CEMENT WORKS AT SHOREHAM-BY-SEA.

FOR over 80 years cement has been manufactured at Beeding, near Shoreham-by-Sea, on the South Downs of Sussex, on a site lying between the Shoreham-Steyning road and the river Adur. After the second World War, the British Portland Cement Manufacturers, Limited, who operate the Beeding works, decided to increase the scale of their activities in this area, and early this year the new Shoreham plant commenced work. Figs. 1 and 2 are aerial views of the new cement works. The layout and many of the constructional details of the plant have been designed by the Company's engineering department to ensure easy maintenance and reliability of the equipment so that the kilns can be kept running continuously for at least 95 per cent. of the year, which is essential for the economic production of cement. The new works is highly mechanised, with an elaborate system of conveyors, the main contractors for the mechanical-handling plant being the Mitchell Engineering Company, Limited; special precautions have been taken to suppress dust, and in this respect, as well as in the efficiency of the general layout, the new works is far in advance of older installations.

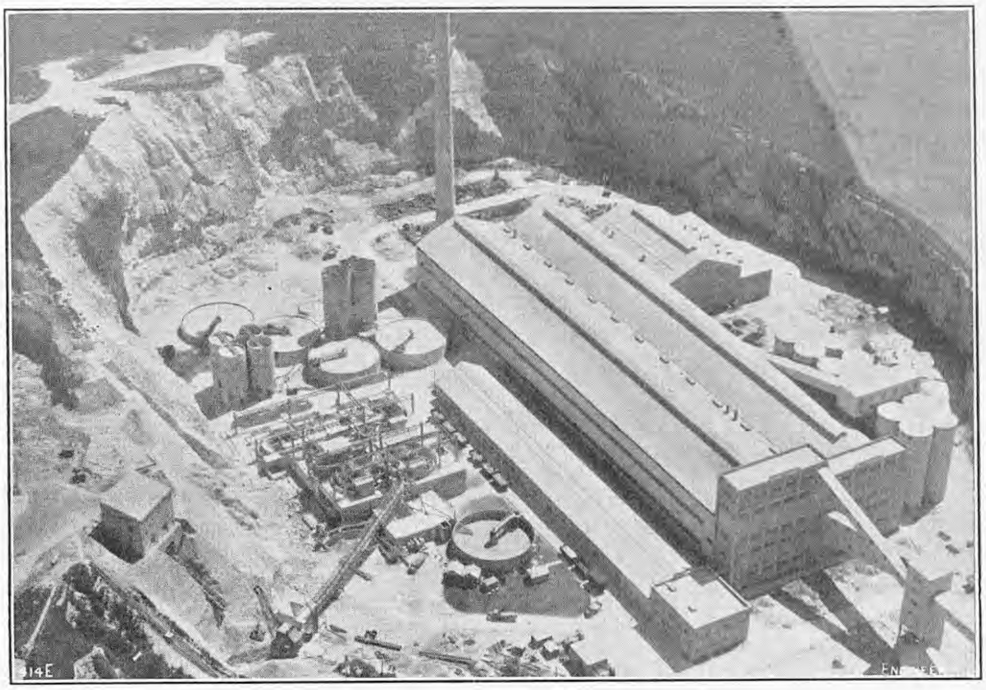


FIG. 1. AERIAL VIEW OF WORKS.

