membership or of fellowship of the Society.

RECOVERY OF WASTE PAPER AND CARDBOARD.—The output of packaging material, on which every industry depends, is being slowed down by the shortage of recovered waste paper and cardboard. Waste-paper merchants are prepared to buy waste from business houses and manufacturing firms; addresses of such merchants can be obtained from the Waste Paper Recovery Association, 52, Mount-street, London, W.1. Last year the total amount of waste paper returned for re-pulping was 847,055 tons, but the total consumption was 887,082 tons. This year the rate of consumption has already reached 1,000,000 tons and more will be needed; a total waste collection of 1,200,000 tons should be attained.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

THE COAL SITUATION.—Many coal consumers are awaiting with some anxiety the extra output promised by the resumption of the 11-day fortnight in the industry after three months during which a five-day week operated. The reduced availability which resulted has made considerable inroads into the favourable margins built during the spring and early summer. Screened coal has been particularly scarce, house-coal stocks have fallen well below last year's standard, and the reserves at gasworks are again lower than in 1950. Ground stocks at power stations are greater, but are not sufficient to cope with the increased generating plant which will be in commission during the winter. General industrial users, although suffering reduced deliveries, have contrived to maintain better supplies than was the case last year.

GREENOCK HARBOUR TRUST.—Speaking at a luncheon on August 28, Mr. W. J. Coutts, chairman of Greenock Harbour Trust, stated that the income of the Trust, for the year ended June, 1951, had established a peace-time record well above the 1939 level. Imports of sugar had brought in the highest revenue, the income from ship repairs and fitting-out coming second in importance.

DUNDEE HARBOUR BOARD.—At a meeting on August 27, Dundee Harbour Board decided not to enter into negotiations with Shell-Mex & B.P., Ltd., for the lease of ground at Stannergate for use as a proposed tanker depot. The Lord Provost, Mr. Richard Fenton, opposing the proposal, said the ground in question had been described as an ideal site for a dry dock.

ECONOMIC EXPANSION IN SCOTLAND.—An interim report by Mr. Tom Burns, the secretary of the Cairncross Committee set up to recommend economic expansion in parts of Scotland where more industrial employment is necessary and desirable, has been published. This states that, while a few new industrial areas came into being in Scotland between 1937 and June, 1951, they were mainly extensions of the old ones. Mr. Burns emphasised the "tremendous concentration" of new plants to the south-east and south-west of Glasgow.

CLEVELAND AND THE NORTHERN COUNTIES.

SUPPLIES OF IRON ORE AND SCRAP.—Following on the recent rise in fixed prices of iron and steel, the announcement of the increase of 2*l.* in the maximum permitted quotations for ferrous scrap was no more than had been generally expected in North-East Coast commercial circles. Apart from small amounts to cover the extra cost of transport, this is the first general allowance in scrap prices for 14 years and it is hoped that the movement will stimulate the home scrap drive, upon the success of which the restoration of the steel industry to peak activity very largely depends. The improvement in ore supplies from home sources and from abroad is now very marked and the continuation of the present rate of deliveries promises to enable consumers soon to re-establish stocks at satisfactory levels. The scarcity of iron and steel scrap is still acute.

BLAYDON TO CARLISLE OVERHEAD TRANSMISSION LINE.—Several public and other bodies in Northumberland are raising objections to the route to be taken by a proposed new overhead power-transmission line to be erected by the British Electricity Authority between Blaydon-on-Tyne, County Durham, and Carlisle. The proposed route, within the Northumberland County boundary, crosses the Tyne at Newburn and on to Heddon-on-the-Wall, Horsley, Stagshaw, Fourstones, Haydon Bridge, Bardon Mill and Haltwhistle. The Ministry of Fuel and Power have arranged for a hearing to be held in Newcastle-on-Tyne, probably on September 26. Some of the objectors, who are numerous, argue that, as the scheme is of concern to many people in all walks of life, the whole question should be discussed at a public inquiry instead of at the Ministry hearing. It is generally agreed that the line must be erected in the public interest, and the only contention is the route to be taken.

REMAINS OF ROMAN BRIDGES AT CARLISLE.—While dredging was in progress in the river Eden near Carlisle, what are thought to be stones from a bridge built by the Romans were brought to the surface. They were found close to Eden Bridge on the main road to Scotland and near the place where Hadrian's Wall is thought to have crossed the Eden. The stones have been examined by archæologists; they are stated to consist of red sandstone and to have been well preserved by the gravel of the river bed. Operations have since revealed evidence of a second bridge.

LANCASHIRE AND SOUTH YORKSHIRE.

FUEL STOCKS.—In Yorkshire, industrial coal stocks are 49,500 tons higher than they were a year ago, and reserves for electric power plants are 16,000 tons greater. Stocks at gasworks, however, are equivalent to 2·6 weeks' supply only, at the anticipated winter level. Moreover, stocks of household coal, in Yorkshire, are lower than they were a year ago. The Yorkshire opencast coal output, it is estimated, has fallen short of the target, on account of bad weather conditions and the exhaustion of the more easily worked deposits.

FURTHER STEEL EXTENSIONS.—A three-year programme of extensions to the Appleby-Frodingham Steelworks, at Scunthorpe, has been submitted by the United Steel Companies, Ltd., Sheffield, to the Iron and Steel Corporation. The chief features will be two new blast-furnaces, a large crushing and sintering installation, and a blowing plant. The primary object is to increase the ironmaking capacity of the works to keep pace with its steelmaking possibilities and to supply iron to one of United Steel's other concerns, the Steel, Peech & Tozer works, at Templeborough, Sheffield.

SHEFFIELD-MANCHESTER RAILWAY ELECTRIFICATION.—The electrical operation of the railway between the concentration yards at Wath-on-Dearne and a point near Wombwell Main Colliery has been officially commenced. It is the first phase of the electrification of the railway between Sheffield and Manchester via Penistone.

STAGGERED WORKING HOURS.—More than 3,000 firms in Sheffield and Rotherham will operate a scheme for staggering working hours, to ease the electricity load at critical peak times this winter. Apart from minor variations, the scheme will be virtually the same as that adopted in the winter of 1949. Staggering will be in force from November 1 to March 31, and will involve a late shift once a week in industry.

THE MIDLANDS.

RURAL WATER SUPPLIES.—The Leek Rural District Council, in North Staffordshire, propose to supply water to 12 parishes in the north-east part of the county. Permission has been sought from the Ministry of Local Government and Planning to build a weir and intake works on the river Manifold, at Hulme End, near the Derbyshire border. The necessary works are estimated to cost 250,000*l.*, and the amount of water to be taken from the river is 300,000 gallons daily. Objections have been raised, however, and a public inquiry will be held at Leek on September 12.

PROPOSED CLOSING OF BRANCH RAILWAY.—The Railway Executive announce that it is proposed to close the branch railway between Leominster and Bromyard. The railway, a single track, is part of the line which joins Worcester and Leominster, but it is not proposed to close the section between Worcester and Bromyard. The part which it is proposed to close serves a rather isolated district.

THE COLLECTION OF SCRAP METAL.—The Town Council of Walsall have started a scheme for scrap-metal recovery which, it is hoped, may be taken up by other towns in the area. The Council propose to collect scrap metal of every description from private houses, and special journeys are to be made by refuse-collecting vehicles into all parts of the town for this purpose. Inhabitants will be notified beforehand when a vehicle is to visit their area, and will be encouraged to put out every piece of scrap metal they can find. The amounts which can be collected from individual householders will obviously be small, but Walsall has a population of over 114,000, and in the aggregate the quantity could reach useful proportions.

THE BIRMINGHAM JEWELLERY QUARTER.—Correspondence in the local Press has once more turned attention to the factories in the Birmingham jewellery quarter. The area concerned is unique in some respects. It still retains some of the small factories which were made out of dwelling houses built in the Eighteenth and early Nineteenth Centuries. At first, the houses themselves sufficed for manufacturing purposes, but in the course of time extensions were added, until the whole jewellery quarter contains a mixture of buildings of many sizes and shapes. The question of these factories has been raised many times in the last decade, and there is general agreement that many of them are unsuitable by modern standards. In 1944, the Birmingham Jewellers' Association started to prepare a plan for rebuilding the entire jewellery quarter, and large blocks of "flatted" factories were proposed, to house the many small businesses which are characteristic of the trade. It was soon realised, however, that the cost would be prohibitive. Since that time, costs have risen, and the question is no nearer to a solution.

ROAD PASSENGER TRANSPORT IN THE MIDLANDS.—A warning has been issued by the Birmingham City Transport authorities, who operate about 1,500 vehicles, mainly in the city itself, that, unless the number of drivers and other operating staff can be brought up to strength, services will have to be cut. There are over 1,100 vacancies at present. Revised schedules have been prepared, and they will be put into operation unless the labour problem is solved soon.

ENGINEERING RESEARCH DISCUSSIONS; UNIVERSITY OF NOTTINGHAM.—During the forthcoming session, the Engineering Departments of Nottingham University, of which Professor J. A. Pope, D.Sc., is Head, will be holding a series of research discussions at post-graduate level in various branches of engineering technology, with the main object of facilitating co-operation between the University and industry. The subjects to be dealt with are the Dynamic Properties of Metals, the Fatigue of Metals, Structural Analysis and the Use of Models, the Use of Analogies in Fluid Mechanics, Photo-elasticity and the Dynamic Properties of Rubber. There will be three or four lectures, each followed by discussions, in each subject, and they will be held on Wednesday afternoons, from 2.30 to 4.30, the first on October 17. The lectures and discussions are open to all interested persons, without fee, but those wishing to avail themselves of the facilities offered are asked to write to the Registrar, University of Nottingham, University Park, Nottingham, to obtain a syllabus and enrolment form. By the interesting innovation of these discussions it is hoped that designers and research workers from firms and institutions within reach of Nottingham will be made familiar with the work being carried on in the University and will be able to make suggestions to facilitate this work. In this way the link between the University staff and those engaged in industry should be strengthened to the advantage of both.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEVILL'S DOCK, LLANELLY.—The second oldest dock in the Bristol Channel, Nevill's Dock, Llanelly, is to be filled in because of the closure of the port of Llanelly by the local Harbour Trust last February. The decision was taken on account of the Trust's financial difficulties. The dock played a great part in Llanelly's industrial development since the early Nineteenth Century and also occupied an important place in the early days of the West-Wales coal-export trade 150 years ago. When filled in, the dock will provide an industrial site.

TROSTRE TINPLATE PLANT.—A number of tin workers have received notification to report for duty at the new Trostre tinplate cold reduction plant at Llanelly No forecast has yet been made by the Steel Company of Wales, Ltd., as to when the works are likely to go into production. A number of men have been called upon for training and a section of the new plant is undergoing preliminary tests.

SUSPENSION OF BUILDING OF DOWLAIS STANDARD FACTORIES.—On account of the great improvement that has taken place in the employment position in the town, the Merthyr District Employment Committee have decided that they were no longer justified in pressing for the completion of two standard-type factories at Dowlais. It was stated at a meeting of the Committee that when the development plans for local factories were completed the difficulty might be to find sufficient skilled labour. Work on the standard factories, on which 30,000*l.* had been spent, has been suspended owing to Government cuts in capital expenditure.

TRAFFIC AT SOUTH WALES PORTS.—During the four weeks ended August 12, the South Wales ports, between them, handled 1,437,366 tons of traffic, which was 104,361 tons more than in the corresponding period of last year. Imports rose by 112,860 to 691,992 tons, but exports fell by 8,498 tons. Coal and coke shipments were down from 292,049 to 216,186 tons, but shipments of oil and spirits jumped from 67,576 to 116,733 tons and general cargo from 6,727 to 11,189 tons.

PRODUCTION OF ARMSTRONG SIDDELEY SAPPHIRE ENGINES.—The Hawker Siddeley group has formed a new company, Brockworth Engineering, Limited, who are to add to the production of Armstrong Siddeley Sapphire axial-jet engines for the Royal Air Force; Sapphires are at present being built in this country by Armstrong Siddeley Motors, Ltd., Coventry. They are taking over three-quarters of the floor space of the Hucclecote, Gloucestershire, works of Hawksley Constructions, Ltd. The directors of the new company are Sir Frank Spencer Spriggs, K.B.E., chairman; Mr. Hugh Burroughes, F.R.Ae.S., Mr. H. T. Chapman, C.B.E., M.I.Mech.E.; F.R.Ae.S., and Mr. W. F. Saxton, M.B.E.

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.

ROYAL AERONAUTICAL SOCIETY.—Monday, September 10, 6. p.m., Royal Institution, 21, Albemarle-street, W.1. 39th Wilbur Wright Memorial Lecture on "The Well-Tempered Aircraft," by Mr. A. E. Raymond.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Central London Branch:* Monday, September 10, 7 p.m., St. Ermin's Hotel, Caxton-street, Victoria-street, S.W.1. "The Engineer and the Welfare State," by Mr. R. F. Mathieson. *South West London Branch:* Tuesday, September 11, 8.15 p.m., St. George's Hall, St. George's-road, Wimbledon, S.W.19. "Mercury-Arc Rectifiers," by Mr. C. H. Brown. *Bradford Branch:* Wednesday, September 12, 7.30 p.m., The Midland Hotel, Bradford. "Modern Factory Lighting," by Mr. A. G. Smith. *Bristol Branch:* Friday, September 14, 7.30 p.m., The Grand Hotel, Bristol. "The Development of the Clyde Passenger Steamer," by Mr. A. S. Miller. *Crewe Branch:* Friday, September 14, 7.30 p.m., Crewe Arms Hotel, Crewe. "Limitations of Science," by Mr. J. Levitt. *Nottingham Branch:* Friday, September 14, 7.30 p.m., The Old Angel Inn, Stoney-street, Nottingham. "Power Cable Design," by Mr. F. V. Howitt.

INSTITUTION OF MECHANICAL ENGINEERS.—"General Discussion on Heat Transfer," organised by the Institution and the American Society of Mechanical Engineers, at Storey's-gate, St. James's Park, Westminster, S.W.1. Tuesday, September 11, 10 a.m., "Heat Transfer with Change of State"; 2 p.m., "Heat Transfer Between Fluids and Surfaces"; 8 p.m., Reception and Conversazione. Wednesday, September 12, 10 a.m., "Conduction in Solids and Fluids"; 2 p.m., "Radiation, Instrumentation, Measurement Techniques and Analogies,"; 8.30 p.m., James Clayton Lecture on "Problems in Design and Research on Condensers of Vapours and Vapour Mixtures," by Professor A. P. Colburn. Thursday, September 13, 10 a.m., "Special Problems"; 2 p.m., Closing Technical Session. For further information, see page 96, *ante*. *Southern Branch:* Wednesday, September 12, 7 p.m., Royal Aircraft Establishment Technical College, Farnborough, Hampshire. Repetition of James Clayton Lecture on "The Aviation Engine," by Air-Commodore F. R. Banks.

INSTITUTION OF WORKS ENGINEERS.—*Birmingham Branch:* Tuesday, September 11, 7 p.m., Grand Hotel, Birmingham. Annual General Meeting. (To be followed by annual dinner.) *Glasgow Branch:* Monday, September 17, 7.15 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.1. Annual General Meeting. "Job Evaluation," by Mr. R. Aston.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 11, 7 p.m., 85, The Minories, E.C.3. Junior Members' Discussion on "Factors Governing the Design of a Modern Tanker, with Special Reference to the Machinery," by Mr. W. Lynn Nelson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Graduate Section:* Tuesday, September 11, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Various sound films, introduced by Mr. R. A. Bishop. *Liverpool Section:* Wednesday, September 12, 7.15 p.m., Offices of North Western Gas Board, Radiant House, Bold-street, Liverpool, 1. Film Display, arranged by Messrs. Taylor, Taylor and Hobson, Ltd.

INCORPORATED PLANT ENGINEERS.—*Glasgow Branch:* Tuesday, September 11, 7 p.m., The Engineering Centre, 351, Sauchiehall-street, Glasgow. Discussion on "Electronics in Production." *East Lancashire Branch:* Tuesday, September 11, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Open discussion Meeting. *South Wales Branch:* Tuesday, September 11, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Modern Applications of Rubber in Industry." *Kent Branch:* Thursday, September 13, 7.30 p.m., Queen's Head Hotel, Maidstone. Discussion on "Electric Motors: Their Characteristics and Application." *Newcastle-upon-Tyne Branch:* Thursday, September 13, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. Film on "Pulverised Fuel."

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*East Midlands Centre*: Wednesday, September 12, 7.30 p.m., Mechanics Institute, Nottingham. Opening Meeting of 1951-52 Session. *Midlands Centre:* Tuesday, September 18, 7.30 p.m., The Crown Inn, Birmingham. "The Servicing of Brakes," by Mr. J. Kinchin.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 19, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "Dynamic Braking for Steam, Diesel and Gas-Turbine Locomotives," by Mr. J. Koffman.

INSTITUTE OF PETROLEUM.—Wednesday, September 19, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Our Unproduced Reserves: What Are They?" by Dr. Morris Muskat.

BRITISH LIGHT STEAM POWER SOCIETY.—Saturday, September 22, 3 p.m., Waldorf Hotel, Strand, W.C.2. "The Problem of the Steam Car," by Mr. M. Harman Lewis.

CONTRACTS.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have received an order valued at 80,000*l*., from the Egyptian Ministry of Communications—The Egyptian Broadcasting Authority—for one of the new 100-kW medium-frequency air-cooled broadcast transmitters. It will be installed at Abu Zaabal, near Cairo, and will be housed in the same transmitter hall as the Marconi 100-kW high-frequency transmitter now being delivered to the Egyptian authorities. The mast radiator is also being supplied by the firm and will be erected by local labour under the supervision of British engineers. The company, moreover, are supplying a 3-kW medium-frequency beacon transmitter, type WB8, with mast, aerial and earthing equipment for installation at an Egyptian airport.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., Trafford Park, Manchester, 17, have received an order from the State Electricity Commission of Victoria, Australia, for 31 units of metal-clad switchgear, type SB14. These are for 20-kV service at the Newport "A" power station and are of the single-'bus type with a rated short-circuit capacity of 750 MVA. They are to operate initially on a 25 cycles per second service but, subsequently, must work on 50 cycles per second. Short-circuit tests have confirmed that the circuit-breaker performance is satisfactory at both frequencies.

LAUNCHES AND TRIAL TRIPS.

M.S. "SPECIALITY."—Single-screw cargo vessel, built by the Grangemouth Dockyard Co., Ltd., Grangemouth, for F. T. Everard & Sons, Ltd., London, E.C.3. Main dimensions: 225 ft. by 37 ft. 10 in. by 16 ft.; deadweight capacity, 1,850 tons on a draught of 15 ft. 8 in. Sirron Diesel engine, developing 800 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Speed on trial, 10 knots. Trial trip, August 13.

M.S. "SCOTSCRAIG."—Twin-screw ferry vessel, to carry 800 passengers and a number of vehicles, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the service of the Dundee Harbour Commissioners between Dundee and Newport, Fife. Main dimensions: 168 ft. by 50 ft. by 8 ft. 3 in.; draught, 5 ft. 3 in. Two vertical-type six-cylinder Diesel engines, developing a total of 1,000 b.h.p. at 600 r.p.m., constructed by the English Electric Co., Ltd., Preston. One totally-enclosed single-reduction double-helical gear unit, manufactured by David Brown and Sons (Huddersfield), Ltd., Huddersfield, fitted to each engine. Speed, 10¾ knots. Trial trip, August 28.

M.S. "TANK KING."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Sigurd Herlofson & Co., Oslo, Norway. Main dimensions: 580 ft. between perpendiculars by 78 ft. by 42 ft. 6 in. to upper deck; deadweight capacity, 24,000 tons on a draught of about 32 ft. Harland-B. and W. seven-cylinder two-stroke single-acting opposed-piston oil engine. Trial trip, August 29-31.

M.S. "KIMANIS."—Twin-screw cargo vessel, carrying 40 first-class, 24 second-class and 500 unberthed passengers, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Singapore/British North Borneo trade of the Straits Steamship Co., Ltd., Singapore. Main dimensions: 312 ft. overall by 51 ft. by 29 ft. 6 in. to shelter deck; gross tonnage, about 3,100; deadweight capacity, 2,400 tons on a draught 17 ft. Two eight-cylinder opposed-piston Diesel engines, developing a total of 2,560 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Speed on trial, 13¾ knots. Trial trip, September 3.

ASWAN DAM HYDRO-ELECTRIC SCHEME.—The Egyptian Government announce that tenders are shortly to be invited for the sluice gates and ancillary works associated with the Aswan Dam hydro-electric scheme. Firms interested in these works are advised that the best time to visit the site, to inspect the up-stream side of the Dam is during the present low up-stream water-level period which is due to expire, this year, on October 5. A further announcement will be made by the Egyptian Government as soon as the tender documents are ready for sale.

PERSONAL.

MR. M. G. R. SMITH, M.B.E., B.Sc., M.I.C.E., assistant civil engineer, Western Region, British Railways, has been appointed civil engineer, Western Region, as from November 10, 1951.

The Iron and Steel Corporation of Great Britain, 1, Chester-street, London, S.W.1, announce that the boards of the Park Gate Iron and Steel Co., Ltd., Rotherham, and of Darwen and Mostyn Iron Co., Ltd., Mostyn, Flintshire, have been reconstituted. Two part-time directors of the Park Gate Co., SIR ALLAN J. GRANT, Wh.Ex., M.I.Mech.E., M.I.N.A., and COLONEL D. S. BRANSON, have retired, and MR. T. FAIRLIE and MR. J. WADSWORTH have been elected to the board. Similarly, two part-time directors of the Darwen and Mostyn Co., MR. R. H. STOREY and MR. R. A. STOREY, have retired, and the board now consists of two, instead of four, part-time, and two full-time directors.

The announcement made on page 271, *ante*, that SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng., while retaining his seat on the board of the Metropolitan-Vickers Electrical Co., Ltd., has relinquished his executive duties as director of research and education of that company, does not mean that he is retiring. He has been appointed director of research and education of Associated Electrical Industries, Ltd.

MR. P. W. CASH, B.Sc. (Eng.), A.C.G.I., M.I.E.E., has been appointed technical executive assistant to Sir John Hacking, M.I.E.E., deputy chairman (operations) of the British Electricity Authority. Mr. Cash succeeds MR. G. R. PETERSON, B.A., M.I.E.E., who, as stated on page 143, *ante*, has been appointed generation operation engineer in the chief engineer's department.