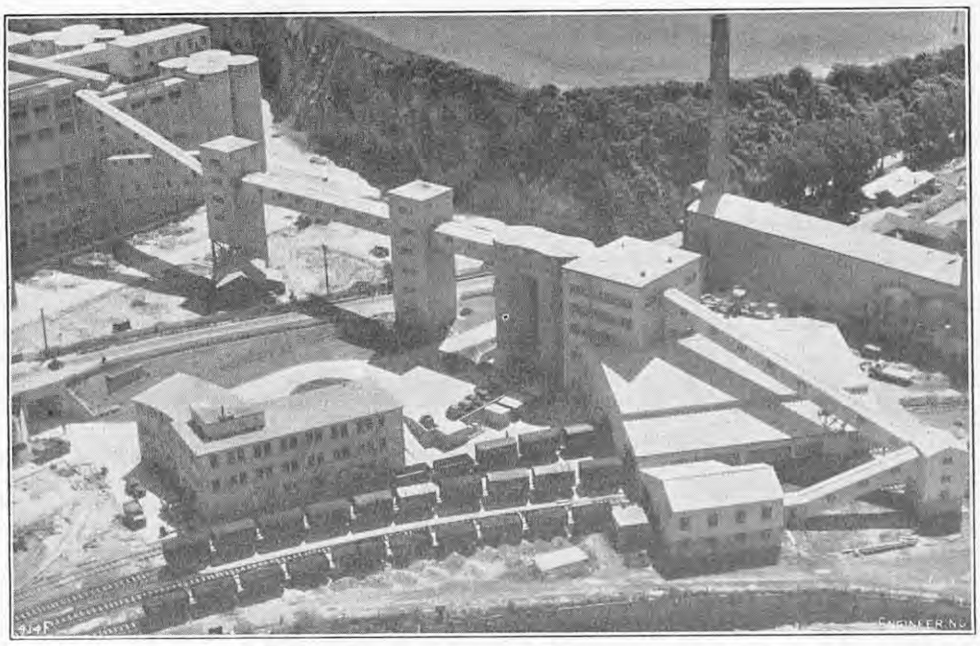


FIG. 2. PACKING PLANT AND CONVEYOR GANTRIES.

The main civil-engineering work involved in the extension at Shoreham was carried out, to the design of the consulting engineers, Oscar Faber and Partners, Limited, by John Laing and Son, Limited, and Bierrum and Partners, Limited. The new plant has been laid out largely in the quarry formed by the chalk excavations of old cement works. Fig. 10, on Plate VII, shows the layout, from which it will be seen that the quarry extends on the opposite side of the road from the old works, over an area some 1,000 ft. long by 800 ft. wide, and of roughly elliptical shape. The chalk cliffs surrounding the quarry are about 180 ft. high at the highest point. The packing plant, the railway sidings and unloading equipment, and a block of office buildings are located on the old site. The foundations of these buildings rest upon piles varying in length between 14 ft. and 74 ft., as the level of solid chalk falls away steeply between the road and the river; on the other side of the road, where the main plant is situated, the foundations are based on solid chalk.

Briefly, the process of making cement consists of calcining, at approximately 2,650 deg. F., a mixture of finely divided chalk and clay, in the ratio of about 3·8 to 1. To the resulting clinker a small proportion of gypsum is added, which has the effect of reducing the setting speed of the cement, which would otherwise be too high. The clinker is then finely ground, usually to a greater fineness than that specified by British Standard 12 : 1947, which requires that, for ordinary cement 90 per cent., and for rapid-hardening cement 95 per cent., must pass through a 170-mesh sieve. In this country it is usual to use the wet process for mixing the raw materials, as it is considered that a more consistent mixture is obtained for a smaller power consumption, and the dust problem is less of a nuisance. Fig. 3, on page 98, shows a simplified flow diagram of the processes through which the raw materials pass.

The clay is excavated in a field at Horton, some $2\frac{1}{2}$ miles to the north-west of the quarry; the contractors for the civil engineering work at Horton were J. L. Kier and Company. Fig. 13, on Plate VIII, shows the multi-bucket excavator, with a capacity of about 70 tons per hour, which is used for digging the clay and loading it on to a 24-in. belt conveyor which carries it to a washmill, 25 ft. in diameter, fed with water pumped from a lake beside the claypit. The lake is replenished from the main water supply at the Shoreham works. The clay slurry, containing about 70 per cent. of water, is discharged from the washmill to a storage tank, 52 ft. in diameter, in which it is continuously agitated by rotating paddles. Adjacent to the storage tank are three reciprocating high-pressure slurry pumps, operating at 300 lb. per square inch, which pump the slurry through one of two 8-in. mild-steel pipelines, more than $2\frac{1}{2}$ miles long and laid underground, to a tank at the Shoreham works; a standby pipeline is essential, as periodic back-flushing by water at fairly frequent intervals is necessary to keep the pipes clean. The pipelines have welded joints and are heavily protected by a bituminous compound and asbestos sheaths, to resist electrolytic corrosion. The clay-slurry tank at Shoreham is 66 ft. in diameter and constructed of concrete. It is 14 ft. 8 in. high, and surmounted by a rotating girder which carries pipes supplying air to the bottom of the tank, to keep the slurry in continuous agitation. Compressed air is a more efficient means of agitation than the paddles employed at Horton, but it was not economic to install a compressed-air plant there. From the tank the slurry flows to a breakhead tank which maintains a constant head of slurry above two centrifugal sand-pumps which pump the slurry to a spoon-feeder supplying the chalk washmills.