The British Broadcasting Corporation, London, W.1, announce that in view of MR. H. L. KIRKE'S prolonged absence on sick leave, it has been decided to appoint MR. F. C. MCLEAN acting assistant chief engineer, with effect from September 1. He will take over Mr. Kirke's work of co-ordination and direction of technical work.

The Pulsometer Engineering Co., Ltd., Nine Elms Iron Works, Reading, announce the appointment of the following as directors, namely, SIR FELIX POLE, who will take the chair at board meetings in place of MR. ELIOT HODGKIN, who has resigned; MR. R. G. W. BLISS, and MR. A. V. PRICE. MR. J. ELLIOTT has been appointed secretary.

MR. D. SHARPE, of Glasgow, a past-president of the Institute of British Foundrymen; MR. OLIVER SMALLEY, O.B.E., of New York, president of the Mechanite Corporation; and DR. J. T. MCKENZIE, of the American Cast Iron Pipe Co., Birmingham, Alabama, U.S.A., have been elected honorary life members of the Institute of British Foundrymen.

COLONEL A. H. COWIE, manager, Eastern Division, Dominion Bridge Co., Ltd., Montreal, has been elected an honorary life member of the Canadian Standards Association, National Research Building, Ottawa, in recognition of his long and valuable services to the Association.

MR. C. L. G. FAIRFIELD, M.A., A.M.I.E.E., A.M.I.Mech.E., has been appointed manager of the valve division of Mullard, Ltd., Century House, Shaftesbury-avenue, London, W.C.2.

MR. S. STANSBRIDGE, manager of the traffic division of the Marconi International Marine Communications Co., Ltd., Marconi House, Chelmsford, Essex, has retired after more than 45 years of service with the company. MR. T. H. F. WILLOUGHBY, chief accountant of the company, has retired after 37 years of service. MR. F. H. REEVES, who became deputy chief accountant in 1940, has been appointed to succeed Mr. Willoughby as from September 1.

MR. E. W. ASHBY, B.Sc. (Eng.), A.M.I.E.E., sales engineer attached to the Liverpool branch office of British Insulated Callender's Cables, Ltd., has been elected chairman of the Mersey and North Wales Centre of the Institution of Electrical Engineers, as from October 1.

MR. J. S. SKINNER has been appointed controller of office-equipment sales in this country, for Remington Rand, Ltd., Commonwealth House, 1-19, New Oxford-street, London, W.C.1.

MR. JAMES DOW, formerly of Thomas De La Rue & Co., Ltd. (Plastics Division), has joined the technical sales staff of R. H. Windsor, Ltd., manufacturers of extrusion and injection moulding machines, Royal London House, 16, Finsbury-square, London, E.C.2.

MR. P. HAY has relinquished his appointment as sales engineer at the Manchester office of the plant division of Crompton Parkinson, Ltd., to take up an appointment as sales engineer at the Manchester office of Lancashire Dynamo and Crypto (Mfg.), Ltd.

The main administrative offices of COOPER AND CO. (B'HAM), LTD., have been transferred from Birmingham to their South Wales factory at Brynmawr, Breconshire (telephone: Brynmawr 312), to which all orders, correspondence and inquiries should now be addressed.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 239.)

FIG. 57. THE GRAND HALL.

FIG. 58. THE NATIONAL HALL

ENGINEERING,

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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"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.

SUBSCRIPTIONS.

"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:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, SEPTEMBER 7, 1951.

VOL. 172. No. 4467.

DOLLAR EXPORTS.

IN view of the present financial position of this country, it is not necessary to emphasise the importance of efforts to extend the sale of British manufactures in America. The matter has been the subject of almost endless exhortations by Government speakers and many times it has been said that firms engaged in such trade will receive preferential treatment in the supply of raw materials. Assistance has been furnished in various ways and particularly by the setting up of the Dollar Exports Board. This organisation, however, is not a Government body, although it is closely associated with the Board of Trade and other Government departments and has received support both in the form of finance and services. The Board was set up by the Association of British Chambers of Commerce, the Federation of British Industries, the Financial Advisory Committee, the National Union of Manufacturers, and the Trades Union Congress. It is closely associated with the Scottish Council (Development and Industry).

Although a government may help or hinder the development of trade with other countries, it is on individual firms that the task of establishing trade relations actually falls, and manufacturers having no previous experience of selling in America may well require more detailed information than is furnished by the generalities of politicians. In view of its constitution, it is clear that the advice and assistance of the Dollar Exports Board must be available to a very large number of firms, but some, even many, having no American connections, may fail to take advantage of its services; they may well be fully occupied with trade in other quarters. As, however, it is of the first importance that sales to America should be increased, even if this involves some curtailment of activities in other directions, results of value may be expected to follow from the Dollar Convention which was convened by the Dollar Exports Board and held in Eastbourne last March. The proceedings* of the Conference have now been published and should be of value to those to whom trade with America is a novelty.

The Convention was attended by representatives of the Economic Co-operation Administration and the Canadian Government and was addressed by three Cabinet Ministers—Mr. Hugh Gaitskell, Mr. George Strauss and Mr. Harold Wilson, at that time President of the Board of Trade. These Government speakers, naturally, and possibly necessarily, expressed themselves in the general terms and the rotund phrases which sound well in public speeches. It is not necessary to criticise their remarks, but it is allowable to say that they are not likely to be of assistance to a manufacturer who desires to enter the American market. Fortunately, the report contains matter of a more specific nature, and a number of manufacturers who have had practical experience of selling in the competitive American market gave some account of their procedure and its results.

A number of the speakers dealt with the sale of textiles, pottery and other consumer goods to the Americas, but although such materials may form an important, and even a major, part of the trade under consideration, they do not lie within the sphere of engineering interest. None the less, they may help to establish trade relations which may possibly be extended and bear fruit in other directions. A diagram indicating the value of the exports of various types of goods in 1949 and 1950 shows "beverages" far exceeding anything else in value. It may be assumed that, in general, this term may be taken to indicate "whisky," and the fact that more than 18 million pounds worth of this commodity were exported in 1950, if it does not reconcile some people to home shortages, may cause them to hope that the friendly feeling which its consumption presumably imparts may be reflected in a favourable consideration of British engineering products also.

As is well known, in terms of value motor vehicles head the list of exports of engineering manufactures, and valuable information about methods of trading was given by Sir William Rootes and also by Mr. J. F. Bramley, of the Austin Motor Export Corporation. Both these gentlemen emphasised the necessity for the proper organisation of service and the supply of spare parts. Mr. Bramley stated that the Austin Company had very large spare-part stocks in New York and Toronto, and sub-depots at Los Angeles, Hamilton, Winnipeg and Vancouver. The stock in New York alone was worth between two and three million dollars. The carrying of spare parts of this value, and the organisation of the service which its handling involves, suggests that only large and wealthy companies can hope to build up a motor-vehicle trade in America.

The question of farm implements and tractors was dealt with by Mr. S. J. Wright, agricultural adviser to the Ford Motor Company. He particularly emphasised the need for a detailed study of the market that it was hoped to serve. He pointed out, for instance, that, in many parts of Canada, thousands of farms grow only one crop; ploughs which could be adjusted to half a dozen different widths and have half a dozen different bodies were not wanted. He was certain that British products might be simplified and the price lowered without departing from the standards of quality and endurance on which their reputation has been built up. In connection with tractors, he pointed out that, up to the middle of 1949, Great Britain had exported virtually not a single tractor to Canada for ten years, but over the last 12 months had sent about 8,000. He added that rather more than half the total were

* *Dollars and Industry.* The Dollar Exports Board, Thames House North, Millbank, London, S.W.1. Obtainable from the BEAMA Export Department, 36, Kingsway, London, W.C.2. [Price 10*s.* 6*d.* post free.]

supplied by the Ford Motor Company, which had an established customer in the Ford Motor Company of Canada. Even with this reservation, however, there would appear to be important business and opportunities for others.

Mr. Wright like other speakers,, stressed the importance of a proper spare-part service, and the Hon. A. C. Geddes, of Associated British Oil Engines, Limited, stated that the importance of this matter was shown by the fact that "a great many American manufacturers rely on spare parts to make their money." In this connection, he referred to the geographical extent of the market it was hoped to serve, and the importance of relating the stocking point to the cost of distribution. Shipping charges should also be studied; it was cheapest to ship to Winnipeg by the Atlantic coast, but to Calgary, via the Pacific. Technically, British oil engines were just as good as American, and in some categories his company could land products in North America at 50 per cent. of the American selling price. This was rather exceptional, after having paid duty, but a 25 per cent. margin was quite common.

Capital goods were dealt with by a number of speakers, including Sir George Nelson, of the English Electric Company and their associates, and Mr. E. Bruce Ball, of Glenfield and Kennedy, Limited. Both these speakers referred in particular to the Canadian market, as did Mr. David Maxwell Buist, of the British and Allied Manufacturers Association. Mr. Buist stated that Canada was the largest importer of capital goods in the world. This was due to the great industrial expansion and to hydro-electrical development. By far the greater part of the imported material came from the United States; in 1949, the capital electrical equipment obtained from the United States was ten times that obtained from the United Kingdom. In the field of heavy electrical engineering, he thought the best prospect of increasing British imports lay in a combination of Canadian consultants and contractors with a group of British and Canadian manufacturers.

Mr. Bruce Ball was concerned with what he termed engineering components not normally sold direct to consumers. He advocated the setting up of a selling organisation, probably of group type, for the maintenance of stocks and spares, and urged that even the simplest and most obvious standards should be complied with. He advocated advertising and showing at exhibitions. In connection with standards, Mr. H. A. R. Binney, Director of the British Standards Institution, gave some account of the international contacts of the Institution, and referred to cases in which common standards had been agreed on. The arrangement under which the British Standards Institution now acts as agent in London of the Canadian Standards Association should be of much value to exporters, but, as pointed out in a note on page 275 of our issue of last week, there is reason to suppose that some British manufacturers of electrical apparatus are not aware that material for the Canadian market must obtain the approval of the Canadian Standards Association; they are not taking advantage of the service provided by the British Standards Institution.

THE LATE SIR HOLBERRY MENSFORTH, K.C.B.

As this issue is being sent to press, we learn of the death, on Wednesday, September 5, at the age of 80, of Sir Holberry Mensforth, K.C.B., formerly a director of Thos. Firth and John Brown, Limited, and other prominent engineering companies, and, for several years after the 1914-18 war, Director-General of Factories in the War Office. We hope to publish a memoir of Sir Holberry next week.

THE APPRENTICE PROBLEM.

The Select Committee of the House of Commons which is "appointed to examine such of the Estimates presented to this House as may seem fit to the Committee," having dealt with the Royal Dockyards in its Eighth and Ninth Reports in the manner which we summarised briefly on page 273, *ante*, has returned in the Tenth Report to the wider subject of "Rearmament,"* and, in particular, to the manpower side of it, to which an important section of the Third Report was devoted, some three months ago. Even in that short interval, it appears, the situation has changed appreciably for the worse; not only among scientific and technical staffs, the supply of whom is stated to fall short of requirements by at least 600 a year, but among the ranks of the skilled tradesmen who, in practice, largely determine the rate of production and of plant expansion. The Ministry of Defence, according to a memorandum submitted to the Committee, stated that, on the staffs of the three Service Departments, "the deficiency of professional staff is 370 out of a requirement of 1,744, and . . . of technical staff is 1,004 out of a requirement of 4,613." The Ministry of Supply also submitted a memorandum in which it was stated that the supply of both skilled and unskilled labour presented problems of "considerable difficulty," and that the shortage was "notable in the aircraft and machine-tool industries, and also on the railways, where the deficiency had increased from 12,137 on January 1, 1951, to 14,584 on May 19."

The Tenth Report, like its predecessors, is a skilful attempt to condense the mass of evidence collected by the appropriate sub-committee; and, as is customary, it is followed by a record, taken by shorthand-writers, of the evidence, supplemented by selected memoranda on particular topics. In dealing with the manpower question, however, we feel that the condensation as inserted in the main Report has been a little too drastic, and hardly does justice (or even draws sufficiently emphatic attention) to the memorandum on "Manpower for To-morrow" put in by the Ministry of Labour and National Service. This is of particular importance in relation to the growing problem of finding, especially for the engineering and associated industries, a sufficiency of apprentices of the right type, to succeed eventually the present generation of skilled craftsmen. As happens so often in the pronouncements of the major Ministries (inspired or infected, it may be, by the succession of *Economic Surveys*), there is a slightly unctuous tone about the memorandum; but any distaste that may be aroused in the mind of the reader by its didactic style and its tendency to rhetorical questions should not be allowed to deflect him from the reading of it, for it contains much on which to ponder.

In a working population of some 23 millions, it appears, there are now only about 200,000 unemployed, and many of those are registering only for a few days, in the course of changing from one job to another. From the rest must be deducted the elderly and disabled, and, though they are not mentioned in so many words, the hard core of the virtually unemployable. Something can be done to increase industrial production, no doubt, by judicious upgrading; but that course does less than nothing towards easing the shortages of unskilled labour and of apprentices. Of these two shortages, the lack of apprentices is undeniably the more serious. To a great extent, the lower-grade occupations can be performed by machines and with the aid of labour-saving devices, assuming that the labourers—using the term in a fairly broad sense—have the sense to accept and welcome such aid and to employ it to the limit. The apprentices, however, are the eventual successors to the men who devise and produce the labour-saving machines; and there is not much point in multiplying the scientists and the technicians in the service of the Government and of industry if there is not manpower to translate their visions into reality.

The crux of the matter is a question of population and of average age. The statistics show that, over the next ten years, the total of the working population is likely to remain fairly stable or, at most, to increase by a mere 350,000 or so, but that the average age will rise appreciably. In 1911, to quote the memorandum, the proportion of persons who were 65 years of age or over was 53 per 1,000. By 1947, this proportion had risen to 105 per 1,000; and by 1977, it will be 160 per 1,000. Concurrently, there has been, and will continue to be, a growing shortage of young persons; in 1939, about 740,000 boys and girls reached the age of 15, but in 1951 the total is not likely to be much more than 635,000. This, it will be observed, is not a matter of school leaving age: it is a total of persons reaching 15. If they continue at school, the industrial shortage will be intensified; but if they all left school at 14, they would not restore the position to that of even one decade ago.

In practice, of course, many will remain at school much longer, to study for professional qualifications, and a very large proportion will seek office jobs, so that the intake of trade apprentices is likely to shrink alarmingly in the comparatively near future. The memorandum seeks to extract some small comfort from the statistical trend, pointing out that there are prospects of a slight increase in the proportion of young people by 1960; but that is not going to solve the engineering industry's apprentice problem, or even to alleviate it appreciably. In fact, the industry in general was acutely aware of that problem long before the Ministry of Labour started to compile statistics on the subject, and might have had to treat it as a matter of urgency years ago, had it not been for the depression between the wars. The foundries probably felt the impact first, among the larger-scale undertakings, but the little individual craftsmen, working alone or in small family firms at such occupations as blacksmithing, wood-turning, and (which may seem rather strange) chronometer-making, were beginning to see difficulties ahead more than 20 years ago. It may be that the main cause of the shortage then was financial—boys could make more money at an early age by engaging in repetition work in large factories than as apprentices learning a trade; but the shortage was there, and gradually it spread to the large establishments.

To some extent, the falling away has been checked by the provision, in many works, of more or less elaborate schemes for training, and of "welfare" organisations which extend to medical attention, sports grounds and various forms of subsidised entertainment. These amenities must have loaded the dice against the smaller firms, though the extent of their influence is almost impossible to evaluate. We do know, however, that the number of employers, especially those operating on a relatively small scale, who have told us of the difficulty they experience in finding apprentices of the right type, has been increasing steadily. The trade unions, of course, have placed limitations for many years on the total numbers of apprentices that can be engaged. At one time, this policy may have been justified by the tendency of short-sighted employers to regard apprentices mainly as cheap labour; but that is not the attitude now, and the craft unions, in our opinion, might do worse than revise or suspend this particular restrictive practice in the cases of works which they know to be good training grounds.

* *Tenth Report from the Select Committee on Estimates, Session* 1950–51: *Rearmament.* H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 5*s.* net.]

NOTES.

ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

THE third Anglo-American Aeronautical Conference has been taking place in Brighton this week and concludes to-day. It was officially opened on Tuesday, September 4, by the Mayor of Brighton, who welcomed the delegates and paid a tribute to the organising secretary of the conference, Captain J. Laurence Pritchard. The President of the Royal Aeronautical Society, Major F. B. Halford, C.B.E., read a message of welcome and good wishes from the Prime Minister, the Rt. Hon. C. R. Attlee. The conference also received messages of goodwill from the President of the United States, Mr. Harry S. Truman, the Secretary of the U.S. Navy and the Secretary of the U.S. Air Force; they were read by Rear Admiral L. B. Richardson, the President of the Institute of Aeronautical Sciences, in his reply to the Mayor and Major Halford. The success of the conferences, he said, indicated they should become a permanent institution. The first Anglo-American Aeronautical Conference, organised by the Royal Aeronautical Society, was held in London in 1947, and 42 delegates from the United States took part. At this year's conference there are 150 representatives from America. The second conference, held in the United States in 1949, was organised by the Institute of Aeronautical Sciences, and 47 delegates represented Great Britain. The fourth conference will again be held in the United States in 1953, the 50th anniversary year of the first powered flight by the Wright brothers. On Wednesday evening, a reception and dance were held for the delegates by the Mayor and Mayoress of Brighton at the Royal Pavilion. The conference dinner is being held this evening (Friday). At the several meetings, 20 technical papers are being read within four days, which means that, in some cases, delegates must choose between concentrating on their own subject or hearing about developments in other branches. It is perhaps inevitable that this should be so in a subject such as aeronautics, which covers a wide and rapidly develop ng field. Reports of some of the papers are given on page 297.

NEW RESERVOIR FOR LONDON WATER SUPPLY.

On the afternoon of Tuesday, September 4, Mr. William H. Girling, O.B.E., chairman of the Metropolitan Water Board, inaugurated the latest reservoir in the system owned and controlled by the Metropolitan Water Board, and announced that it would be known in future as the William Girling Reservoir. While under construction—a matter of some 16 years, as a result of war-time and other interruptions—it has been referred to as "Chingford South reservoir." The official party and their guests assembled at the headquarters of the Board in Rosebery-avenue, E.C 1—the "New River Head"—and, after a buffet lunch, proceeded by road to the site, where an open-fronted marquee had been erected on the reservoir embankment, in front of the two inlet pipes, each of which has two branches. The chair was taken by Mr. D. L. Evans, A.M.I.Mech.E., chairman of the Works and Stores Committee of the Metropolitan Water Board, who delivered an address of welcome to the chairman of the Board and Mrs. Girling, which Mr. Girling briefly acknowledged. Mr. Evans then presented to Mr. Girling, Sir Jonathan Davidson, C.M.G., M.I.C.E., the former chief engineer to the Board, who was mainly responsible, prior to his retirement, for the design of the new reservoir; Mr. G. A. Marshall, M.I.C.E., the engineer for new works; Mr. Baxter Wilson, A.M.I.C.E., the resident engineer for the reservoir; Mr. W. J. A. Sutton, chief inspector; and Sir George M. Burt, M.I.C.E., chairman of John Mowlem and Company, the contractors. Sir George then introduced Mr. H. A. Henry, M.I.C.E., their chief engineer, and a number of officials and foremen in the contractors' organisation, after which Mr. Evans invited Mr. Girling to inaugurate the reservoir; this was duly done, and the water admitted. Mr. H. F. Cronin, C.B.E., M.I.C.E., the present chief engineer to the Board, gave some particulars of the undertaking. The new reservoir has a perimeter of 3½ miles and an area at top water-level of 334 acres (only about 16 acres less than that of Hyde Park) and, at that level, will hold about 3,400 million gallons. Its completion marks the final stage in the scheme of reservoir construction in the Lee Valley, initiated in 1893. The contract was placed on July 12, 1935, but, in 1937, difficulties were encountered, in part of the clay subsoil, which necessitated changes in the design of the retaining embankment and caused considerable delay. The war also retarded progress, most of the contractor's plant being requisitioned and the men transferred to munition-works construction, etc. The reservoir bank as now finished, Mr. Cronin stated, contains about 5 million cubic yards of material, protected by 50 acres of concrete slabs. Over 300,000 cubic yards of puddled clay were required for the core and foundation, and 750,000 cubic yards of weak material were removed. The total estimated cost of the reservoir is about 2,344,000*l.*

THE MINISTRY OF WORKS.

It is recorded in the latest report of the Ministry of Works that the value of all building and civil-engineering work carried out in Great Britain in 1950 was 1,307*l.* million, compared with 1,248*l.* million in 1949. No further information is given, but it may well be that the increase of 59*l.* million in the work done represents rising costs not rising output. Housing was apparently responsible for the greatest expenditure in any of the categories mentioned in the report; the figure for permanent houses is given as 236·6*l.* million. Another large item is "Factories and Industrial Premises," at 109·6*l.* million. In view of the power-supply position, it might be contended that the construction of generating stations should have preference over all other building work. No separate figure is given for this class of structure; it is included under "Work for Electricity, Gas, Water and Transport Undertakings" at 46·8*l.* million. The above figures, apart from the overall totals, refer to work carried out by building and civil-engineering firms with operatives. To make up the sum of 1,307*l.* million, work carried out by building and civil-engineering firms employing no operatives, by specialist firms and by direct labour, has to be added. The total value of work accredited to direct labour employed by local authorities, public utilities and Government departments is 209·4*l.* million. The type of work covered by these latter figures is not explained, but it may be assumed that most of the local-authority contribution to the total went to swell the figure for permanent housing. The emphasis on housing is further illustrated by the figures for the number of workers engaged on the various classes of building; these are given separately for the four quarters of 1950. For the fourth quarter 202,000 were employed on "industrial, agricultural and commercial work," 216,000 on "new house construction" and 547,000 on "other housing and all other work." The supply of building materials was, in general, satisfactory during the year, but the demand for bricks necessitated drawing on accumulated stocks and there were local shortages of cement, although the total output was greater than in 1949. a wider recognition of the advantages of prestressed concrete is referred to; by the end of the year, 20 factories were making prestressed concrete products and 20 prestressed concrete bridges had been built. In October, 1947, the Ministry became responsible for the production of prestressed-concrete railway sleepers, through contracts with private firms and Royal Ordnance Factories. In 1950, the Railway Executive reduced its demand for these sleepers from 700,000 to 300,000 per annum. Production at Royal Ordnance Factories ceased in the summer of 1950, and contracts with private firms were transferred to the Railway Executive. During the three years when the Ministry was responsible for the contracts, 1,160,000 sleepers were produced. A final matter which may be mentioned is that in April, 1950, the Chief Scientific Adviser's Division of the Ministry was transferred to the Building Research Station as "it had become clear that economies in staff and expenditure could be achieved by amalgamating the two principal Government bodies conducting building research." The Ministry has, however. set up a technical information service and appointed information officers in the various regions in England, Scotland and Wales.

REFRIGERATION CONGRESS.

The eighth International Congress of Refrigeration, sponsored by the Institut de Froid, finished in London on Wednesday this week, after a highly successful series of meetings. To mark the occasion of the London meeting, a banquet was held at the Connaught Rooms, which was attended by some 400 persons, many of them visitors from overseas. Prior to the banquet, those attending were received by the President of the Congress, the Rt. Hon. Viscount Bruce of Melbourne, and Lady Bruce. The toast of the Congress was proposed by Mr. J. M'Ewan, Minister for Commerce and Agriculture in the Commonwealth of Australia, who said that no country in the world was so dependent on refrigeration as Australia. It had shaped the economy of the country and had also had a considerable influence on the economy of other countries, including Britain. Australia regarded it as her duty to see that increasing quantities of foodstuffs were made available to the Motherland, but, although great advances had been made in the technique of refrigeration, much remained to be done to encourage its use. Mr. W. S. Douglas, chairman of the organising committee of the Congress, proposed the toast of the overseas visitors, and Mr. P. B. Christensen, President of the American Society of Refrigerating Engineers, and Mr. A. Blanc, Director-General of Engineering Services, Ministry of Agriculture, France, responded. At the conclusion of the proceedings, the President announced, amid applause, that Dr. Ezer Griffiths, O.B.E., F.R.S., of the National Physical Laboratory, Teddington, had been appointed the new President of the general conference of the Institut de Froid. Dr. Griffiths will hold office till the end of the next Congress, four years hence. The venue of the latter has not yet been fixed.

GAS-TURBINE MERCHANT SHIP.

The work of fitting the Shell Petroleum Company's tanker Auris with a gas-turbine alternator unit at the Hebburn-on-Tyne yard of Messrs. R. and W. Hawthorn, Leslie and Company, Limited, is nearly completed. The unit is replacing one of the four Diesel-alternator sets with which the ship was fitted when she was built in 1947, the object being to obtain operating experience with a main propulsion gas-turbine set under service conditions at sea. The Auris was designed for this purpose, the space available being made sufficient for the installation of a gas-turbine set of adequate size, though the shape of the space, particularly its small width, had a considerable influence on the general arrangements; it also led to the adoption of vertical compounding and restricted the amount of heat recovery in the heat exchanger. In view of the small mass flow of air, intercooling during compression was found to be impracticable. The gas turbine was designed for a moderate initial gas temperature to ensure an adequate length of life, and a low fuel consumption was not sought, the chief object being to find out whether a gas turbine can meet marine requirements in regard to reliability. The gas-turbine alternator unit was built by the British Thomson-Houston Company, Limited, and was described in the issue of ENGINEERING for February 23, 1951. The Auris, in the three years since she was commissioned, has operated as a normal oil tanker. She was designed by Mr. John Lamb, O.B.E., head of the Shell Marine Research and Development Department, as an experimental ship for testing at sea many of the devices developed by his department. The ship is expected to undergo sea trials within the next month.

THE OLD CENTRALIANS.—The next monthly luncheon of the Old Centralians will be held on Friday, September 14, at the "Chez Auguste" restaurant, 47, Frith-street, London, W.1, at 12.45 for 12.55 p.m. The after-lunch address will be given by Sir Frederick Leggett, K.B.E., on "Management and Labour Problems."

OPENING OF HOLME MOSS TELEVISION STATION.—The Holme Moss television station will be formally opened by the Postmaster-General (the Rt. Hon. Ness Edwards) from the Manchester Town Hall, on Friday, October 12. Test transmissions on full power were started on Monday, September 3, and have been continued during the present week between 10 a.m. and 12 noon. Further tests will be carried out during the same hours until Monday next, September 10.

OBITUARY.

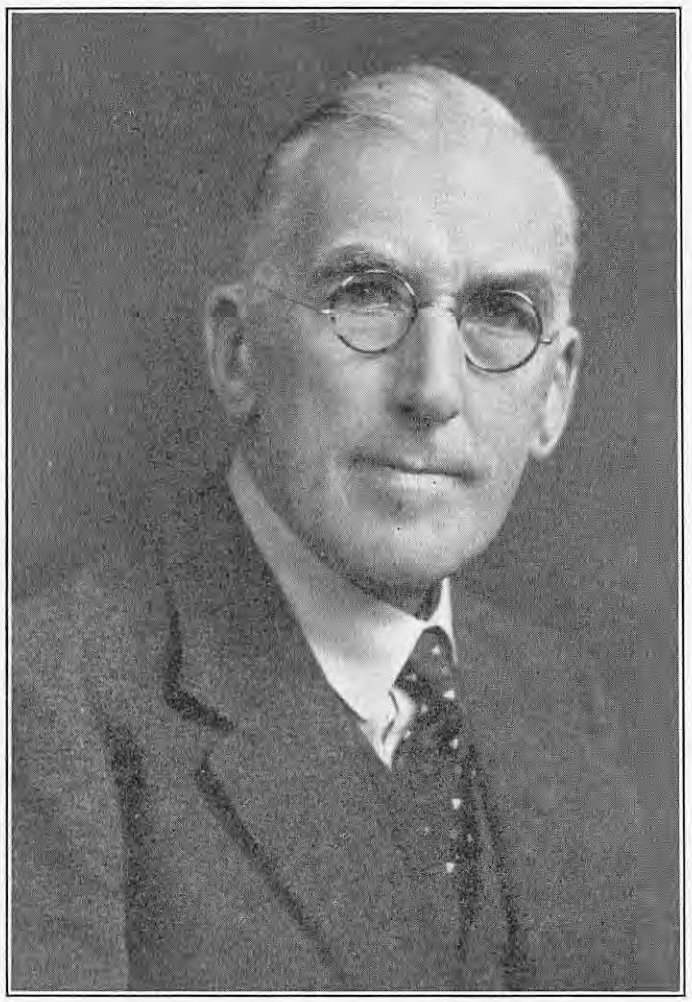
PROFESSOR GILBERT COOK, F.R.S.

IT is with a keen sense of personal loss, which will be shared by an exceptionally large circle of friends and former students, that we record the death on August 28, in hospital in Glasgow, of Professor Gilbert Cook, D.Sc., F.R.S., Regius Professor of Civil Engineering and Mechanics in the University of Glasgow, and President of the Institution of Engineers and Shipbuilders in Scotland since 1949. He was 65 years of age, and had been in poor health for a considerable time. Shortly before the visit of the International Conference of Naval Architects and Marine Engineers to the Clyde in July, he underwent an operation and, for that reason, was unable to take the place in that meeting that, as President of the Scottish institution concerned, he would have done; but he was understood then to be making satisfactory progress, and sent the members a cheerful message. A few weeks later, however, he returned to hospital for a further operation, from which, unhappily, he did not recover.

Gilbert Cook was a native of Liverpool, where he was born on October 26, 1885, and received his general education at the Roomfield School, Todmorden, where he obtained a scientific grounding for his subsequent studies at Manchester University, which he attended from 1902 to 1905. Having obtained there a B.Sc. degree, he was then articled for three years to D. C. Rattray, M.I.C.E., at that time chief engineer of the Lancashire and Yorkshire Railway. During this period, and in the further year that he spent on the railway, he had a varied experience in surveying and construction of branch lines and bridges, and the Parliamentary work associated with the promotion of railway Bills; and, rather outside the usual run of railway civil engineering, with the Manchester Corporation's water-supply pipelines from Thirlmere, which were constructed partly on railway-owned property. This work occupied him until 1910, when he was awarded a Vulcan Research Fellowship, established by the Vulcan Boiler Insurance Company, and returned to Manchester University to carry out an investigation of the strength of thick hollow cylinders. A report on this research was his first contribution to the British Association, delivered before Section G at the 1910 annual meeting, held in Sheffield. A natural development from this work was an appointment as lecturer in the Engineering Department of the Victoria University and he remained in Manchester, continuing his researches the while, until the outbreak of war in 1914, when he was granted a commission in the Royal Garrison Artillery.

As an artillery officer, Cook was soon recognised to possess useful technical qualifications, and most of his Army service was spent on the installation of range-finding equipment for coast defence; including, however, experimental work which brought him to the notice of the Admiralty. At their request, he was transferred in 1917 to the Royal Naval Volunteer Reserve and appointed to H.M.S. Vernon, the Portsmouth mining and torpedo establishment, for duties in connection with mines, minesweeping and anti-submarine work. He remained there until the end of the war, and on demobilisation returned to Manchester University as senior lecturer in engineering, a post which he held until 1921, when he was appointed to the chair of mechanical engineering at King's College, University of London.

Professor Cook remained at King's College for 17 years, during much of this time serving also as Dean of the faculty of engineering. In 1938, however, he was appointed Regius Professor of Civil Engineering and Mechanics at Glasgow—the chair which will always be associated with the name of William John Macquorn Rankine, whose memorial in Sighthill cemetery, Glasgow, was cleaned and restored by the Institution of Engineers and Shipbuilders in Scotland during Professor Cook's last few months' tenure of the presidency of that institution. For the past dozen years, therefore, Professor Cook made Clydeside his home; but he retained many contacts with his friends and former colleagues, serving on the Council of the Institution of Civil Engineers from 1940 to 1943, and holding a number of appointments on Government and other committees.



THE LATE PROFESSOR GILBERT COOK, F.R.S.

In addition to his membership of the Institution of Civil Engineers, which he had joined as a student in 1909, Professor Cook was a member of the Institution of Mechanical Engineers and frequently took part in discussions on papers, though he contributed only one to the *Proceedings*; this was on "Stresses in Thick-Walled Cylinders of Mild Steel Overstrained by Internal Pressure," delivered in 1934. The subject was typical of the main interest of his professional life—the strength of engineering materials, especially iron and steel. On various aspects of this almost inexhaustible branch of research he wrote and spoke extensively, his contributions appearing in the transactions of the Royal Society (of which he became a Fellow in 1940), the Institution of Civil Engineers, the Royal Institution and other societies, in the *Philosophical Magazine*, and in the technical Press. Several of them were printed in ENGINEERING, either as direct contributions, or as papers delivered before institutions and to Section G of the British Association; and it has been a matter of interest to us to note how frequently they have been quoted by subsequent writers, and how often we have been approached to supply copies of the issues containing them. It was typical of the man that, whatever information he had, he imparted it freely; so far as we are aware, he never produced a text-book, preferring to place the results of his researches on record in publications to which future students could be sure of ready access. The two most recent to appear in our own columns were his presidential addresses to the Institution of Engineers and Shipbuilders in Scotland. The earlier of them, delivered on October 4, 1949, and dealing with the properties of engineering materials, was the longer of the two, and extended to two issues, those of October 28 and November 4, in which it can be found on pages 443 and 473, respectively.

The second, much shorter, touched upon some of the many controversial aspects of higher technological education. In it he condemned roundly the proposal that the teaching of engineering subjects should be taken away from the universities and concentrated in special institutions. This policy he denounced as an "abrogation of all that such men as Rankine, and his successors . . . have achieved" in giving engineers the benefits of a cultural training, and a broader outlook on human affairs. "The need of the world for such men was never more insistent," he declared; "how such a proposal could be reconciled with the demand that men destined for leadership in our profession . . . should be encouraged to develop a broader outlook on human affairs is beyond comprehension." Gilbert Cook himself certainly possessed that broader outlook; and though, in any case, he would have retired shortly from professorial duties, it is a matter for deep regret that the engineering and teaching professions should be deprived so soon of his scientific scholarship, balanced judgment and friendly companionship.

CDR.(E) L. J. LE MESURIER, O.B.E., R.N.

To many who are engaged to-day in the construction of Diesel engines, especially for marine propulsion, the name of Commander(E) L. J. Le Mesurier may be known mainly as a bibliographical reference in the less recent literature of the subject: but he deserves to be remembered as a pioneer in this field, and there are still many of his contemporaries who will learn with regret of his death, which occurred on August 31. He was 69, and had been living in retirement in Devon for a number of years.

Louis John Le Mesurier had intended to make the Navy his career, and showed at an early age an ability above the average. He was trained at the Royal Naval Engineering College at Keyham, where he spent 4½ years, and was then selected to proceed to the Royal Naval College at Greenwich for a further three years' course in marine engineering. This was followed by a sufficient period at sea to qualify him for promotion to the rank of engineer lieutenant, after which he was appointed to H.M. Dockyard at Chatham, to take charge of the drawing office, and with special responsibility for the construction and installation of oil engines for submarines, at that time (1910) a somewhat close preserve. The desirability of widening the field was evident to the Admiralty, however, and in 1913 Le Mesurier was released from the Navy to become manager of the newly-formed Diesel-engine department of Sir W. G. Armstrong, Whitworth and Company at Elswick. The outbreak of war, a year later, made it necessary to concentrate on building existing types of engine, and this work occupied Le Mesurier until 1918. He then designed and built a new engine, but the need for it had passed, and eventually he left the Tyne to become chief engineer in the marine department of Sulzer Brothers, Limited. He remained with them for five years and then transferred to the Anglo-Persian Oil Company, also as chief engineer. In association with Mr. R. Stansfield, of the company's research department, he did particularly valuable work in investigating the combustibility of Diesel fuels and the eventual evolution of the cetane number as an criterion, and it was for this work, more especially, that they were jointly awarded in 1932 the Gold Medal of the North-East Coast Institution of Engineers and Shipbuilders. In addition to his membership of that institution, he was a member of the Institution of Naval Architects and of the Institute of Marine Engineers.

LETTER TO THE EDITOR.

THE BRITISH ASSOCIATION.

TO THE EDITOR OF ENGINEERING.

SIR,—In writing to you for the purpose of asking, in effect, what is wrong with the British Association, I must say at once that I thoroughly enjoyed the annual meeting, recently concluded at Edinburgh. The occasion attracted the usual large attendance; members seized the opportunity to renew old friendships and to make new; the social side, as always, was admirably catered for; the local arrangements ran with their usual smooth efficiency; and everything possible was done to satisfy the visitor's curiosity about local industry and history, and to afford him the enjoyment of the varied amenities of "the Athens of the North." Important, however, as these aspects of the meetings indubitably are, the prime function of the British Association is "the Advancement of Science," and, in that respect, I feel all is not equally well.

When the Association was founded, it served as the shop window of science and provided a unique meeting ground for workers in various fields of study. All this has changed, for, with the passing years, a vast number of scientific societies, professional institutions and the like have been established, and innumerable journals, specialist and general, now cater for every class of reader interested in science. There is probably no section of the Association the activities of which are not duplicated by central bodies and local branches which provide continuously the facilities which the sectional meetings of the British Association can offer for one week only in each year. No man of science would now, as Darwin, Wallace, Joule, Bessemer and others did in the past, hold back for the B.A. meeting the announcement of an important discovery; nor is any author likely to offer to his Section a communication on which a brisk discussion might appropriately take place in a meeting of some more specific scientific or professional body. It would thus appear that much of the work hitherto undertaken by the Sections is now redundant. I suggest, therefore, that the time has come for a change of policy, and that the Association should concentrate in future on the staging of extempore discussions on broad or border-line topics to which members of several Sections could equally contribute, and on the further development of lectures in which specialists address themselves to audiences who are not specialists in the same field.

At most of the sessions which I attended, the greater part of the time was occupied by the monotonous reading *in extenso* of typewritten scripts. A meeting so conducted is nearly always a dreary business, for most men of science are no more adept at the art of reading aloud than they are at public speaking. I would propose, therefore, that, except on those privileged occasions when Presidents of Sections address their members, written communications should be circulated as preprints, taken as read (as they are in most other learned and professional societies) and the author confined to a brief extempore summary of his main points and the display, by slides or otherwise, of supplementary illustrative material. Meetings advertised as "discussions" would then no longer be monopolised, as they often are now, by contributions more appropriate to the study than the rostrum; and an opportunity would be afforded for real discussion, which is now all too frequently relegated to the last half-hour of a morning, while those with afternoon excursions to attend creep stealthily away to make sure of lunch.

By the courtesy of ENGINEERING nearly all the papers submitted to Section G have, for many years, been available beforehand in print, so that Section G could forthwith set a good example in this respect without throwing additional burdens on the hard-pressed office staff of the Association. Would it not be possible, however, in all Sections, to accelerate the delivery of scripts so that papers should appear in numbers of *The Advancement of Science*, issued before the meeting instead of after it, as now, even if the management had to "get tough" with contributors and tell them, "No script-in-time, no platform"?

Admirably delivered popular lectures are already a feature of the meetings. In these days, when few scientific workers can keep abreast of even the main advances in branches of science outside their own immediate field, an extension of such lectures could provide a most useful service which would not duplicate the work of the specialist societies. Unless some such move in the direction of fewer, but better, addresses is taken, the British Association may find itself the depository mainly of contributions which other bodies have rejected, and the usefulness of a great institution, justly proud of its past, may gradually decline; an event which many members would regard as a deplorable calamity.

Yours faithfully,
S. B. HAMILTON.

17, Littleheath-road,
Selsdon, Surrey.
August 29, 1951.

OPPOSITION TO HYDRO-ELECTRIC SCHEMES.—A body called the Hydro-Electric Protection Committee is raising a 5,000*l.* fund to oppose various North Wales hydro-electric schemes of the British Electricity Authority.

UNITED KINGDOM PRODUCTION OF IRON AND STEEL.—The production of steel ingots and castings in the United Kingdom, during July, was affected by the annual holidays and was at an annual rate of 13,317,000 tons, compared with 14,367,000 tons in July, 1950. The output of pig iron was at an annual rate of 9,484,000 tons, against 9,099,000 tons a year ago.

THE ROYAL GREENWICH OBSERVATORY.

THE recent Report* of the Astronomer Royal for the year ended April 30, 1951, is addressed from the headquarters establishment at Herstmonceux, but the progress of building laboratory accommodation and instrument housings on the new site is proving to be even slower than was expected, and it now seems unlikely that the transfer of the Observatory to Herstmonceux can be completed by the end of 1953, as was estimated. Actual work has not yet been started on the site of either the meridian group or the equatorial groups. Exact locations have been selected, however, for the individual meridian instruments, with the differences in latitude and longitude adjusted, for convenience, to integral multiples of 0·1″ and 10 milliseconds, respectively. Some sources, within the Castle buildings, of electrical interference with the recording of solar flares by radio-technique have been located and suppressed. The most noteworthy positive piece of construction is a run-off housing for the coelostat of the spectro-heliograph cellar, where air conditioning has been installed and tested. The adaptation of the Great Hall of Herstmonceux Castle as a library is now nearly complete.

Most of the year's optical and observational work has, necessarily, been conducted as heretofore at Greenwich, where the Cooke reversible transit-circle has received further attention. An investigation of screw errors in the microscope micrometers used with the transit instrument has been discontinued, and the micrometers are to be replaced with photographic recording equipment. One of the collimators is being tested this summer on the proposed site of the meridian buildings at Herstmonceux, to enable the position of the azimuth marks to be decided. The causes of large changes, with temperature, of collimation error are also under investigation for this instrument.

The constructional work for the new photographic zenith tube is nearing completion and a preliminary assembly will shortly be tested. One point of uncertainty, which can be settled only by test *in situ*, is whether or not the stellar-plate carriage must be clamped during reversal of the rotary. The control and indicating console, the chronographic system, and the carriage-drive mechanism are completed; and, since the efficacy of flotation as an anti-vibration principle has been experimentally confirmed, a mercury floating basin has been constructed, of similar design to that of the new photo-zenith instrument in the United States. The requisite measuring machines for analysing the stellar plate of the photo-zenith tube are presenting some difficulty. The machine is to be capable of measuring X co-ordinates only, measurements in the Y direction being derived after the plate has been rotated through 90 deg. Since this angle of transposition is critical, it is proposed to determine it for each plate by autocollimation on a precise 90-deg. stainless-steel prism, mounted on a turn-table carrying the plate, the rotation being measured on a calibrated scale with a comparator system employing two microscopes.

Among the year's astrographic work, special interest attaches to long-exposure photography of intense discrete sources of galactic radio noise in *Cassiopeia*, *Coma Berenices* and *Cygnus*, the intention being to repeat the photographs after a year's interval to discover whether any faint object has displayed a large proper motion. Either negative or positive results from the experiment will be welcome, since none of these "radio-stars" has yet been satisfactorily identified with a visible celestial object. The most useful comet photography of the year was a set of five pictures of Comet 1951*a*, obtained during an unexpected sequence of fine February mornings. On the whole, observing weather has been very poor, and only 105 spectra of 72 different stars have been secured with the Yapp 36-in. reflector. Nevertheless, photographs of the sun were possible on 277 days, the granulation

* *Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory*, read at the Annual Visitation of the Royal Observatory, June 2, 1951.

of the photosphere being clearly shown on a number of the plates.

The mean daily sunspot number for the year is 70, the largest spot, having an area 2,300 millionths of the sun's hemisphere, being that which crossed the sun's disc from April 12 to 25, 1951. The rotation period of the sun, calculated from observation of recurrent sunspots during 1934-44, has been found in satisfactory agreement with the values derived from comparable data over the five preceeding eleven-year cycles, and there is no evidence of any change in the rate of solar rotation, such as has been suggested by spectrographic observations. Just as the large spot was disappearing, on April 25, 1951, the only solar flare of major importance during the year was observed on the west limb of the sun's disc. After May, 1950, when several short-wave radio fade-outs were reported, solar flare occurrence dropped abruptly and remained at a low minimum until the early part of 1951. The Observatory staff are collaborating with astronomers at Washington in working out the results of the solar eclipse of November 1, 1948. The reductions are sufficiently advanced to establish that the methods of observation then employed were suitable and accurate, and plans are being developed accordingly for a more extensive application of the same procedure during the total eclipse due on February 25, 1952. It is proposed to make observations at two places near Khartoum, just outside the region of totality on each side of the central line, and at two similarly situated sites near Basra. At Khartoum, long-focus cameras will be used to photograph the precise contour of the moon's limb at the time of the eclipse.