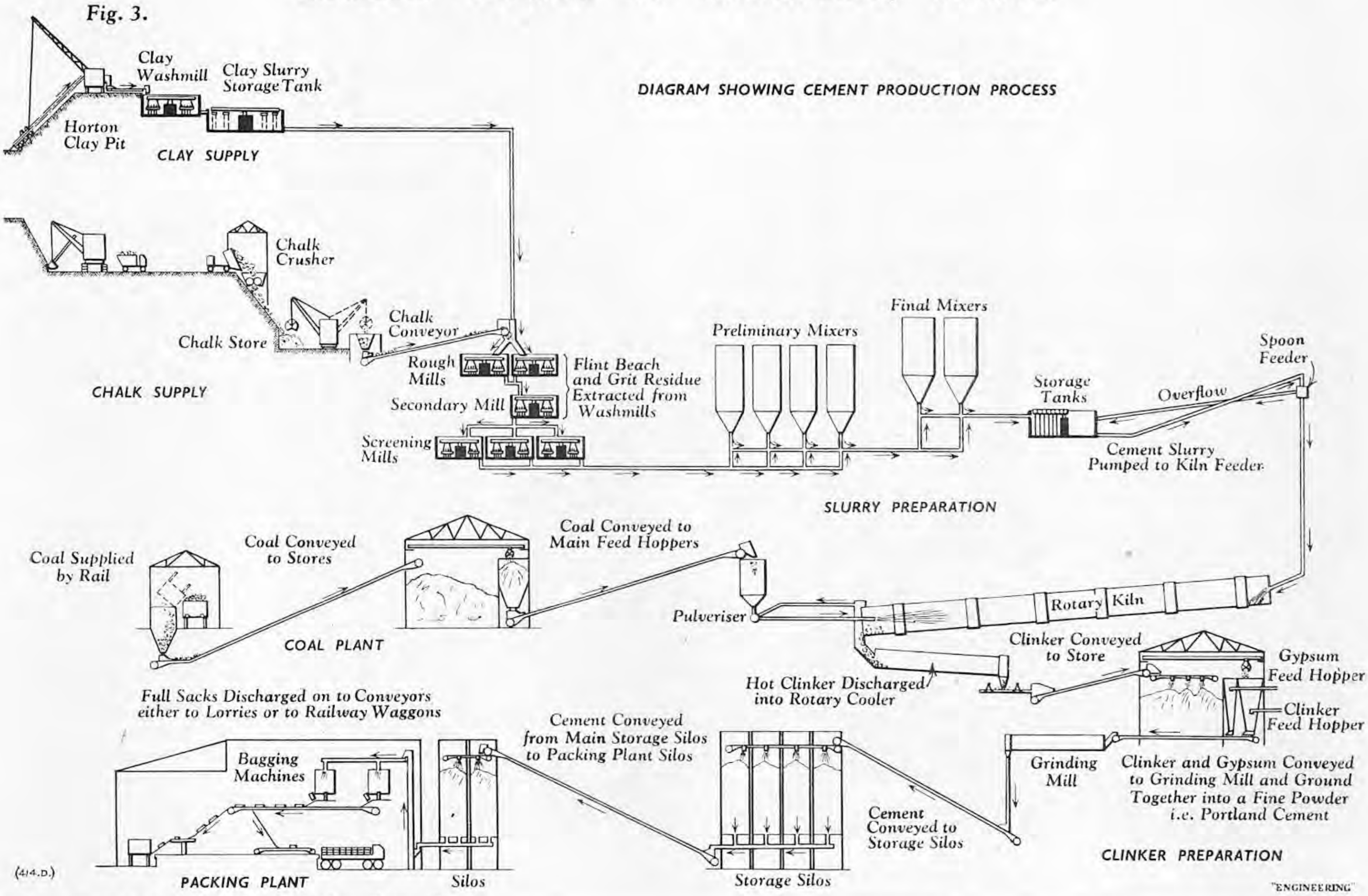
The old chalk quarry, in which the new works are laid out, was worked as a single face. The new quarry will be benched; the first cut, about 40 ft high, is being made along the top, some distance back from the old face. The chalk is excavated by a $3\frac{1}{2}$ cub. yard electric navvy and is deposited in 9 cub. yard dumpers, holding about 12 to 13 tons of chalk. The dumpers carry the chalk back to a chalk-crusher house, which can be seen in Fig. 8, Plate VII, built on to the solid chalk on the face of the old quarry; within the crusher house is a twin-roll claw crusher, with a capacity of 300 tons per hour of chalk, supported on reinforced-concrete foundations about 100 ft. above the floor level of the works. The crusher reduces the chalk to dimensions less than a 10 in. cube, and discharges it down a gravity chute to a stockpile holding sufficient for a day's supply to the chalk-washing plant.