As regards general photographic and observational astronomy in England, it is satisfactory to remark that experience so far obtained indicates that conditions at Herstmonceux are fully up to expectations and markedly superior to those at Greenwich. Although night sky records reveal only a moderate excess of clear sky at Herstmonceux, the transparency is much greater, especially during November, when Greenwich experiences sky fogs, and the absence of glare from street lighting will be most beneficial. As for daylight conditions, the year's records have shown that the amount of sunshine at Herstmonceux was nearly 50 per cent. higher than at Greenwich. A Campbell Stokes sunshine recorder, similar to that in use at Greenwich, was mounted on the East Tower at Herstmonceux during the early part of last year and has been in regular use since July 1, 1950. The greater intensity of sunshine at Herstmonceux is exemplified by the wider lateral spread of the traces. This effect is most serious on summer days when there is broken cloud in an otherwise transparent sky, and the question of the allowance to be made for such spread is still under consideration. In view of the pending complete cessation of meteorological observations at Greenwich Observatory, it has been proposed that a local institution should undertake the task, since the Meteorological Office has no other station in the vicinity.

Meanwhile, the analyses of the year's Greenwich weather records fully confirm the general impression of exceptionally wet weather with less sunshine than usual. The total rainfall during the 12 months from May 1, 1950, to April 30, 1951, amounted to 31·1 in., which is nearly 7 in. above the average for the hundred years 1841-1940. February was the wettest month, with 5·939 in., this being the highest February rainfall ever recorded at Greenwich, the previous highest being 4·03 in. in 1866. The succession of fine February mornings, on which, as mentioned earlier, Comet 1951*a* was photographed, is thus the more remarkable. During the year, there were 82 entirely sunless days, and the bright sunshine recorded was only 27·8 per cent. of the total theoretically possible. In December, there were only 11·2 hours of sunshine, the lowest figure for any calendar month ever recorded at Greenwich. No extremes of high or low temperature occurred, and the greatest wind pressure, of 28 lb. per square foot, recorded on February 4, is not an exceptional year's maximum.

Regular observations of terrestrial magnetism have been taken, as usual, at the Observatory Station at Abinger. The estimated mean annual values for 1951, tabulated below in comparison with the accepted values for the four previous years, exhibit regular trends in all respects and call for no comment.

Year.	Declination (West).	Horizontal Intensity.	Vertical Intensity.	Inclination.
	Deg. Min.			Deg. Min.
1947	9 43·1	0·18577	0·43246	66 45·2
1948	9 35·4	0·18593	0·43255	66 44·4
1949	9 27·5	0·18607	0·43273	66 44·0
1950	9 19·7	0·18628	0·43288	66 43·0
1951	9 10·8	0·18648	0·43304	66 42·1

A valuable report from the Abinger station concerns a project for improving the performance of marine chronometers, so that errors could be relied on within 10 milliseconds throughout the day. Tests were first carried out on a chronometer fitted with remontoir mechanism, the purpose of which is to give an exactly uniform impulse to the balance wheel. At normal room temperatures, the error of this chronometer never deviated from a uniform rate, throughout a period of 48 hours, by more than 6 milliseconds. Over a wider range of temperature, however, it was found that rewinding of the remontoir could not be relied upon below —10 deg. C. The remontoir method has been discarded, therefore, in favour of a new approach by reconstructing the existing fusee. Results to date show a deviation of about 30 milliseconds from the predicted error. The investigation is being continued in the hope of achieving a compromise between this value and the original objective of 10 milliseconds, due weight being accorded to the fact that the reconstructed fusee is a less complicated form of control than the remontoir mechanism.

The Observatory time service has been maintained throughout the year, based on 249 night observations with the Bamberg broken transit instrument at Abinger, and 320 with the small "B" transit at Greenwich. These data have been corrected to minimise the effects of the annual fluctuation of the earth's rotation and of the polar motion, in order to provide the most uniform achievable time system for assessing the performance of the standard quartz oscillator clocks maintained at various stations. Two new quartz ring oscillators put into use at Abinger have exhibited little ageing effect, and after only a few months have proved to be better than any previous Abinger clocks. Still further improvement is hoped from mounting these oscillators on single piers in the Abinger clock cellars, instead of on the racks hitherto used. The influence, on regularity of frequency, of the method of cutting the quartz is evident from the installation at the Post Office Research Station, Dollis Hill, London, where silk-suspended Z-cut ring oscillators, introduced in 1948 and 1949, continue to show marked superiority over the GT-cut quartz plate type. At the National Physical Laboratory, similarly, a new standard fitted with a silk-suspended quartz ring has displaced the GT-plate oscillator as the primary quartz standard. A German quartz clock at Abinger, on the other hand, has a performance only comparable with that of a normal GT-plate oscillator

A considerable amount of experimental work has been carried out to develop new types of crystal drive circuits, working with extremely low amplitude of crystal oscillation. Concurrently, an improved type of quartz crystal oven, with a battery-operated control circuit, has been tested and found satisfactory. Another newly-constructed auxiliary is an accurate phase-meter, capable of measuring phase variations of less than 0·01 radian, which will facilitate performance checking of the quartz crystal drive circuits. A decimal counter chronometer, built for the control room at Greenwich, embodies an electronic pulse divider which can convert from 100 kilocycles per second to 1 pulse per mean time second. Alternatively, the apparatus can be arranged to give pulses at intervals of one sidereal second, and to delay a pulse by any desired interval, in steps of one-tenth of a millisecond, within the range from 0 to 0·9999 second, the delay being selected by means of four decade switches.

The practical outcome of these, and other, developments in the Observatory's time-keeping apparatus is a world-wide radio-transmitted time service comprising a choice of suitable signals. Phonic motor transmitters at Abinger provide the international time signals and the "six pips" broadcast by the British Broadcasting Corporation, as well as the hourly signals used by the Post Office for controlling the "speaking clock." Since October 1, 1950, a five-minute series of dots at 1-second intervals has been radiated twice daily, just before 10 and 18 hours G.M.T., followed immediately by rhythmic signals, whereby high-precision instrumental standards of time and frequency, as well as chronometers for navigational and field survey work, may be regularly checked. It is of interest to mention that, during the early part of the year, repairs to the war-damaged Ball Lobby at Greenwich were hastened and the mechanism put into working order so that, starting on the first day of the Festival of Britain, the traditional dropping of the time ball at the Observatory might be resumed.

As the concluding item of this review, it is satisfactory to note that the preliminary designing of the new, nominally 100-in. telescope for the Isaac Newton Observatory, to be established on the Herstmonceux site, continues to make steady progress. The disc—actually 98 in. in diameter—has now been ground and polished on both faces by Sir Howard Grubb, Parsons and Company, and diamond milling of the better of the two faces has been started. In the course of this work, some cracks developed along cords in the glass, which have a higher coefficient of expansion than the rest of the disc. The depth of cut was accordingly reduced and no further development of cracks has occurred.

Small models have been used to display the relative merits of alternative principles to be adopted for mounting the telescope. No decision has yet been reached, though the horse-shoe type of mounting, on the lines of that designed for the 200-in. Hale telescope, has been discarded as unsuited to the latitude of Herstmonceux. The principle of tube construction, suggested by Mr. B. N. Wallis, the aircraft designer, would, if acceptable on all other grounds, reduce deflections in the tube and permit a great saving in weight. The results of tests on his proposal are accordingly being watched with close attention. Meanwhile, Professor A. Tustin, of Birmingham University, is working on methods of photo-electric guiding intended to compensate, by an automatic control system, for the apparent motion of heavenly bodies. Of two such systems now under development, one controls the position of a photographic plate to maintain the register of a selected star image, and the other maintains photo-electric control of the position of a star image symmetrically on the slit of a spectroscope. When these designs have reached finality, it is intended to try them on the 36-in. reflector at Greenwich, and the experiments are assured of widespread interest.

THE RADIO EXHIBITION.

THE eighteenth National Radio Show at Earl's Court, London, which closes to-morrow evening, is likely to prove the most successful of the series. Although the number of exhibitors is not so large as it was two years ago, mainly owing to the fact that many manufacturers of communications and radar equipment are fully engaged on defence contracts, the exhibits occupy a greater floor space than ever before. The exhibition is being held at a time when the British radio industry has surpassed all its previous figures for production. The annual value of the radio equipment manufactured in Britain now exceeds 85,000,000*l*., of which almost exactly a quarter is exported. These figures, which represent a considerable advance even on last year's totals, are a tribute to the organisation of the radio industry and to the excellence of its products. Although it is stated that manufacturers of components have recently experienced shortages of raw materials occasioned by the rearmament drive, the industry as a whole has not been seriously affected so far, partly owing to the fact that its requirements for raw materials amount to a comparatively small proportion of the value of its finished products. What the situation as regards materials will be next spring is uncertain, but it is greatly to be hoped that the industry's leading position in overseas markets will not be endangered owing to a lack of the means to supply, and that the home market also will not have to suffer unduly from restricted production.

EXHIBITS AT THE NATIONAL RADIO SHOW.

FIG. 1. MULTI-RANGE ELECTRONIC METER; AUTOMATIC COIL WINDER AND ELECTRICAL EQUIPMENT COMPANY, LIMITED.

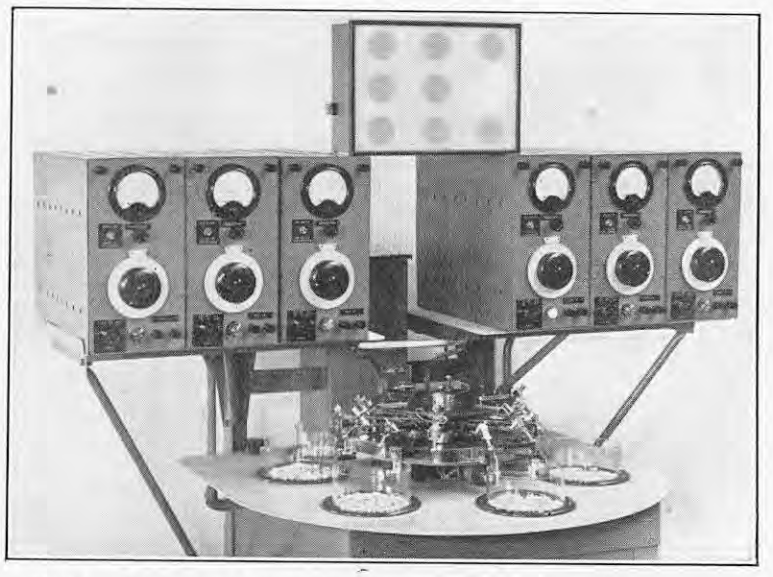


FIG. 2. AUTOMATIC CONDENSER-SORTING EQUIPMENT; TELEGRAPH CONDENSER COMPANY, LIMITED.

As was to be expected, since there are many foreign visitors in London this year for the Festival of Britain, manufacturers have taken the opportunity to display equipment suitable for use abroad; nevertheless, the accent at the show is still largely on equipment for the home market and, in particular, for the expanding television service. With over a million television sets already sold, a monthly output of some 60,000, a new transmitter at Holme Moss about to come into operation and others scheduled to follow it within the next six months, television in Britain is experiencing a boom, in spite of the fact that costs are tending to rise, that purchase tax on sets has doubled since last year's show, and that, despite considerable technical progress, the standard of picture reproduction still leaves something to be desired.

The main trend in the television receivers on show is towards larger pictures. The 12-in. cathode-ray tube has displaced the 9-in. tube as the standard size and more sets than ever are equipped with 15-in., 16-in., or even larger, tubes. The Gramophone Company, Limited, Blyth-road, Hayes, Middlesex, for example, are exhibiting a receiver equipped with a 21-in. metal Emiscope tube for direct viewing. There are numerous examples of flat-ended tubes and a larger number of models than ever are fitted with tubes having aluminised screens. Higher voltages may be applied to such tubes without reducing their useful life, and brighter pictures are the result. Other tubes are fitted with ion traps to prevent ions from reaching the screen and damaging it. A number of sets have tinted screens fitted in front of the cathode-ray tube. These cut out unwanted reflections and improve contrast, although, inevitably, their use results in some decrease in picture brightness. More models than before are to be seen which employ an optical system to project the picture on to a translucent screen. These are rather more expensive than models for direct-viewing, but the extra cost of the optical system is partly offset by the use of a 2½-in. cathode-ray tube as the source of the picture.

An example of projection television in which a separate screen, which may be the wall of a room, is employed is being shown by Messrs. Valradio, Limited, New Chapel-road, Feltham, Middlesex. This equipment, which would be suitable for schools, gives a picture measuring 4 ft. by 3 ft. and employs the technique known as "spot-wobbling" to hide the lines produced by the scanning system. This technique, which consists in applying an alternating magnetic field to the electrons in the cathode-ray tube, in order to broaden the lines, is also used in a receiver exhibited by Messrs. E. K. Cole, Limited, Ekco Works, Southend-on-Sea. At the other extreme in sizes, there is a small bedside television set weighing 8 lb. which gives a picture 2¾ in. in diameter. This is to be seen on the stand of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, but is not a production model. As in former years, visitors to the show are afforded an admirable opportunity of comparing different makes of television receiver, ranging from table models to cabinet consoles, in Television Avenue, an enclosed gallery 250 ft. long in which over 70 receivers are to be seen in operation side by side.

A notable feature of the exhibition is a television studio of prefabricated construction, which is being

FIG. 3. INDUCTIVE HEARING-AID; OSSICAIDE HEARING AIDS.

used by the British Broadcasting Corporation for both sound and vision transmissions. The studio, which is fireproof, soundproof, and fully equipped with all the paraphernalia required by the broadcasting and television engineer and producer, measures 90 ft. by 60 ft. by 25 ft. high, and is fitted with windows running continuously round three sides of the structure which afford spectators an uninterrupted view of the proceedings. Visitors are also able to see into the cubicles used by the producer, sound engineer, and senior maintenance engineer for direction and supervision. The studio was erected completely in a week. Its walls are a foot thick and are built of air-cavity bricks separated from an inner shell of five-ply wood by an air space. To ensure complete sound insulation the entire wall and its steel stanchions are supported on a blanket of fibre glass.

Numerous types of broadcasting receiver are to be seen, ranging from miniature models to large consoles. Portable receivers accommodated in handbags or attaché cases retain considerable popularity, especially since models are obtainable which operate on direct or alternating current mains supplies, as well as on dry batteries or car accumulators, and therefore serve a variety of purposes as well as being economical to maintain. The ordinary domestic cabinet receiver is on show in a wide variety of pleasing designs in which an increasing tendency to use loudspeakers of elliptical rather than circular outline may be noted. Not only do such loudspeakers fit more easily than those of conventional shape into many forms of cabinet or container, they also have the advantage that their low-note response is similar to that obtainable from the much bulkier circular loudspeaker having a diameter equal to the major diameter of the ellipse. Furthermore, the technical problems involved in producing a diaphragm consisting of a cone on an elliptical base are not very much more difficult than those involved in producing a circular cone.

In addition to the ordinary receiver and to radiogramophones of various types, a number of high-performance receivers designed for amateur enthusiasts are on show. These cover a wide range of wavelengths and incorporate various refinements, such as bandspread tuning on the high-frequency ranges, which is also being introduced on certain lower-priced sets. A commendable tendency in many receivers is that towards an improved quality of sound reproduction, made possible by the use of push-pull output stages, negative feedback, tone-compensated volume controls, and proper attention to the scientific aspects of cabinet design.

The great improvements that have been made in the reproduction of recorded music are reflected in the various designs of radio-gramophones and record-reproducers on view. The better quality electric gramophones incorporate the features, already mentioned, which characterise the better models of radio receivers, and several are fitted with separate bass and treble controls for adjusting the low- and high-frequency levels in the amplified output. The availability of long-playing gramophone records has resulted in most models of reproducer being fitted with a two-speed or three-speed motor, and light-weight high-fidelity pick-ups are to be seen in a variety of designs. Tape recording has gained considerable popularity recently, and there are several models of recording and reproducing equipment of this kind. There are also several examples of record players designed for attachment to radio receivers or separate amplifiers.

A tendency observable in all the radio equipment on show is that towards "miniaturisation" and weight reduction. Miniature valves are to be seen on a number of stands, and the ranges now available include directly-heated types for battery sets and indirectly-heated types for mains operation. An outstanding feature of the newer valves is the smallness of their heater current. Sub-miniature valves designed primarily for use in hearing aids and having an extremely low current consumption are likely to find applications in industrial equipment and in electronic computing. There have also been important developments in valves suited to high frequencies, and in disc-seal types of valve. Economies have also been effected in the size of components. This represents a trend which is likely to continue for a number of reasons. In the first place, as radio equipment becomes more complex and involves an increasing number of components, a reduction in the size of these becomes imperative if the bulk of the complete equipment is to be kept within reasonable limits. More important than this, however, is the fact that only by using small components can equipment be built which will operate efficiently at high frequencies. Apart from these considerations, the use of miniature components effects a saving in raw materials and makes for weight reduction and ease of portability in equipment. Size and

weight reduction are particularly noticeable in the case of transformers and chokes, where modern high-permeability alloys have been of great service. In some cases, however, in television receivers, for instance, manufacturers are tending to dispense with transformers and to employ metal or other rectifiers as voltage multipliers. Small components mounted close together in a confined space tend to run hot. Ventilation is often a difficult problem, and in order to solve it manufacturers have developed components which can stand high temperatures without danger. In miniature transformers, for instance, some of which operate at temperatures above 100 deg. C., the wire may be insulated by glass or by its own layer of oxide.

In addition to the exhibits of domestic radio and television receivers, electric gramophones and recording equipment, the show also includes a number of special exhibits. Each of the three Services is staging a demonstration of its work in the radio field with an obvious eye to attracting youthful visitors. The Admiralty is illustrating the use of radio and radar by the Royal Navy by demonstrating how a modern ship is defended against attacking enemy aircraft. The Army, represented by the Royal Corps of Signals and the Royal Electrical and Mechanical Engineers, have an exhibit illustrating the development of military signalling methods from ancient times to the present day. The Royal Air Force exhibit, also, is largely a display of signals and telecommunications equipment, the radio and radar equipment on view including the types known as A.I., H_2S, Rebecca, and Gee.

The Ministry of Civil Aviation is showing a model of London Airport as it is planned to be, and the General Post Office has a display of special equipment for communications, including means for transmitting high-frequency television signals by coaxial cable. Attention is being directed to the causes of interference in radio reception, and the type of receiver used by Post Office engineers to detect sources of interference is on view. The Department of Scientific and Industrial Research have an exhibit illustrating the reflection of radio waves by the layers of the ionosphere, and another illustrating the effect of weather conditions on freak television reception from a comparatively distant station—in this case, Sutton Coldfield.

Several recently developed instruments are on view, of which space permits only a few to be mentioned. The Automatic Coil Winder and Electrical Equipment Company, Limited, Winder House, Douglas-street, London, S.W.1, are showing two test-meters which have recently been added to their well-known ranges. One of these is the Model 8 Universal Avometer, a multi-range instrument of high sensitivity; the other, which is illustrated in Fig. 1, on page 311, has been produced for the Services and is not at present on sale to the public. Known as the CT38, the instrument is a multi-purpose multi-range thermionic-valve voltmeter which is fully "tropicalised" and has had to pass stringent tests. The operating supplies are drawn from the mains, and the instrument incorporates a voltage stabiliser, an amplifier and a diode-valve rectifier for alternating-current and voltage measurements, which is housed in the test probe.

The Telegraph Condenser Company, Limited, Wales Farm-road, North Acton, London, W.5, include in their exhibits equipment illustrated in Fig. 2, on page 311, for automatically sorting small condensers according to capacity. The condensers are poured into a hopper whence they are fed automatically to a series of stations on a revolving turret beneath which is a circular table on which lie a number of trays. As the turret revolves, the condensers are tested by a set of capacitance bridges preset to balance at a number of selected capacities, each bridge being associated with one of the trays. When a condenser passes over the tray appropriate to its capacitance, the balancing of the corresponding bridge results in the condenser being ejected from its holder into the tray by means of a solenoid-operated mechanism.

A novel form of hearing-aid of small dimensions, which is illustrated in Fig. 3, page 311 has been developed by Ossicaide Hearing Aids, Suffolk Hall, 1, Upper Richmond-road, London, S.W.15. This instrument incorporates a magnetic pick-up which works by induction from a nearby circuit. In listening to speech on the telephone the aid is merely laid on the table beside the instrument. When the user desires to listen to wireless broadcasts, an inductive circuit is formed by fixing a loop of wire round the walls of the room and attaching its ends to the loudspeaker terminals of the receiving set. Induction from the loop enables the programme to be heard anywhere in the house or even out-of-doors. The loudspeaker itself may be disconnected, if desired, so that persons of normal hearing who may not wish to listen to the transmissions need not do so. The instrument illustrated incorporates both a microphone for direct hearing and an inductive pick-up. It also houses the high-tension and low-tension dry batteries, a thermionic valve amplifier containing three sub-miniature valves, tone and volume controls and an on-off switch.

LABOUR NOTES.

THE eighty-third annual Trades Union Congress, which has been in session during the past week, was opened at Blackpool on Monday last, under the presidency of Mr. Alfred Roberts. In his opening address to the Congress, Mr. Roberts made some forthright comments on the pamphlet *One Way Only*, issued recently by Mr. Aneurin Bevan and his supporters. In his view, it was a grave disservice to the trade-union movement to embark on a campaign which could only have the effect of weakening Great Britain's defence efforts. To endeavour to convince the British people that their country's rearmament was excessive and more than the nation's economy could sustain was to play right into the hands of the extremists' propaganda. Mr. Roberts said that there was more than one way of regarding the Government's rearmament programme, and he felt that it should not be regarded by the trade-union movement as a political question.

A good deal of ground was covered in the remainder of his address. Much could be done by trade unions, he considered, to secure the redeployment of manpower required to meet the demands of the rearmament programme. The trade-union movement was grateful to the United States for its aid to Britain under the Marshall Plan, but the country had been unable to profit by the improvement in its economic situation last year and it was once again threatened with a trading deficit and a substantial rise in living costs. He attributed these evils to panic buying and stock-piling, which had forced import prices to high and even unwarranted levels. In these circumstances, demands for wage increases seemed to be unavoidable, but, if wages continued to chase prices, inflation and tragic hardship for persons with small fixed incomes would result.

On the subject of strikes, Mr. Roberts considered that workpeople taking part in unofficial stoppages often did so in the belief that they were striking a blow for working-class democracy and did not understand that they were also striking a blow against their own union's prestige, good faith and power. In many cases, advantage was taken of unofficial disputes by extremists, whose sole object was to disturb the minds of workpeople and to hamper their productive efforts. In this section of his address, Mr. Roberts paid a tribute to those trade unionists—the great majority—who had rejected proposals for strike action and who had fulfilled their trade-union responsibilities by pursuing their claims through constitutional machinery.

Prior to the opening of the Congress on Monday, the customary meetings of the general purposes committee of the General Council of the T.U.C. had been held, to settle outstanding business matters and to draw up composite resolutions in some cases. At the close of these discussions, Sir Vincent Tewson, the general secretary of the T.U.C., announced that the membership of the Congress at the end of December, 1950, numbered nearly 7,828,000, of whom 6,608,000 were men and 1,220,000 were women. The number of women members had increased during 1950 by 2,675, but there had been an overall decline in membership of 55,410 during the year. The losses had arisen principally in affiliated unions representing the railways, the mining industry, and the Civil Service. On the other hand, increases had occurred in the printing, cotton and local-government groups. Sir Vincent stated that the Congress was being attended by over 900 delegates, representing some 180 trade unions.

Warnings of the need for caution in the presentation of wage claims, especially during the next few months, were given by Mr. Hugh Gaitskell, the Chancellor of the Exchequer, in his address to the Trades Union Congress on Tuesday. He maintained that the country dare not take any risks with its security and added that what little extra cake there was to cut had been pledged to the rearmament programme. Although there were some signs of world inflation commencing to subside, the increases in prices now working their way through the economic system would probably cause a further rise of two or three points in the interim index of retail prices before the end of 1951. Even if world prices were to be stabilised, a new inflationary process would be started if costs were pushed up by further substantial rises in wages and salaries. If rises in income were not justified by increases in production, prices must advance. The truth, Mr. Gaitskell emphasised, was as simple as that.

Although he declared that he was not suggesting a "freezing" of wages or any rigid restraint in the making of new claims, Mr. Gaitskell reiterated that there was a special need for the exercise of moderation during the coming months. He expressed the view that Britain's economic prospects for the present year were not bright and foresaw a deficiency in the country's foreign-trade balance and a "potential threat to our solvency." He referred to the possibility of some form of partnership being conferred on employees in individual firms or industries, through the distribution to them of bonus shares in proportion to the increase of undistributed profits in the firms or industries concerned. Such action might contribute to the solution of the present economic problem.

Among the motions which were due for discussion at later stages of the Congress were some urging that profits should be strictly curtailed. In particular, there was a motion standing in the name of the Electrical Trades Union stating that additional increases in wages were essential for all sections of employees and that the general standard of living must be improved at the expense of profits. Possibly with these motions in mind, Mr. Gaitskell stated that the effect on salaries and wages of transfers from profits was much less than most people expected. If all the dividends paid to shareholders after tax in 1950 had been reduced by one quarter and the amounts so saved used to increase salaries and wages, the average addition would have amounted to only 3*d.* in the pound, equivalent to 1*s.* 6*d.* a week for a man earning 6*l.* a week. And it had to be remembered, Mr. Gaitskell added, that a reduction of one quarter, after taxation, would be a fairly savage cut. Of taxation, Mr. Gaitskell expressed doubts whether this could be increased without damaging industry and seriously affecting incentives.

An appeal to the miners to accept foreign recruits was made by Mr. Alfred Robens, the Minister of Labour, in the course of an address to the fifth annual summer school for coal-mining employees, on August 31. The school was held at Oxford last week under the auspices of the National Coal Board and Mr. Robens delivered the closing address, taking as his subject "The Human Factor in Mining." He urged that Italian workers, in particular, should be readily accepted into British collieries and into the lodges of the National Union of Mineworkers, and reminded members of the school that the post-war stream of foreign workpeople into Britain had almost ceased about the middle of 1949. The fact that an admixture of foreign manpower was not welcomed at many British pits was much to be regretted. Mr. Robens concluded by stating that an additional twenty million tons of coal per annum, for export and home consumption, would change this country's economic position "overnight."

Some 1,595,000 workpeople in the United Kingdom received net increases in their full-time wage rates during July, amounting in the aggregate to 492,000*l.* a week. The principal increases affected persons employed in the drapery, outfitting, and footwear trades, the retail food trade in England and Wales, the wool-textile industry, furniture manufacture, and the iron and steel industry. The *Ministry of Labour Gazette* for August records that of the total increase of 492,000*l.*, about 170,000*l.* resulted from Orders made under various Acts of Parliament; 97,000*l.* resulted from direct negotiations between employers and workpeople; 93,000*l.* was the result of arrangements made by Joint Industrial Councils; and 87,000*l.* was due to the operation of sliding-scale agreements based on the cost of living. Increases arising from arbitration awards constituted the remainder and amounted to relatively small sums. During the first seven months of this year, 7,921,000 workpeople received net increases in their full-time weekly-wage rates, totalling approximately 3,288,000*l.* a week. In the corresponding months of last year, there were net increases of 478,000*l.* in the weekly full-time wages of 2,638,000 employees.

Industrial disputes occurring in the United Kingdom declined sharply during July, both in number and in severity. The total for the month, the *Gazette* reports, was 110, of which nine were commenced before the month began. Some 16,900 workpeople were involved in the 110 disputes and about 42,000 working days were lost. During June, there were 193 stoppages, of which 25 were in progress when the month began, and, in all, 86,300 persons were involved and over 305,000 working days were lost. These are the Ministry's revised figures. There were 91 disputes in progress during July last year and, in these, 44,200 men and women took part, with a loss to production of 25,000 working days. During the seven months, January to July, 1951, there were 1,007 stoppages, in which a total of 254,800 employees were concerned and some 1,263,000 working days were lost. Unfortunately, there were 620 strikes, involving 77,000 men and the loss of 231,000 days, in the coal-mining industry.

HYDRO-ELECTRIC DEVELOPMENT IN SCOTLAND.

Fig. 1. POWER STATIONS AND MAIN TRANSMISSION LINES

ELECTRICAL ASPECTS OF MODERN HYDRO-ELECTRIC DEVELOPMENT IN SCOTLAND.*

By T. LAWRIE.

THE North of Scotland Hydro-Electric Board were created by the Hydro-Electric Development (Scotland) Act, 1943. The Board's duties include responsibility for all future hydro-electric development in the Highlands and for the generation of electricity also by any other means which include steam turbines, gas turbines, Diesel engines and wind power; the priority duty of distributing electricity in the Board's Area, which is that part of Scotland lying north of a line from the Firth of Tay to Loch Lomond and the Mull of Kintyre as shown on the map, Fig. 1; the export of surplus power to the British Electricity Authority in Central Scotland; and collaboration in carrying out measures for the economic development and social improvement of the Board's area.

* Paper read before Section G of the British Association at Edinburgh on Monday, August 13, 1951. Abridged.

Turning first to the Board's priority duty of distributing electricity, the Board themselves, until April, 1948, were only responsible for the West Highlands and the Islands and a start had been made with distribution schemes in Morar, Lochalsh, Skye, the Orkneys, and other places hitherto without a supply. Local authorities and electricity companies were then supplying Aberdeen, Dundee, Perth, Inverness, and the other larger towns and the more populous country districts of the Eastern and Central Highlands. From April, 1948, however, under the Electricity Act, 1947, the duty of supplying electricity in these places was transferred to the Board and the position which faced them was as follows. The enlarged area for which the Board were now responsible, contains three-quarters of the land area of Scotland but only one-quarter of the population. The more populous parts of the area had already been served, but the percentage of the population still without a supply was no less than 47 per cent., or 170,000 potential consumers; each consumer represents on the average about 3½ persons, so that approximately 600,000 people were still without a supply. They were widely scattered and the task of supplying them was considerable, being both uneconomic and geographically difficult. Sometimes it was said that it was too expensive and difficult to supply these potential consumers at all and that they were not worth bothering about, but this is a view which the Hydro-Electric Board do not accept. Their area is a food-producing and food-exporting area and now it is, in addition, exporting hydro-electricity to help the rest of the country, and the people who live in their Area have therefore earned the right to the amenities which most of us already enjoy.

If de-population of the countryside is to be arrested, electricity is required as an essential modern amenity and if the vital task of food production is not to be hampered, electricity is required as an essential aid on the farm and the croft. There are some 41,000 farms in the Board's Area, but in 1948 only one farm in 14 was connected to the mains whereas, in the rest of the country, about one farm in three was already receiving a public supply. A correspondingly high proportion of farmworkers' cottages were still dependent on paraffin oil and so were almost all the crofting communities. In the three years since April, 1948, progress has been substantial. Distribution networks have been extended and the Board have connected over 63,000 new consumers to their mains, about three-quarters of them being in country districts and remote parts of the area. Approximately 220,000 people, therefore, have enjoyed the benefit of an electricity supply for the first time, and in those three years more than one-third of the potential consumers remaining to be connected in the Board's Area have been given a supply. The work is still being pressed ahead for much has yet to be done, and the task will not become easier since those who have still to be connected to the mains live in the more inaccessible parts of the area. It remains, however, an urgent task to bring supplies to every possible farm and croft and to the cottages of shepherds and farmworkers so as to aid agriculture and bring the standards in the Board's Area up to those already existing in the rest of the country.

Some of the measures with which the Board are concerned for the economic development and social improvement of the area are not strictly related to electricity but they are worthy of brief mention in this paper. One of the most important is the encouragement of building in stone. Stone was the native building material of Scotland, but in recent years there has been a very serious decline. The slightly greater cost of building in stone has been a discouragement and not enough importance has been attached to the durability, long life and low maintenance costs of stone buildings. Starting modestly with one small power-station building in the West Highlands near Lochalsh, the Board have already completed the following stone buildings: two 132,000-volt sub-station control buildings of substantial size at Beauly and Glen Affric, one of red sandstone quarried locally, and one of golden-yellow sandstone, quarried near Elgin; one large Diesel-engine power-station built entirely of stone at Kirkwall; and 13 houses at Tarbet, Loch Lomond, and Pitlochry. In addition, the following are under construction: 71 houses at Tarbet, Pitlochry, Gairloch, Beauly and Cannich; one hydro-electric power-station at Luichart to be built entirely of local stone; and three large water-power stations at Fasnakyle, Fannich and Errochty which are being faced with stone, the first being of golden-yellow and the second of red sandstone, while the third is of stone excavated from the tunnel which brings the water into the station. Further work of the same kind will follow and it is proving, in several important cases, to be actually as cheap as brick or concrete; several local authorities in the Board's Area are also striving to carry out an increasing proportion of their housing schemes in stone.

As a matter of social importance, the housing of staff in remote areas has been carefully considered in relation not only to the requirements of the job, but of the people involved. Wherever possible, engineers and workmen engaged on the operation of hydro-electric stations have been housed in existing villages, which is much better than being in isolated self-contained communities. The control of a number of stations is grouped and there will be control centres, for example, near Pitlochry for the Central Perthshire power stations; at Fort Augustus for those in Glen Garry and Glen Moriston in Inverness-shire; in Ross-shire, for those of the Glascarnoch, Luichart, Torr Achilty, Fannich and Orrin group; and near Killin for those round about the western end of Loch Tay. Research is being carried out into subjects as diverse as the production of power from peat, the perfecting of an electronic counter to count salmon ascending fish passes, the devising of a transportable electric hay-drier for use on crofts and small holdings, the development in collaboration with the Electrical Research Association of wind-power research and, in collaboration with John Brown and Company, of a closed-cycle gas turbine, and the fostering, in collaboration with the Scottish Office, of research into the improvement of the stock of trout in river and loch.

I have dealt first with the problems of electricity

distribution and with the Board's duty to collaborate in carrying out measures for the economic development and social improvement of the area because it is important to emphasise the wide range of the Board's responsibilities and their priority duty of extending electricity supplies in their own Area. The most important part of the Board's activities, however, is hydro-electric development; first, because of the work and prosperity and hope which it brings to the Highlands; second, because it enables electricity distribution to be carried out on a scale which would otherwise be quite impossible; third, because it has brought new industries and the expansion of existing industries to Glasgow, Edinburgh and the Scottish industrial Lowlands, and to Dundee and Aberdeen, and, finally, because it makes a vital contribution to meet the growing power requirements of the Board's area and Scotland as a whole.

Although the industrial development mentioned above has partly taken place outside the Board's area, it is of interest to Scotland as a whole. In the first place, a completely new industry has come to Scotland, namely, the manufacture of large water turbines. They are now being made for the English Electric Company at the works of Messrs. Harland and Wolff, Limited, Scotstoun, and for Messrs. Boving and Company at the Clydebank works of the well-known shipbuilding and engineering firm of Messrs. John Brown and Company, Limited, and by Messrs. Glenfield and Kennedy, Limited, at Kilmarnock. In addition, the Harland Engineering Company, of Alloa, have embarked on water-turbine manufacture under American licences. Messrs. Bruce Peebles and Company, Edinburgh, have extended their manufacturing capacity and are now making water-wheel generators of a substantial capacity while Messrs. Harland and Wolff are making large electric generators as well as water turbines. This new industry in Scotland has received orders for 898,290 h.p. of water turbines and 369,950 kW of generators from the Board. A further important result has been that large orders for export have also been brought to Scotland, aggregating about 1,400,000 h.p. of water turbines and 209,000 kW of generators. The capacity of Messrs. Bonar, Long and Company, transformer makers, in the Board's area at Dundee, has been greatly expanded.

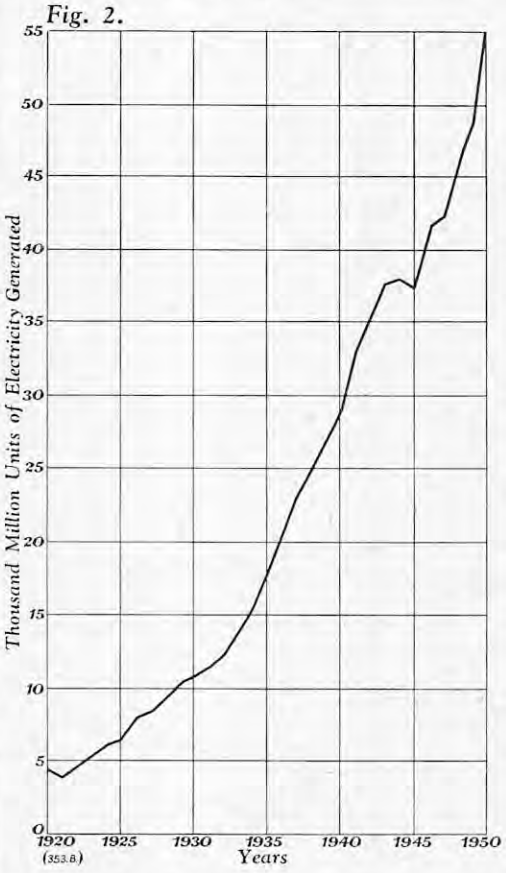
Before looking at present and future hydro-electric schemes, it is interesting to glance back at the water-power developments of the past. The old mill wheels were the foundation of many a country industry, and, though small by modern standards, some of them were outstanding in their time. They have been described in a paper read by Mr. James Williamson, M.I.C.E., before a joint meeting of the Institution of Civil Engineers and the Institution of Civil Engineers of Ireland in 1949. These old developments included no fewer than 43 mills along the course of the Fifeshire River Leven, which flows out of Loch Leven, famous for its trout-fishing, and the many industries served by that power included spinning mills, bleachfields, corn-mills, papermills (several in each class), two saw-mills, a wood mill, a flour mill, a lint mill, a snuff mill, a distillery, a flint mill, and a foundry. Probably the most famous of the old wheels were at the mills at Catrine in Ayrshire and Deanston, on the River Teith, in Perthshire; the former was built in 1827 and contained two large water wheels, 50 ft. in diameter and 10 ft. 6 in. wide, operating on a single fall of 48 ft. 9 in. and producing 250 h.p. Their efficiency was 75 to 77 per cent., and their speed was barely two revolutions per minute. In 1863, the speed of the wheels was increased to three revolutions per minute. The power, with increased water supply, was raised to about 500 h.p., and they continued to run until 1947 when they were replaced by electric drive. At Deanston, four large wheels, 36 ft. in diameter, were installed shortly after 1807. They produced 400 h.p. and they have continued to run up to the present year.

The first of the more modern hydro-electric developments was at Foyers in Inverness-shire in 1896, where water turbines of the impulse Girard type drive an aggregate of 5,000 kW of direct-current plant for the production of aluminium. This was followed, in 1909, by a 23,000 kW power station for the same purpose at Kinlochleven, and, in 1929, by a still larger 83,000-kW scheme at Fort William, consisting of 10,000 h.p. Pelton turbines, each driving two direct-current generators in tandem. These schemes, producing about 800 million units of electricity per annum, depended on the industrial use of current on the spot where it was produced and it was only with the development of high-voltage transmission that public supplies of electricity from water power began to be developed. The first public supply of any size in Scotland was the Lanarkshire Hydro-Electric Scheme at the Falls of Clyde, which was promoted in Parliament in 1924. There are two power stations of an aggregate capacity of 16 000 kW producing about 88 million units per annum which feed into the network of the Clyde Valley Electrical Power Company by 11,000-volt transmission lines.

With the coming of the 132,000-volt grid, constructed by the Central Electricity Board in the late 1920's and early 1930's, large developments became practicable because the Grid provided a market or a route to the market. The Grampian Scheme, which is now in the Hydro-Electric Board's area and operated by them, provided 70,000 kW of capacity and an average annual output of 280 million units of electricity at the Rannoch and Tummel Bridge stations, and, soon afterwards, the Galloway Water Power Scheme in South-West Scotland, provided 102,000 kW with an average annual output of 225 million units. Up to this point, therefore, the hydro-electric resources of Scotland had been harnessed to the extent of 111,000 kW of direct-current generating about 800 million units of electricity per annum for industry and 188,000 kW of alternating current producing about 593 million units per annum for public supply.

After the promotion of the Galloway Water Power Scheme in 1929, however, there was a long gap of 13 years without further development, during which six attempts were made to promote large schemes in

Fig. 2.



the Highlands; none of these attempts succeeded, but a positive result of this lack of success was the appointment of a committee, under Mr. T. M. Cooper, K.C. (now Lord Cooper, President of the Court of Session). That committee made recommendations which resulted in the establishment of the North of Scotland Hydro-Electric Board by Act of Parliament in 1943. Surveys of a number of hydro-electric schemes were at once put in hand by the Board, some being small schemes for local supplies in isolated districts, such as Morar and Lochalsh, and some large to meet the growing demands of the Board's area and to provide a surplus for export to Central Scotland. There has been a steady progression of survey, promotion construction and setting to work, and, at the beginning of 1951, the Board's hydro-electric programme had reached the stage which is summarised in Table I.

TABLE I.

Schemes.	Total Capacity. in kW.	Estimated Annual Output in kWh.
In operation	199,700	376,000,000
Under construction	229,300	465,000,000
Promoted and just starting construction	198,200	736,000,000
Promoted	8,100	27,500,000
Under survey	278,500	1,068,000,000
	913,800	2,672,500,000

Table II shows the names and capacities of most of the individual power stations which go to make up the substantial totals summarised in Table I and the map, Fig. 1, shows where they are situated. Of these schemes, the Sloy Power Station, on Loch Lomond, is the largest individual station, with a capacity of 130,000 kW, made up of four machines of 32,500 kW, each running at 428 r.p.m. The machines are of the vertical-shaft type driven by Francis reaction turbines operating under a maximum head of 910 ft. of water.

TABLE II.—*Hydro-Electric Schemes.*

	Capacity. kW.	Annual Output, kWh.
In Operation—		
Sloy*	97,500	90,000,000
Nostie Bridge	1,250	4,000,000
Morar	750	2,000,000
Pitlochry	15,000	54,000,000
Clunie	61,200	143,000,000
Grudie Bridge	24,000	83,000,000
Total (i)	199,700	376,000,000
Under Construction—		
Sloy*	32,950	30,000,000
Errochty	75,000	103,000,000
Gairloch	750	3,000,000
Cowal	6,000	14,000,000
Affric	66,000	223,000,000
Shira	45,000	80,000,000
Lussa	2,000	8,500,000
Storr Lochs	1,600	3,500,000
Total (ii)	229,300	465,000,000
Promoted and Just Starting Construction—		
Gaur	6,000	17,000,000
Glascarnoch	24,000	112,000,000
Luichart	24,000	124,000,000
Torr Achilty	15,000	36,000,000
Achanalt	2,000	8,000,000
Quoich	18,000	63,000,000
Invergarry	20,000	82,000,000
Ceannacroc	17,500	70,000,000
Doe	2,700	7,000,000
Dundreggan	13,000	45,000,000
Invermoriston	20,000	75,000,000
Livishie	6,000	17,000,000
Lawers	30,000	80,000,000
Total (iii)	198,200	736,000,000
Promoted—		
Allt-na-Lairige	6,000	17,000,000
Loch Dubh (Ullapool)	600	1,500,000
Mucomir	1,500	9,000,000
Total (iv)	8,100	27,500,000
Under Survey—		
Orrin	18,000	79,000,000
Kilmelfort	3,000	9,000,000
Shin	44,000	168,000,000
Breadalbane	88,500	304,000,000
Farrar, Beauly, Tay Basin, Affric extensions	125,000	508,000,000
Total (v)	278,500	1,068,000,000
Grand Total (i) to (v)	913,800	2,672,500,000

* The Sloy Scheme, being partly completed, appears under two different headings.

The neighbouring Shira station on Loch Fyne will contain a similar machine of 40,000 kW, the largest capacity of any so far ordered by the Board, and designed to operate under the high head, for a Francis turbine, of 965 ft.

Another interesting and important machine is the 30,000-kW horizontal alternator in the Lawers station, which is to be driven by two Pelton wheels, overhung one on each end of the generator shaft, and operating under a gross head of 1,362 ft. of water. A number of generators, driven by Kaplan turbines, are also installed and on order. From the electrical power of view, one of the points of interest is the high run-away speed which the alternators must be designed to withstand, namely, up to about 2·8 times normal operating speed From the water-turbine point of view, the 20,000-kW. Kaplan type machine on order for the Invergarry station is of interest because it will operate under a head of 175 ft., which is about the present upper limit for Kaplan-type turbines.

Under the 1947 Electricity Act, the Board were required to take over the steam-generating stations at Dundee and Aberdeen. An old turbo-alternator of 6,000 kW has recently been removed from the Dundee power station and in its place there will be installed a 12,500-kW gas turbine operating on a closed cycle. Further replacements, either gas or steam driven, will soon be required, for the existing plant is mostly old, and a certain amount of steam capacity forms a valuable partner to hydro-electric generation, providing base load in times of prolonged drought and peak load, if necessary, when water is plentiful. In some isolated districts, water power is not available or cannot be economically developed, and the Board are therefore large users of Diesel-engine driven generating plant in places such as Campbeltown in Kintyre, Stornoway in the Island of Lewis, Bowmore in Islay, Kirkwall in the Orkneys, and Lerwick in Shetland. The largest machines, ten of which are being installed in various places, are British Polar engines of 1,540 h.p., built at Govan, running at 300 r.p.m. and driving 1,000-kW Bruce Peebles alternators. The economic burden on the Board of running these stations with fuel oil at its present price, is considerable.

An experimental windmill, of a capacity of 100 kW, is being put to work on Costa Head, a hill in the north of the mainland of Orkney where winds are strong and calm weather seldom occurs. The most difficult problem, in fact, is to make the windmill, and particularly its blades, strong enough to withstand the gales. The windmill will feed electricity into the distribution network on the island, and continuity of supply will be secured by the fact that, at Kirkwall, there is a large new Diesel station. Further researches are being carried out by the Electrical Research Association, supported by the Board, into the extended use of wind power.

The map, Fig. 1, shows the routes of main 132,000-volt transmission lines, present and projected. There is a ring main linking Aberdeen, Dundee, the Perthshire generating stations on the River Tummel, and continuing down Spey side to Keith and back again to Aberdeen. This ring is connected with a line which already runs northwest to Beauly and Fannich in Ross-shire and will later be extended from Beauly to Sutherland and Caithness. In the south, a line runs from the Tummel stations in Perthshire to Bonnybridge near Falkirk, and in the south-west two lines connect Sloy with Windyhill near Glasgow, while a new line is being built to connect Sloy with the Perthshire stations and the rest of the Board's network.

It will be seen that, whereas most of the grid in the rest of the country is for interconnection and mutual support of generating stations in large centres of population, the Hydro-Electric Board's grid is mainly for the purpose of transmitting hydro-electric power for considerable distances. By this means, not only are the consumers in the Board's Area being supplied on the widest scale but the surplus hydro-electric resources of the Highlands are being marketed at a profit so as to meet part of the cost of bringing these extensive and uneconomic supplies of electricity to the scattered inhabitants of the Board's Area at a reasonable price. It might be added that the price at which the surplus is sold to the British Electricity Authority is also reasonable, being based on the cost of steam production, and the peak supply exported to them last winter amounted to 156,000 kW.

A paper about the electrical aspects of hydro-electric development cannot well be brought to a close without dwelling on that bugbear of modern times—the electricity cuts and shortages and load shedding. Next to the production of enough coal, the production of enough electricity is perhaps the most vital industrial requirement of this country, both for peace and rearmament, for raising the standard of living, for increasing industrial output, for relieving drudgery in the home and for expanding agricultural production. The cuts are matters of common knowledge, but it is not generally known how great is the continuing growth of consumption. The consumption of electricity doubles itself every ten years or so, and there is no sign that saturation of demand is approaching yet. In proof of that, the present industrial consumption in the United States of America is about three times as high per workman as it is here and domestic consumption there is 50 per cent. higher than here.

For years now, electrical engineers have been saying that the curve of increase must flatten soon, that growth cannot continue, and they have always been wrong. Let me repeat again—the workman in the United States has three times as much power at his elbow as the workman here, and that is one of the principal reasons for the high standard of living which the States enjoy. Fig. 2, opposite, is a graph of the growth of electricity generation in this country since 1920; it goes up and up, and it does not look like stopping. While the consumption of electricity in the past has doubled itself about every ten years, there has been an increase for this year to date of about 13·6 per cent. over last year, so there is no sign yet of a slackening of the growth of demand. The task in the next ten years is therefore formidable: formidable but vital. If we are to avod chronic power cuts for the next ten years and more, with all the industrial dislocation that they cause, we must do three things: we must (*a*) overtake the present winter deficiency; (*b*) meet the normal growth of load which should about double itself in the next ten years; and (*c*) replace old, obsolete and worn-out plant which ten years hence will be about one-third of our present power-station capacity. These three requirements will involve putting about 20 million kW of generating plant into commission in the next ten years.

The most awkward aspect of the large task of increasing power-station capacity faster is that a power-station takes up to seven years, in this country, from planning to completion; consequently, even the promptest decision to increase progress now cannot produce immediate results and during this intervening period, there will be much criticism and misunderstanding, both public and private, about the continuation of cuts. Cuts may be mitigated by restrictions of one kind or another, but palliatives are not a substitute for a cure; they are a confession of failure. The brighter side is that, notwithstanding our present difficulties, the results we so much desire can be achieved. The industrialists in the electric manufacturing industry say that it could and should be done. They say (British Electrical and Allied Manufacturers' Association Annual Report, 1950-51) ". . . The turbine makers would be able to provide the Authority with 2,000 MW of plant per annum, but the British Electricity Authority's programme only calls for about 1,500 MW a year over the next five years. The opinion was very strongly expressed that it is imperative that these programmes should be increased to at least 1,800 MW." They also say that while 1,000 MW were commissioned at home last year, no less than 800 MW went for export and 600 MW were awaiting the completion of other parts of power stations. Nearly as much went for export as we commissioned ourselves. Was this really in our own best interests? It is also said truly that steel is scarce, but steam-power stations need only 212 tons of steel per 1,000 kW, so that if last year's effort were doubled and two million kW of steam plant were commissioned each year, the steel requirements would still only be 2½ per cent. of the country's steel production. It is also true that coal is scarce, but owing to the high efficiency of modern power stations compared with other ways of burning coal, increased electrification will save rather than waste coal and, indeed, if we were in a position to electrify all our railways, we should save nearly 9,000,000 tons of coal a year, or about two-thirds of all the coal they burn. The problem of overcoming electricity cuts in Scotland is the same as in the rest of the country and it can only be solved in the same way, by building more power stations faster. Hydro-electric development, fortunately, helps very greatly, because it competes very little for scarce materials or for the factory space required for steam-power plant. It requires only 145 tons of steel per 1,000 kW, and the demand for skilled engineering labour is less because so much of the work requires the different skill of the civil-engineering navvy.

The Board's programme, as shown in Table I, aggregating 913,800 kW and 2,672,500,000 units, will help to meet the growth of demand in Scotland, and further potential water power amounting to two or even three times that total still remains to be surveyed and developed. It is even possible that, as coal becomes dearer, water-power resources up to 10,000 million units of electricity per annum may be worth developing. It will, in any case, take the best efforts of steam power and water power together to overtake arrears, to meet the natural growth of demand, and to replace worn out obsolete plant, and it is to be hoped that the efforts of the present decade will be great enough to give the 1960's no grounds for reproach.

FIRE RESEARCH.

THE heating of wooden panels in the vicinity of flue pipes, the critical radiation intensity required to ignite certain timbers, the use of optical systems in the calculation of heat radiation, electrical analogues applied to the simulation of heat transmission through structures, the ignition of inflammable gases and vapours by sparks from aluminium paint, the inflammability of gases, spontaneous heating and ignition, and the value of smoke extractors in fighting fires in basements, are some of the subjects included in *Fire Research*, 1950, the annual report of the Joint Fire Research Organisation (H.M. Stationery Office, 2*s.* 6*d.* net, or, in the U.S.A., 65 cents). In the section on flue systems, a simple diagram gives the temperature distribution on the surface of a panel which is near a flue pipe, assuming that, as a result of over-running a stove or of a flue fire, the pipe remains at a dull red heat for half an hour. If an asbestos shield is interposed, an air gap between the shield and the surface to be protected is advantageous; but little further reduction in panel temperature is achieved by increasing the distance of separation beyond ½ in. The results, given in the report, on an investigation into the relationship between the intensity of heat radiation and the time required to ignite certain timbers are regarded as useful in understanding the conditions under which structural materials become endangered in the neighbourhood of hot surfaces and in the design of heating appliances.

In order to study the radiation of heat from a hot surface to a cold surface, particularly in connection with radiation from burning buildings, practical use has been made of the fact that the transmission of light obeys the same geometrical laws as the transmission of heat. The effect of the geometrical relationship between the hot surface and the cold surface is determined by this technique, thus avoiding tedious calculations. A model is constructed of the radiating surface, and the thermally-emissive parts are illuminated. The various light intensities are measured by a photo-electric cell, so that it is possible to determine the ratio of the intensity of illumination at any point on the receiving surface to the intensity of light leaving the emissive body; this ratio is known as the configuration factor, and is an important factor in the rate at which heat travels by radiation from a hot to a cold surface. An instrument described in a previous report was used during the year to estimate the thickness of sprayed-asbestos covering required on wood partitioning in ships to give a fire resistance of one hour, as well as for other similar estimations; electrical networks have now been developed which represent accurately the heat losses due to convection and radiation, and they are being incorporated in a second analogue. This instrument will give the temperature at any point in a material when its surface is irradiated. An investigation into the hazard of sparks when an iron tool strikes certain kinds of aluminium paint or rusty iron has shown that there is no practical risk from the best types of aluminium paint. An improved apparatus has been constructed for the determination of self-heating or spontaneous-combustion tendencies of suspected materials. The inquiry into the value of smoke extractors in fighting fires in basements, which was undertaken as a result of a large fire in Covent Garden flower market in December, 1949, has shown that only a limited use can be found even for powerful smoke extractors at such large fires; but extractors may be of some use at small fires in extracting smoke, thus facilitating access to the seat of the fire and in dispersing smoke after the fire has been extinguished. The report also contains information on the importance of drop size in water sprays used on kerosene fires, on carefully recorded experimental fires in buildings, etc., as well as the customary statistics relating to fires during the year.

DIESEL LOCOMOTIVES ON THE CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway will have 230 Diese locomotives when 40 ordered this year have been delivered. The Railway has not acquired any steam locomotives since 1949, when six engines of the Selkirk type, the largest in the British Empire, were delivered, and Mr. N. R. Crump, vice-president, has since stated on several occasions that they do not expect to buy any more steam locomotives.

"Dieselisation" was started on the C.P.R. in 1943 with five 1,000-h.p. yard switchers. Rather than use streamlined Diesel locomotives on important passenger trains, it was decided to embark on a programme of conversion area by area, choosing territories where the greatest economies and improvements in service could be effected, and locating maintenance and servicing facilities at strategic points which would permit future expansion and the maximum use of Diesel power. The railways first road switchers—13 Baldwin 1,000-h.p. locomotives—were received in 1948 and placed in service on the Esquimalt and Nanaimo Railway, on Vancouver Island, the operation of which is completely separate from that of the C.P.R.'s main lines. Since then, orders for further Diesel locomotives have included one for 23 units for the line from Montreal to Wells River, Vt.; and 58 for freight service on the difficult line, 517 miles long, between Fort William, Ontario, and Cartier, Ontario. In 1950, a five-year plan for the expenditure of 68,000,000 dols. on Diesel locomotives was announced. There are now three major builders of Diesel locomotives in Canada; the Canadian Locomotive Company, at Kingston; the Montreal Locomotive Works; and General Motors Diesel, Limited, London, Ontario.

COURSES IN HYDRO-ELECTRIC POWER ENGINEERING.

A POST-GRADUATE course in hydro-electric power engineering is again available this year in the Department of Civil Engineering, City and Guilds College, Imperial College of Science and Technology, Exhibition-road, London, S.W.7. The course covers one session of three terms, commencing on the first Tuesday in October and concluding in the last week in June, 1952. It comprises 30 lectures on applied fluid mechanics; 20 lectures on surges, water hammer and waves; 60 lectures on hydraulic structures; two courses, each of 30 lectures, on hydraulic machinery, and 40 lectures on electrical power. Design exercises and other practical work are also included, while, at Easter, a fortnight's study tour is organised and visits paid either to hydro-electric projects and laboratoires in France and Switzerland or to water-power schemes in Scotland. Moreover, in term times, visits are arranged to mechanical and electrical works to view turbines, generators and transformers in course of construction. Satisfactory completion of the course qualifies the student for the award of the Diploma of the Imperial College (D.I.C.). Six bursaries a year, each of a value of 200*l.*, are provided for the course by the English Electric Company, Limited. Details may be obtained on application to the Deputy Registrar, City and Guilds College, Exhibition-road, South Kensington, London, S.W.7

CANTILEVER SHEET PILING IN COHESIONLESS SOIL.*

By P. W. ROWE, Ph.D., A.M.I.C.E.

CANTILEVER sheet piling has generally been designed on the assumption of one of the two types of pressure distribution shown in Figs. 1 and 2. The pile rotates about a point X beneath the dredge level, and in Fig. 1 the passive pressure due to rotation is assumed to be distributed parabolically between X and the dredge level. The parabola is continued on the "active pressure" side of the wall to account for passive pressure between X and the toe. The parabola is assumed to be given by the equation,

$$p = m\,z^n\,y. \quad . \quad . \quad . \quad (1)$$

where m and n are empirical coefficients. In Fig. 2, the curve has been replaced by straight-line boundaries. For this type there are three unknowns, namely the position of X, the penetration coefficient α and the value of the passive pressure coefficient K_p. Taking the maximum value of K_p, the value of α at failure may be obtained; or for a series of values of α, values of K_p and X necessary for equilibrium may be calculated and used to determine the maximum moment on the wall.

These approximations have been necessary in view of the complex nature of the exact calculation of the earth-pressure distribution. The distribution is governed by the flexure of the piling after the equation,

$$E\,I\frac{d^4y}{dz^4} = p. \quad . \quad . \quad . \quad (2)$$

The resultant pressure on the piling beneath the dredge level, assuming the simple parabola taking $n = 1$ and active pressure on the passive side operating before rotation commences, is given by

$$p = m\,z\,y - (K\gamma)_a\,\alpha\,H, \quad . \quad . \quad 1(a)$$

and the substitution of equation 1(*a*) in (2) gives a fourth-order non-linear differential equation to which there is no direct analytical solution. In addition, the simple parabolic assumption can only apply under limited conditions so that a direct approach to the problem using equation (2) is not possible.

However, the maximum moment on the piling has been calculated by the methods illustrated in Figs. 1 and 2 without regard to the values of the flexibility of the piling or the relative density of the soil beneath the dredge level. These values are connected with E I and m and would enter into equations (1) and (2) if they could be solved. It is necessary first to determine the behaviour of an infinitely stiff pile in loose and dense soil, and then to study the effect of the variation of the flexibility of the pile on the maximum bending moment.

The first part of the apparatus, Figs. 3, 4 and 5, consisted of a model pile 3 ft. 6 in. high, 7 ft. long, carrying 42 soil pressure gauges.† The pile section was built with two 8-gauge steel plates separated by wood blocks and bolted rigidly together at regular intervals. The deflection of the section under a constant bending moment exceeding the maximum value in any test did not exceed 0·003 in. over a span of 30 in. so that the pile remained straight for all practical purposes during the test. The bin was filled with fine dry sand in even layers on both sides of the model, and the test was conducted by dredging the sand from the outside in stages, readings being taken at values of the dredge level given by $\alpha = 0{\cdot}4$, 0·5, 0·6 and 0·7. Sand in the loose state was obtained by pouring from a height of about 3 ft. above the placement level; sand in the dense state was obtained by vibrating during filling using a Westool-Stewart high-frequency vibrator.

Typical results from these tests are shown in Figs. 6 to 11, where the observed pressure distributions are compared with those calculated from Figs. 1 and 2. The following conclusions may be drawn. (1) The parabolic type of passive pressure distribution depends only on the value of the active pressure coefficient K_a and does not vary with subsoil density. In some cases, such as for the loose sand at safe penetration depth, the curve taking $n = 1$ gives a good approximation, as found by Rifaat.‡ However, the curves do not follow the variations of density and dredge level sufficiently close to warrant general use. (2) At the instant of failure of the wall by rotation, the observed distribution approached the classical triangular type, but this agreement does not apply at safe penetration depths. (3) The observed passive pressure coefficient K_p just below the dredge level is of the order of the theoretical value taking full wall friction, i.e. $\delta = \frac{2\phi}{3}$ for values of $\alpha \geqslant 0{\cdot}45$. With further dredging the depth below the dredge level at which the coefficient was fully mobilised increased.

The observed resultant pressure distribution arose from active and passive distributions of the types shown in Figs. 12 to 17. Fig. 12 shows the distribution for a stiff wall rotating into the soil about a point below the surface. Fig. 13 shows this applied to a stiff pile which rotates about a point very close to the toe. Fig. 14 shows that if the rotation occurs about a point at the surface, the centre of pressure acts close to the bottom of the wall. The shape of this distribution accounts for the point of rotation of the stiff pile being located close to the toe. Fig. 15 shows that the effect of the high local compressive strain on the "active pressure" side of the wall is to reduce the active pressure above the point of rotation due to shear stress. In addition, a shear force acts between the wall and the subsoil due to the weight of the wall and the vertical component of the active pressure. Fig. 16 shows that the combination of Figs. 13 and 15 leads to the observed type of resultant distribution in Figs. 6 to 11.

The diagrams lead to the proposed simple triangular type of distribution, Fig. 17, where straight-line boundaries are substituted for the observed resultant distributions and a point load is applied almost at the toe, being the resultant of the high local compressive stress and the toe shear stress. By taking moments about the toe, the moment of this force may be neglected and the distribution solved for given values of K_a and K_p.

In order that the validity of this diagram may be fully investigated, it is necessary to use it to calculate the maximum bending moments and the penetration depths at failure, and compare these quantities with those measured directly.

Taking moments about the toe of the pile, in Fig. 17, we have,

$$(K\gamma)_a\frac{H^2\alpha^2}{2}\left(1-\alpha+\frac{\alpha}{3}\right)H + \frac{(K\gamma)_a\,H^2\alpha^2}{2\,[(K\gamma)_p-(K\gamma)_a]}\left[1-\alpha-\tfrac{1}{3}\frac{\alpha\,(K\gamma)_a}{[(K\gamma)_p-(K\gamma)_a]}\right]H$$
$$= \tfrac{1}{2}\,[(K\gamma)_p\,\theta\,H - (K\gamma)_a\,H\,(\theta+\alpha)]$$
$$\times H^2\left[\begin{array}{l}\left(\theta-\dfrac{(K\gamma)_a\,\alpha}{(K\gamma)_p-(K\gamma)_a}\right)\\ \quad\left[1-\alpha-\theta+\tfrac{1}{3}\left(\theta-\dfrac{(K\gamma)_a\,\alpha}{(K\gamma)_p-(K\gamma)_a}\right)\right]\\ \quad+\tfrac{2}{3}\,(1-\alpha-\theta)^2\end{array}\right] \quad . \quad . \quad . \quad (3)$$

This reduces to

$$\theta^2 - 2\,(1-\alpha)\,\theta + \frac{2\,\alpha\,\chi\left(1-\frac{\alpha}{2}\right)}{[(1-\alpha)-\alpha\,\chi]} = 0. \quad (4)$$

where

$$\chi = \frac{1}{\dfrac{(K\gamma)_p}{(K\gamma)_a} - 1}.$$

For given values of χ the values of θ, i.e., the depths below the dredge level to the maximum resultant passive pressure, are obtained. The maximum value

Fig. 1. *Parabolic*

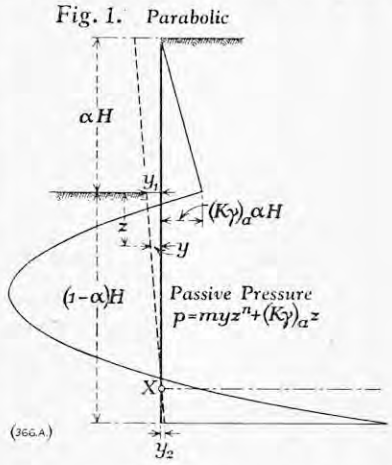


Fig. 2. *Triangular*

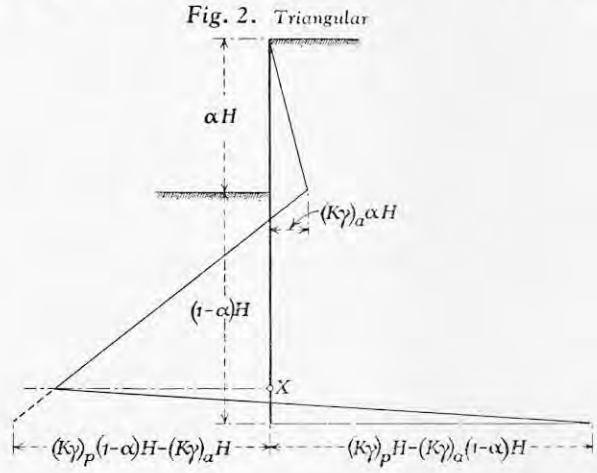


Fig. 3. ELEVATION, PASSIVE SIDE

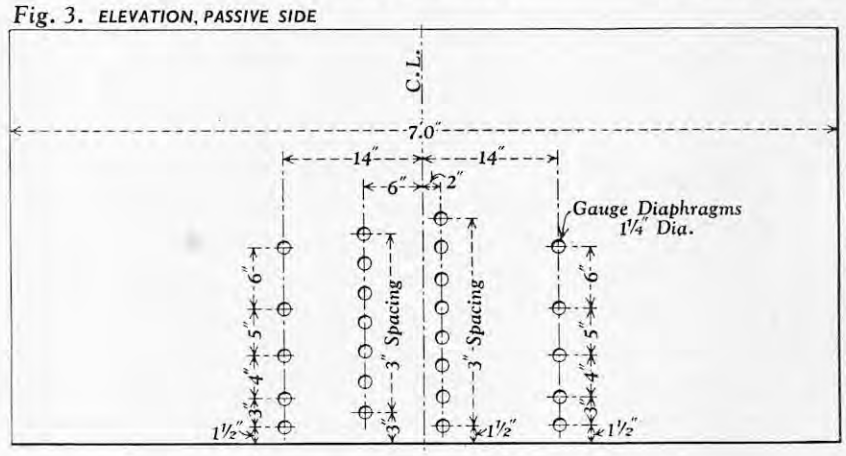


Fig. 4. SECTION

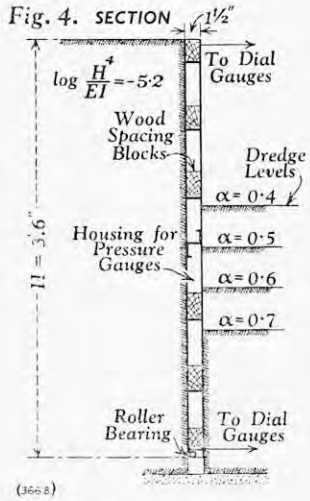
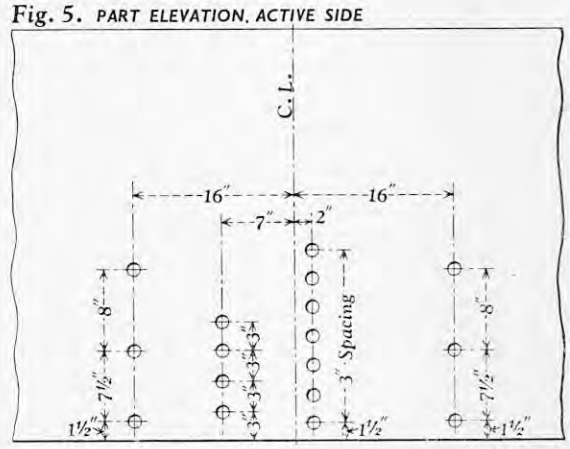


Fig. 5. PART ELEVATION, ACTIVE SIDE



* Paper read before Section G of the British Association at Edinburgh on Tuesday, August 14, 1951.

† P. W. Rowe, "A New Soil Pressure Gauge for Laboratory Investigations," Inst. C.E. Paper No. 5708 (not published; available in Institution library).

‡ T. Rifaat, "Die Spundwand als Erddruckproblem," *Mitt. Inst. Baustatik*, Zürich, 1935.

CANTILEVER SHEET PILING.

Loose Sand $\phi = 30$ *Deg.*

Fig. 6.

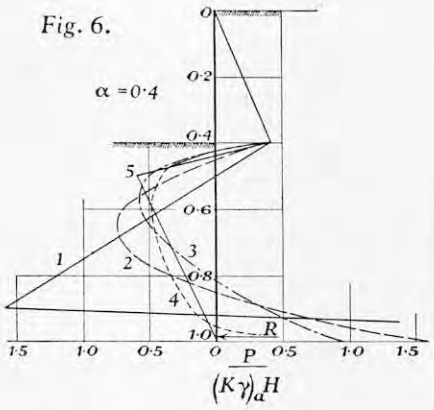


Fig. 7.

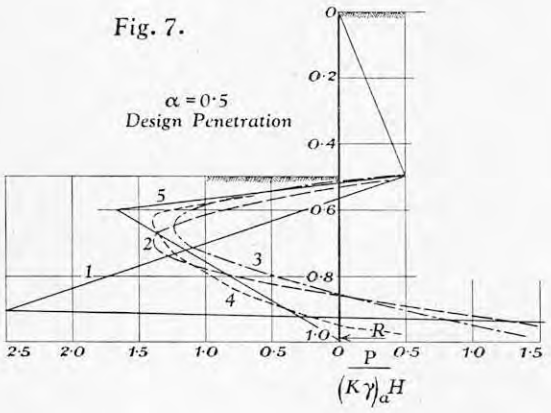
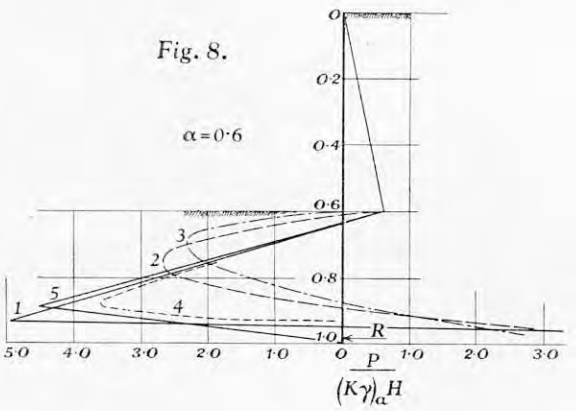


Fig. 8.



1. *Classical Triangular Distribution* 2. *Parabolic* $n = 1$ 3. *Parabolic* $n = 1/2$ 4. *Observed* 5. *Proposed*

Dense Sand $\phi = 41$ *Deg.*

Fig. 9.

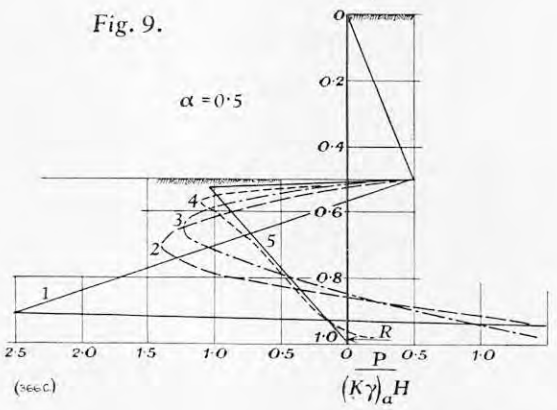


Fig. 10.

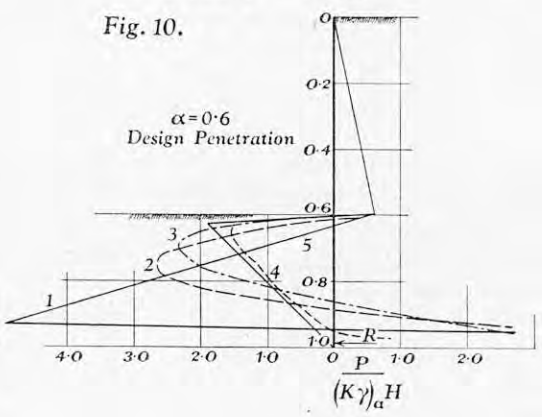


Fig. 11.

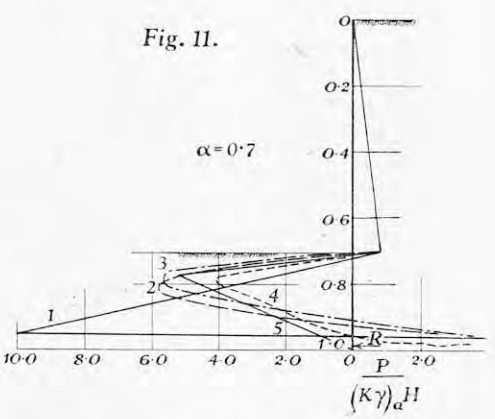


Fig. 12.

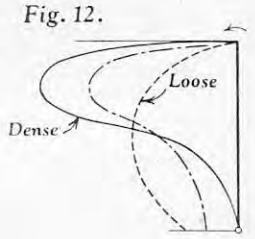


Fig. 13.

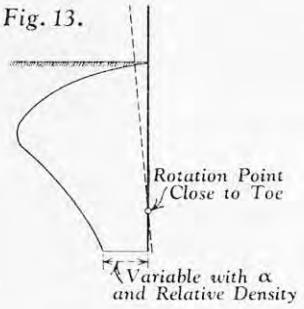


Fig. 14.

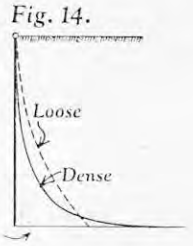


Fig. 15.

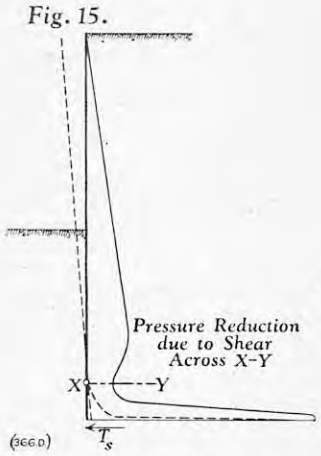


Fig. 16.

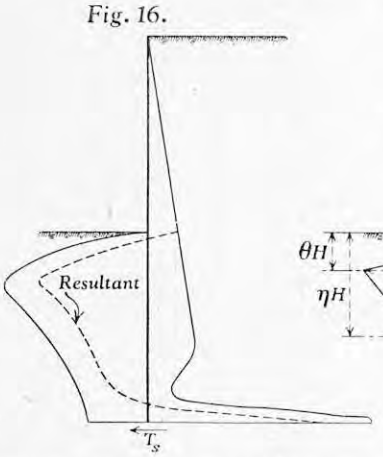
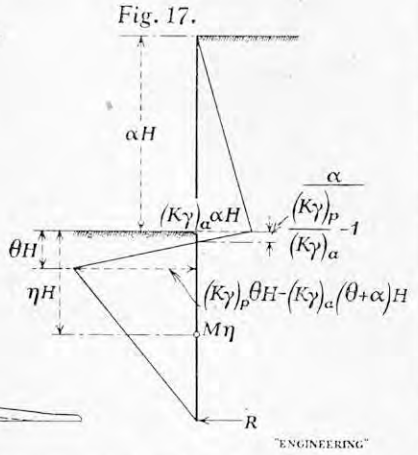


Fig. 17.



that θ may have is given by $\theta = (1 - \alpha)$ and the substitution of this value in equation (4) gives the value of α at failure.

$$(1-\alpha)^2 - 2(1-\alpha)^2 + \frac{2\alpha\chi\left(1-\frac{\alpha}{2}\right)}{(1-\alpha)-\alpha\chi} = 0$$

$$(1-\alpha)^3 = \frac{\chi}{1+\chi} = \frac{(K\gamma)_a}{(K\gamma)_p}$$

$$\alpha = 1 - \sqrt[3]{\frac{(K\gamma)_a}{(K\gamma)_p}} \quad . \quad . \quad . \quad (5)$$

The values of α obtained from equation (5) are plotted in Fig. 18, on page 318 (full line), together with the values obtained at failure for sand and whinstone chips in the loose and dense states. Close agreement results. Equation (5) will also be fou d to be a close approximation to the quartic equation* obtained for the penetration depth using Fig. 2. This agrees with conclusion (2) above.

It is convenient to establish a value for a safe penetration depth before the discussion of bending moments. A factor of safety G_p may be applied to the value of $(K\gamma)_p$ in equation (5) so that only part of the passive pressure acting at failure is mobilised. If a constant value, $G_p = 3$, is taken, the locus of safe penetration is given by the dashed line, Fig. 18. An alternate procedure is to take K_p equal to $\frac{1}{1 \cdot 5} \times (\delta = 0)$ value, giving the dotted line. This method gives approximately a constant depth coverage for all soils and would appear advisable in view of the possibility of over-dredging or erosion for other than temporary structures. The diagrams Fig. 7 and Fig. 10 correspond therefore to safe penetration.

The maximum bending moment on the wall may be calculated from Fig. 17, as follows. At depth η H below the dredge level, where $\eta > \theta$,

$$\frac{M_\eta}{(K\gamma)_a H^3} = \frac{(\alpha+\eta)^3}{6} - \frac{(K\gamma)_p}{(K\gamma)_a}\frac{\eta^3}{6} + \frac{K'}{K_a}\frac{(\eta-\theta)^3}{6} \quad . \quad (6)$$

where

$$K' = \frac{K_p \frac{\gamma_p}{\gamma_a}(1-\alpha) - K_a}{(1-\alpha-\theta)}.$$

The maximum moment occurs at the value $\eta = \bar{\eta}$, where $\frac{dM_\eta}{d\eta} = 0$.

Differentiating equation (6) and equating to 0,

$$\bar{\eta}^2\left[\theta\left(\frac{(K\gamma)_p}{(K\gamma)_a} - 1\right) - \alpha\right] + 2\bar{\eta}\left(\alpha - \theta\frac{K'}{K_a}\right) + \alpha^2 + \frac{K'}{K_a}\theta^2 = 0 \quad (7)$$

For a given value $\frac{(K\gamma)_p}{(K\gamma)_a}$ the value θ is obtained from equation (4) and the value of $\bar{\eta}$ from equation (7). Substituting θ and $\bar{\eta}$ for η in equation (6) gives the value $\frac{12\,M_{max.}*}{(K\gamma)_a H^3}$. The full height H being known from the penetration coefficient α, the moment is determined.

The maximum moment coefficients have been calculated in this way from equations (4), (6) and (7) taking full wall friction for the K_a and K_p values, and are plotted in Fig. 19, against the logarithm of the ratio $\frac{(K\gamma)_p}{(K\gamma)_a}$. The values of ϕ given are for uniform soil

* *Sheet Piling, Cofferdams and Caissons*, by D. H. Lee ; page 46. Concrete Publications, Ltd.

* The units are : (12 M) lb.-in per ft. ; H ft. ; $(K\gamma)$ lb. per cub. ft.

CANTILEVER SHEET PILING.

Fig. 18.

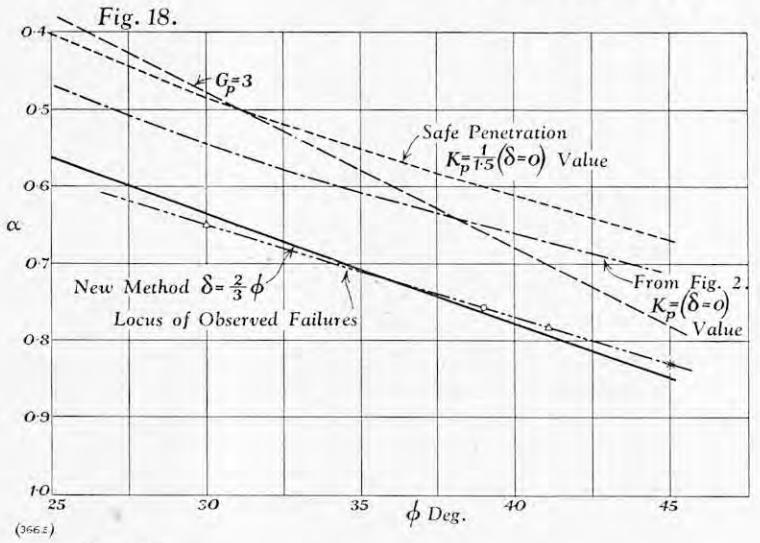


Fig. 19.

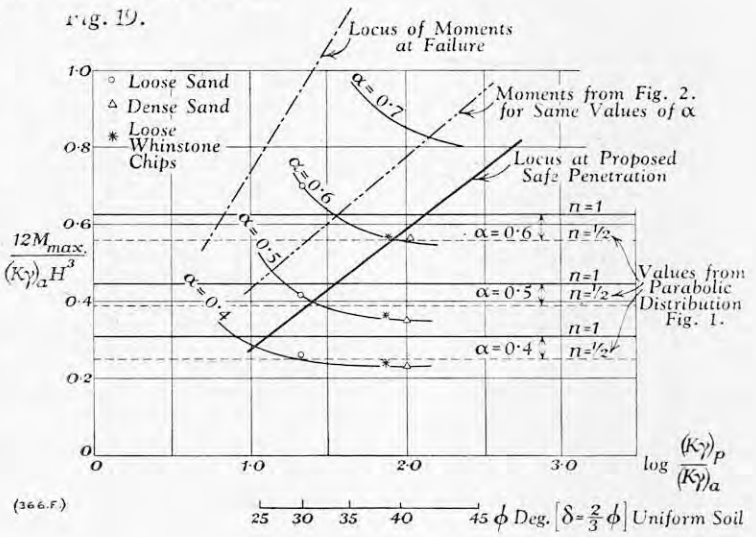


Fig. 20.

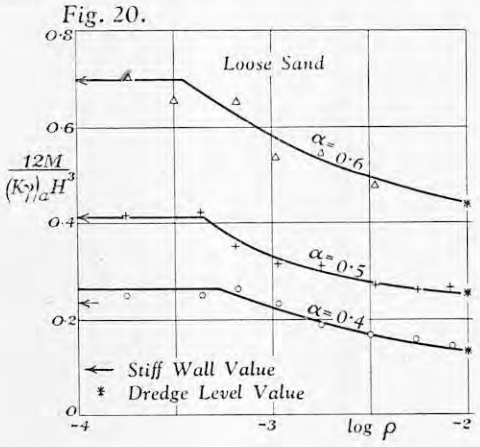


Fig. 21.

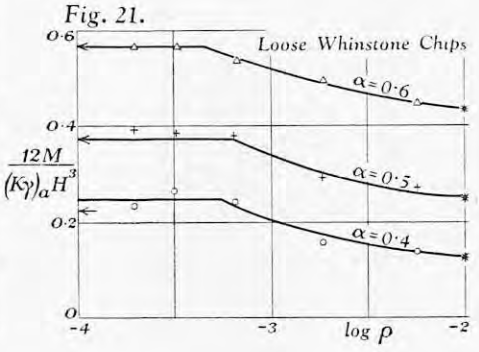


Fig. 24.

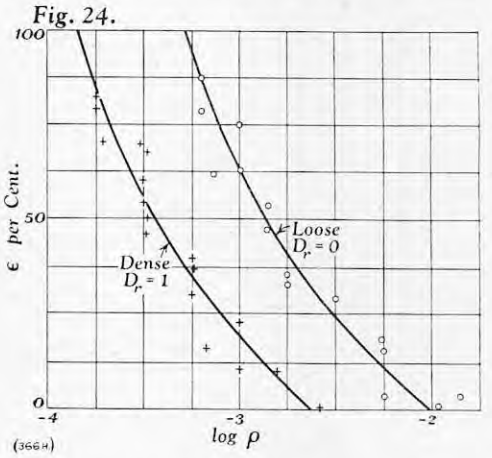


Fig. 22.

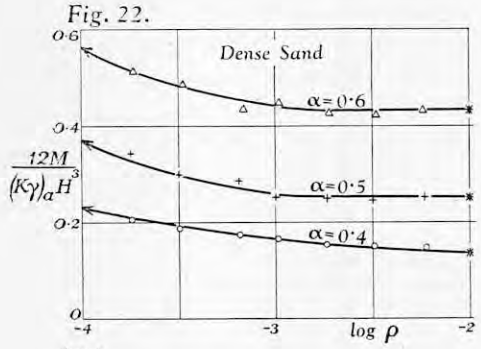


Fig. 23.

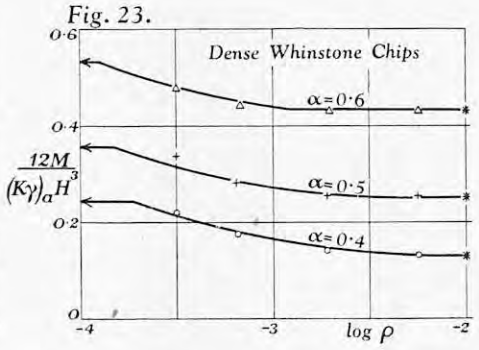
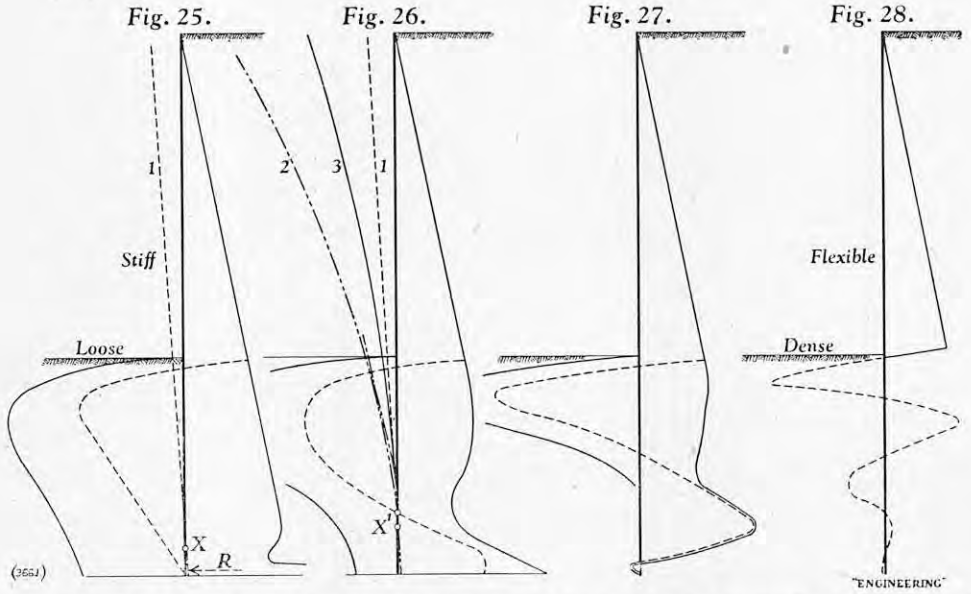


Fig. 25. Fig. 26. Fig. 27. Fig. 28.



on both sides of the pile. The graph shows: (1) the classical triangular distribution, Fig. 2, gives too large a moment for stiff walls; (2) the parabolic distribution gives a close value for loose soils, but does not allow for variation in subsoil density; (3) the proposed triangular distribution gives a close estimation of the stiff-wall moment at all values of the dredge level and takes account of variation in subsoil density.

The influence of pile flexibility on the maximum bending moments was next studied by making a series of tests with identical soil conditions on steel and Duralumin models of varying height and thickness. The results of these tests are given in Figs. 20 to 23, where the maximum observed bending moments are plotted against the logarithm of the flexibility number $\rho = \frac{H^4}{E\,I}$ for the cases of sand and whinstone chips in the loose and dense states. It is seen that the maximum moment decreases from the stiff-wall value, with increase in flexibility, to the bending moment acting at the dredge level on a flexible pile, encastré in the soil. This minimum value is given by

$$\frac{12\ M_{min.}}{(K\ \gamma)_a\ H^3} = 2\,\alpha^3 . \quad . \quad . \quad (8)$$

In Fig. 24, points from the curves of Figs. 20 to 23 have been replotted* so that the difference between the observed maximum moment, corresponding to a particular flexibility number, and the dredge level value is represented as a percentage of the difference between the maximum stiff-wall value and the dredge-level value. For practical purposes, mean curves are drawn for all the points in the loose and dense states respectively, otherwise independent of the value of ϕ or α. Reasons for the moment decrease are given in Figs. 25 to 28. The stiff wall shown in Fig. 25 tends to rotate about X near the toe into position 1. If it is replaced by a more flexible pile as in Fig. 26, the new pile would require to deflect further to position 2. This involves a further rotation into the soil, effectively about X′ due to the curvature of the flexible pile, and, X′ being above X, the centre of pressure of the passive distribution is raised and fixity below X′ is increased. The pile therefore only deflects to position 3. Increase in flexibility leads in this way to the encastré condition, Fig. 28. The decrease in moment occurs at lower flexibilities with dense soils compared to loose, since the higher shear modulus of dense soil causes a more rapid raising of the centre of passive pressure for a given wall rotation.

The proposed method of design is therefore to determine a safe penetration depth from equation (5) and to calculate the maximum and minimum moments that may act on the pile. Knowing the relative

* In Fig. 24, $\epsilon = \frac{M - M_{min.}}{M_{max.} - M_{min.}} \times 100$. Where M = Max. moment on a pile of flexibility ρ, $M_{max.}$ = Max. moment on stiff pile and $M_{min.}$ = Max. moment on flexible pile.

CANTILEVER SHEET PILING.

Fig. 29.

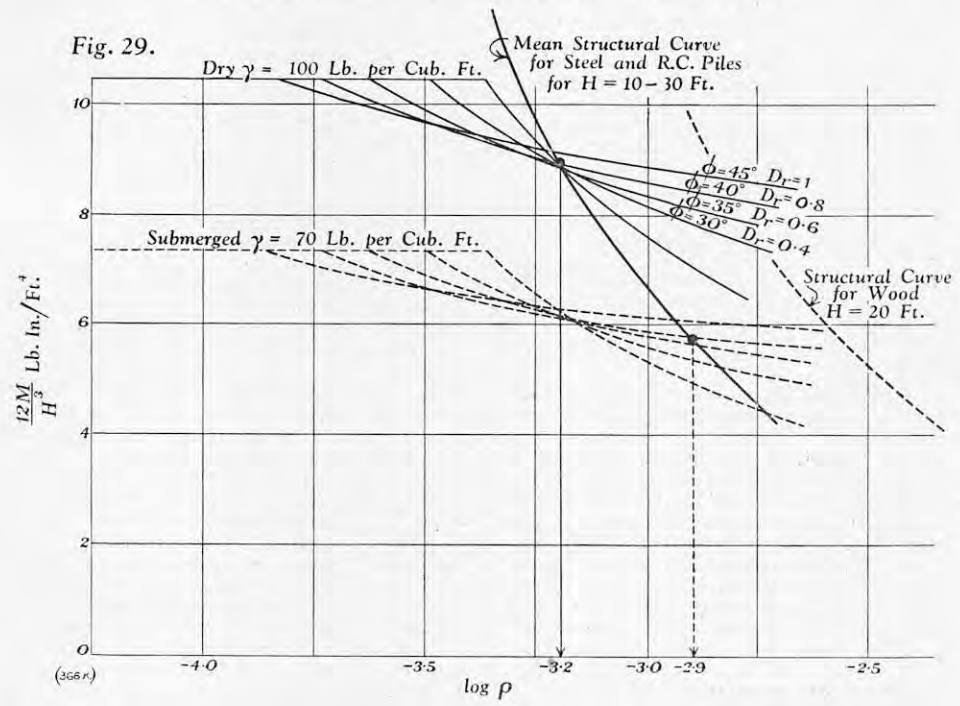


Fig. 30.

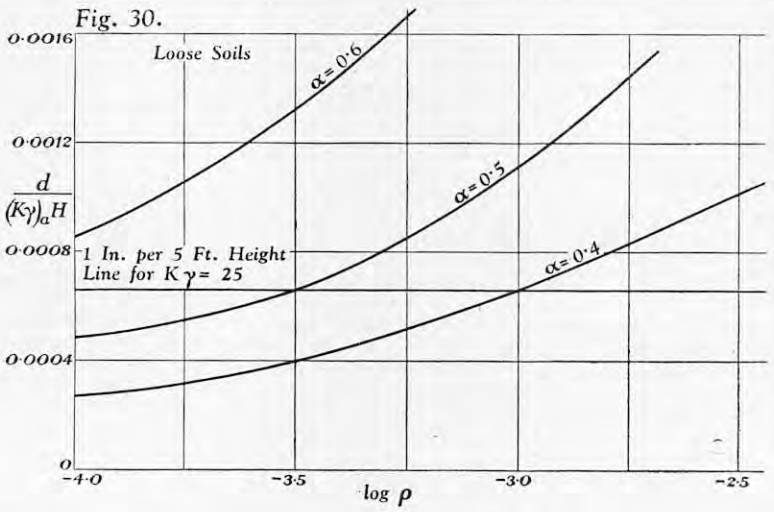


Fig. 31.

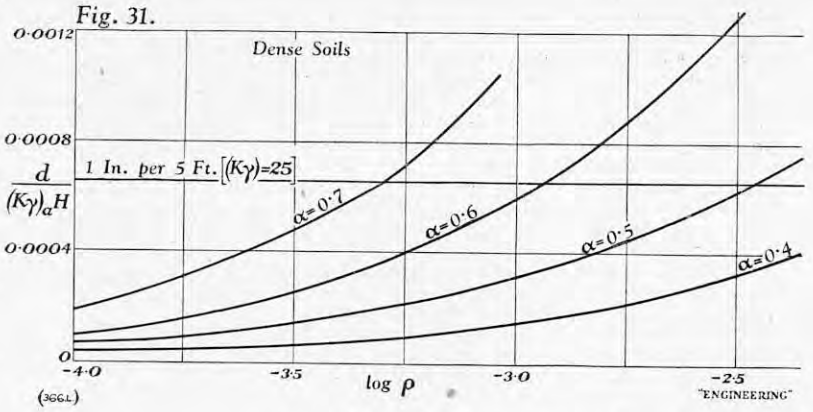


TABLE I.

φ	Rel. Density Dr.	α Eq. 5.	12 Mmax. / (Kγ)a H³ Fig. 19.	12 Mmax. / H³ lb. in./ft.⁴ (γ = 100)	12 Mmin. / H³ = 2 α³ (Kγ)a.	d/H log ρ = −3·2 (γ = 100)	d/H log ρ = −2·9 (γ = 70)
25	0·2	0·41	0·29	10·1	4·8	0·016	0·015
30	0·4	0·49	0·39	10·7	6·5	0·015	0·016
35	0·6	0·55	0·47	10·6	7·5	0·018	0·016
40	0·8	0·61	0·58	10·5	8·1	0·012	0·014
45	1·0	0·67	0·74	10·4	8·5	—	—

K_a = Coulomb value $\delta = \frac{2\phi}{3}$.

K_p: (1) For value of α, $K_p = \frac{1}{1{\cdot}5}$ Coulomb value $\delta = 0$.

(2) For $\frac{M_{max.}}{H^3 (K\gamma)_a}$, K_p = Coulomb value $\delta = \frac{2\phi}{3}$.

density of the subsoil, the percentage moment-flexibility curve is interpolated from Fig. 24 and used to draw the operating moment-flexibility curve for the proposed structure. As an example, Table I gives the values of α and $\frac{12\,M}{H^3}$ lb. in./ft.⁴ for a range of soils. It is seen that the value $\frac{12\,M}{H^3}$ corresponding to the proposed safe penetration depth is approximately constant at a value 10·5 for $\gamma = 100$ lb. per cubic foot. Where water acts on both sides of the piling, the value is in direct proportion to the submerged density. If differential water pressure may operate the value of $\frac{12\,M}{H^3}$ due to the water alone must be added to the submerged value for the soil. Assuming that soils with low values of ϕ will be in a loose state and those with high values in a dense state, a series of possible operating curves using $\frac{12\,M}{H^3} = 10{\cdot}5$ and 7·35, respectively, have been drawn using Fig. 24, and plotted in Fig. 29. A mean curve showing the relation between the size of a steel pile by Dorman, Long or Frodingham stressed to 8 tons per square inch or a reinforced-concrete pile designed to stresses 1,250 and 22,400 lb. per square inch., respectively, for heights H = 10 to 30 ft., is drawn and labelled "structural" curve. For initial design purposes all the operating curves may be taken as crossing the structural curve at one point for each soil density. The section modulus is then given by

$$E\,I = 1{\cdot}58 \times 10^3 \frac{h^4}{\alpha^4} \text{ lb. in. per ft. (Dry)} \quad . \quad . \quad (9)$$

$$E\,I = 0{\cdot}79 \times 10^3 \frac{h^4}{\alpha^4} \text{ lb. in. per ft. (Submerged)} \quad (10)$$

where h is the free height between the dredge level and the coping in feet. For exact design purposes, the correct structural curve for the proposed wall height, design stress and wall material must be drawn.

Finally, it is necessary to determine the value of the outward deflection of the top of a wall designed in this manner. Figs. 30 and 31 give the deflections as a ratio of the wall height and active pressure for a range of flexibilities and for soil in the loose and dense states. Taking the design values of log ρ as − 3·2 and − 2·9 for dry and submerged soil, respectively, the values of the deflections for a series of possible soils have been interpolated from Figs. 30 and 31 and are given in Table I. The deflection is seen to be 1 in. per 5-ft. height of the wall for all the soil conditions considered. This value is not excessive but it shows that it is unlikely that advantage may be taken of the greater flexibility of wooden piling (see Fig. 29) to allow smaller bending moments on the structure, unless the wall height is small or the structure is only a temporary one.

In conclusion, the proposed design method may lead to a saving of up to 20 per cent. by weight of the wall compared to the use of the classical triangular method. The possibility of a cantilever design may be assessed rapidly using equations (5) and (9) before proceeding to the exact design as illustrated in Fig. 29.

SILICA BRICKS.—During the past few years confusion has been experienced between makers and users of refractories on the meaning of the terms silica bricks, siliceous bricks, semi-siliceous bricks and firebricks. The Ministry of Supply were therefore asked to ascertain whether agreement could be obtained between the interested organisations. The Ministry have now reported that the term silica bricks should refer to bricks containing at least 92 per cent. silica; the term siliceous bricks to bricks containing from 85 per cent. to 92 per cent. silica; the term semi-siliceous bricks to bricks containing from 78 per cent. to 85 per cent. silica; and the term firebricks to bricks the silica content of which is below 78 per cent. The British Ceramics Research Association and the director of the National Federation of Clay Industries have been consulted, and are in agreement with the classification.

PREVENTING FREEZING ON RAILWAY ROLLING STOCK.—Last year, four screens 11 ft. high, three of them 870 ft. long, were built between the tracks in the London Transport train sidings at Hainault, on the Central Line, to protect stabled trains from cold winds which cause freezing troubles in the winter. They were found to be very effective. It is impossible to avoid some accumulation of moisture in the several compressed-air systems of the trains, and though certain beneficial precautions have been taken in the past, they have not given complete protection; these precautions included keeping the air circulating by operating the equipment at intervals, feeding anti-freeze alcohol into the air system through the compressor intake, and keeping car heaters on. The sidings at Hainault, which accommodate 29 eight-car trains, are divided into bays of four roads each by the screens. Corrugated-asbestos sheets bolted to a steel framework are used, and sliding doors are fitted at openings half-way along the screens. Provision is made at the north end for motor-driven roller shutters.

NOTES ON NEW BOOKS.

Elementary Electrical Engineering.

By A. E. CLAYTON, D.Sc., M.I.E.E., and H. J. SHELLEY, O.B.E., B.Sc., A.M.I.C.E. Third edition. Longmans, Green and Company, Limited, 6, Clifford-street, London, W.1. [Price 14*s.* net.]

WHEN this book was first published in 1927 it was pointed out that the subject matter covered sufficient ground to render it suitable for those studying for the Ordinary National Certificate or Diploma in Electrical Engineering. Direct-current and alternating-current circuits, direct-current machines, transformers, measuring instruments, secondary batteries and electric lamps were all dealt with in an elementary manner, and there were many numerical examples. In the present edition, in addition to the revision necessitated by the passage of time, there are two new chapters, one dealing with general circuit theorems and the other giving a detailed treatment of series and parallel alternating-current tuning circuits. Much of the chapter on illumination has been rewritten and the information on electric lamps has been brought up to date. The book should form a useful introduction to a more advanced study of the subjects covered.

Telephony.

By J. ATKINSON, A.M.I.E.E. Volume II. Sir Isaac Pitman and Sons, Limited, Parker-street, London, W.C.2. [Price 50*s.* net.]

THE complications, which are necessary to enable one telephone subscriber to communicate with another without human intervention, may be illustrated by saying that this book, which deals only with automatic exchange systems, consists of no less than 872 large pages. It forms a companion volume to an earlier work, in which general principles and manual exchange systems were covered. The two together should prove useful to those studying for Grades I, II and III of the City and Guilds of London examination in telephone exchange systems and the telephone aspects of elementary telecommunications practice. The facilities, switching principles and circuits described in the present volume relate almost entirely to the current practice in the United Kingdom and other countries, where British automatic exchange equipment is used. Stress is laid on the fundamental elements upon which the complete circuits are built and the merits and limitations of these elements are carefully analysed. A number of complete circuits are, however, described, so that the way in which these basic circuit elements are associated to give the desired facilities can be appreciated. After discussing the objects and advantages of automatic switching, the broad principles of the step-by-step system are described. The theoretical aspects of telephone traffic, the quantity of switching equipment required and the methods of interconnecting it are next examined, while descriptions are given of the standard switching mechanisms and of the cable arrangements in an automatic exchange. After dealing with the various component circuit elements, it is shown how these are integrated in typical selector circuits, like the trunking arrangements and special circuits used in the "non-director" and "director" systems and in "unit automatic exchanges" are described in detail. After brief accounts of a number of other automatic systems, the problems of dialling over long distances and the mechanisation of trunk and toll switching are discussed. If the author's style is a little dry that is rather an advantage than a disadvantage in this class of work and, at any rate, he has succeeded in packing a great deal of information into an amount of space which is small relative to the ground covered. The numerous diagrams are clear and are really illustrative of the text. The volume provides a complete survey of present practice and is a tribute to the excellent work which has been done in this branch of engineering.

Tables to Facilitate Sequential t-Tests.

United States National Bureau of Standards. Applied Mathematics Series No. 7. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 45 cents.]

ALL statisticians are familiar with the *t*-test devised by W. S. Gosset ("Student"), in 1908, which had such a profound influence on small-sample theory. Multiple or sequential sampling offers certain advantages and economies compared with the taking of a single sample, and the present tables have been prepared by the National Bureau of Standards to facilitate sequential *t*-tests like those devised by A. Wald in the United States for use in the sequential analysis of statistical data. They may be employed to determine, with an assigned probability, whether a particular numerical value m is the mean of a normal population of unknown variance. Before employing the tables, however, the user must decide on an acceptable level of probability q on which to reject the hypothesis that the mean is m when the mean is, in fact, m; and a probability p and a value d of the deviation of the true mean from m, expressed in units of the standard deviation, must also be selected on which it will be satisfactory to accept the hypothesis that the mean is m when, in fact, it differs from m by d. The test procedure is such that, if the deviation of the true mean from m is greater than d, the probability of assuming that the mean is m is less than p.

Drainage and Sanitation.

By E. H. BLAKE, C.B.E., and W. R. JENKINS, B.Sc. (Eng.), A.M.I.C.E. Tenth edition, revised by LEONARD B. GUMBRELL, A.R.I.C.S. B. T. Batsford, Limited, 15, North Audley-street, London, W.1. [Price 15*s.* net.]

MANY changes have been made in the legislation affecting drainage and sanitary arrangements in dwellings, factories and public buildings since the first edition of this book was published in 1913, but examples of obsolescent arrangements and fittings are still to be found. It is a useful feature of the book, therefore, that descriptions and illustrations of such equipment are retained, and their shortcomings discussed, for comparison with the improved systems and appliances which are recommended and, in many instances, required by law. The principal regulations are quoted at length, and local departures from general practice noted; and the concluding chapter of "Legal Notes" summarises all the most important requirements that an architect, builder or sanitary engineer is likely to need in his ordinary work. Ventilation, heating, lighting and water supply are also discussed, so far as they bear upon the main subjects. The illustrations are generally good, though the time is evidently approaching when some of them should be redrawn and new blocks provided.

The Modern Soap and Detergent Industry.

By GEOFFREY MARTIN, D.Sc., Ph.D., F.R.I.C. Two vols. Third edition, revised by EDWARD I. COOKE, M.A. (Cantab.), B.Sc., A.R.I.C. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 50*s.* net per vol.]

THE two volumes of this compendious work appeared first in 1923, and the second edition in 1931. Vol. I deals with "Theory and Practice of Soapmaking," and Vol. II, which has been enlarged since the previous edition, with "The Manufacture of Special Soaps and Detergent Compositions." There have been some additions to Vol. I also, but they consist mainly of more recent references to research work, statistics, etc., and the introduction of more modern illustrations of plant. Vol. II, however, has been expanded by the addition of a section on synthetic surface active materials, and the inclusion of new material on spray-drying of powders, and the synthesis of fatty acids. The bibliographical references and statistics have been brought more up to date, as in Vol. I. The expressed hope that the work now presents a comprehensive picture of present practice in the manufacture of soap appears to be well realised; but readers might find it easier to locate a particular item if the pages were numbered consecutively through each volume, instead of by sections. The index is above the average in completeness, but some practice is required to turn quickly to the desired page.

The East Coast Route.

By GEORGE DOW, M.Inst.T., A.I.Loco.E. The Locomotive Publishing Company, Limited, 88, Horseferry-road, Westminster, S.W.1. [Price 7*s.* 6*d.*]

ALTHOUGH one effect of railway nationalisation has been to transfer Mr. George Dow to the London Midland Region, readers of this book may suspect that his personal leanings are still towards the East Coast route which he describes with such a wealth of intimate detail. In the first chapter he traces its growth from the beginning to the present day. The next three chapters deal with the features that a passenger is likely to notice, or to be interested in, between King's Cross and Aberdeen. Chapter V is devoted to locomotive and carriage development, and the book concludes with a chapter on "Some Famous East Coast Expresses." The illustrations include a number of considerable historical interest, and most are likely to be novel to a majority of readers; one, for instance, of the original Tay Bridge under construction shows what a light structure it really was, for such an exposed situation. From experience, we can say that the book is an agreeable companion over the route that it describes, though the type is rather small to read in a fast-moving train.

BOOKS RECEIVED.

Research and Scholarship in the University of Sydney: A Short Record of Original Work Done During 1946 *and* 1947. Prepared by a Committee appointed by the Vice-Chancellor. Australasian Medical Publishing Company, Limited, Seamer-street and Arundel-street, Glebe, Sydney, New South Wales, Australia.

Department of Scientific and Industrial Research and Fire Offices' Committee. Report of the Fire Research Board, with the Report of the Director of Fire Research for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Overseas Economic Surveys. Pakistan. By WALTER GODFREY. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 5*s.* net.]

Productivity Report. Welding. Report of a Specialist Team which visited the United States of America in 1950. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 3*s.* 6*d.*, post free.]

Beama Guide to British Electrodes. Prepared by the Arc Welding Electrode Section. The British Electrical and Allied Manufacturers' Association, 36-38, Kingsway, London, W.C.2. [Price 2*s.* net.]

Recommended Designs for Metal Arc Welded Mild Steel Building Structures. Beam and Column Connections. British Welding Research Association, 29, Park-crescent, London, W.1. [Price 2*s.* 6*d.*]

Dollars and Industry. A Record of the Dollar Convention held at Eastbourne in March, 1951. Dollar Exports Board, Thames House North, Millbank, London, S.W.1; and BEAMA Export Department, British Electrical and Allied Manufacturers' Association, 36, Kingsway, London, W.C.2. [Price 10*s.* 6*d.*, post free.]

United States National Bureau of Standards. Applied Mathematics Series No. 12. *Monte Carlo Method.* [Price 30 cents.] No. 15. *Problems for the Numerical Analysis of the Future.* [Price 20 cents.] The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.

The Works Engineer. By W. R. J. GRIFFITHS, in collaboration with W. O. SKEAT. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 25*s.* net.]

Work Study and Incentives. By A. J. SPEAKMAN. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 4*s.* net.]

The "M.E." Lathe Manual. By EDGAR T. WESTBURY. Percival Marshall and Company, Limited, 23, Great Queen-street, London, W.C.2. [Price 12*s.* 6*d.*]

The Oxide-Coated Cathode. By DR.-ING. G. HERMANN and DR. S. WAGENER. Vol. Two. *Physics, Including Thermal Emission from Metals and Semi-Conductors.* Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 42*s.* net.]

Der Ingenieur im Chemiebetrieb. By FRIEDRICH JÄHNE. Verlag Chemie, Hauptstrasse 127, Weinheim a.d. Bergstrasse, Germany. [Price 14.80 D.M.]

Adhesion and Adhesives. Edited by N. A. DE BRUYNE and R. HOUWINK. Elsevier Publishing Company, Incorporated, Spuistraat 118, Amsterdam, Netherlands. [Price 37.50 florins.]; and Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 70*s.*]

Britannica Book of the Year 1951. Encyclopædia Britannica, Limited, 102, Dean-street, London, W.1. [Price 60*s.*]

POWER STATION CONSTRUCTION.—The British Electricity Authority have received the consent of the Ministry of Fuel and Power to the establishment of a power station at Marchwood, near Southampton. This station will have a capacity of 480 MW, made up of eight 60-MW turbo-alternators, which will be supplied with steam from eight 550,000-lb. boilers. Consent has also been received to the extension of the Goldington station, near Bedford, by four 30-MW sets, four 300,000-lb. boilers and three cooling towers. Two other sets for this station, with their associated boilers, have already been authorised.

RAILWAY APPRENTICES' SCHOOL AT CREWE.—Work is to commence soon on the building of a school at Crewe locomotive works for giving new apprentices, who have left day-school at the age of 15, their first year's training in the theory and practice appropriate to the type of work in which they will specialise while serving the main part of their apprenticeship in the works. It is estimated that 270 boys will pass through the school each year; accommodation will be provided for three times as many apprentices as at the existing British Railways school at Derby. The building will be in two storeys: on the ground floor, the workshop, rooms for the principal and lecturers, and administrative facilities; and, on the upper floor, classrooms, drawing offices and a library. Adjacent to the school there will also be an assembly hall which can be used as a gymnasium or cinema. The apprentices' wages will rise from 29*s.* a week at the age of 15 to 71*s.* a week at 20.