At the side of the stockpile, and supported on a reinforced-concrete platform is an electric jib crane, with a $5\frac{1}{2}$-ton grab, which transfers the chalk on to a feeder, whence it passes to the 30-in. belt conveyor which carries it to the roughing washmills. At the delivery end of the conveyor belt, an "Adequate" weigher records the feed rate and integrates it. At each 10 tons, the mechanism operates a relay which actuates the motor of the clay-slurry spoon-feeders, delivering the slurry to mix with the chalk in the roughing washmills. After a pre-set interval, which is adjusted as required by the works chemist, a timing mechanism switches the spoon-feeder out of action until the next 10-ton load of chalk has passed. By this means it is possible to control the proportions of chalk and clay entering the roughing washmills.

In order to remove stones and to break up the

CEMENT WORKS AT SHOREHAM, SUSSEX.

Fig. 3.



chalk, the mixture of chalk and clay slurry is washed and screened in three sets of washmills on different levels; as may be seen in Fig. 10, and Fig. 14, on Plate VIII, there are two rough mills, which work intermittently and perform the main work of breaking up the 10-in. chalk cubes into slurry. A single secondary mill, which undergoes considerably less wear and tear than the rough mills and works continuously, is fed by gravity from the rough mills. The three screening-mills are also gravity-fed from the secondary mill; most of the breaking-down of the material has been completed in the roughing and secondary mills, and the screening mills act, in effect, mainly as sieves. Each of the washmills consists of a tank of circular cross-section, 35 ft. in diameter, in which revolve, about a fixed king-post, a steel structure carrying harrows, or, in the case of the screening mills, splash plates. It is the action of these revolving harrows that breaks down the chalk and produces an intimately mixed chalk-clay slurry. Hand-operated overhead travelling cranes are provided above each level for maintenance work. The washmills have been designed in detail by the engineering department of the Associated Portland Cement Company; drawings of one of the rough mills are reproduced in Figs. 5, 6, and 7, opposite. The rough mills and the secondary mill are driven by 350-h.p. Metropolitan-Vickers slip-ring motors operating from a 3-kV supply; the 100-h.p. motors for the screening mills operate from a 415-volt alternating-current supply.

In earlier mills, the practice was to install the driving motor at some distance from the mill and to transmit the drive through a long counter-shaft and machine-moulded bevel gearing, which caused vibrations and consequent wear and tear. In each of the present machines, the driving motor is mounted on an upper bridge spanning the mill, and is connected to a combined helical and bevel double-reduction gearbox. The vertical output shaft of the gearbox is coupled to the pinion shaft of the final reduction gears, which are machine-cut spur gears. The pinion-shaft bearing is mounted on the lower bridge across the mill, which also carries the top location for the king post of the washmills.

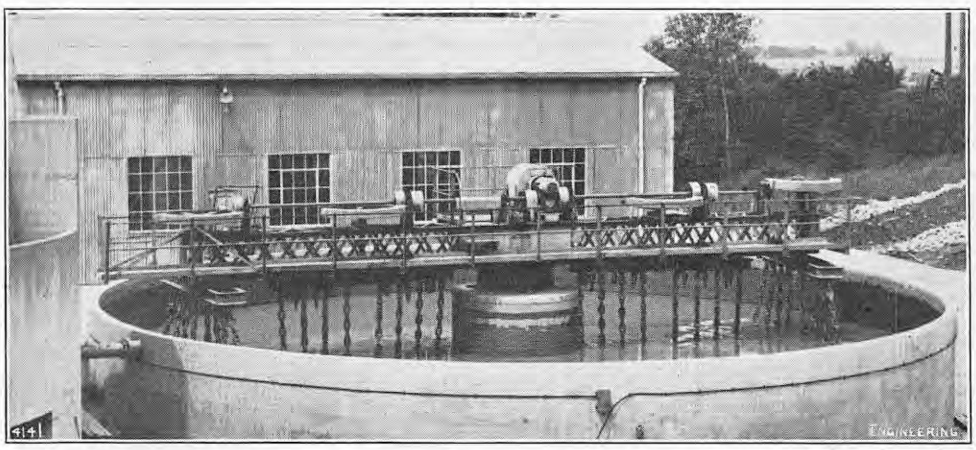


FIG. 4. CLAY SLURRY STORAGE TANK.

The use of two bridges serves to insulate the motor and gearbox from any vibrations generated in the mill. The first reduction gears are totally enclosed and are lubricated by an oil spray. The spur wheel is mounted on the rotating-harrow frame, which consists of a braced cruciform structure of rolled-steel joists from which the harrows are suspended by chains; it rotates at about 10 r.p.m.

Round the circumference of the mill are arranged vertical gratings through which the slurry is forced into an annular trough. The openings in the gratings are slots ranging from $\frac{3}{4}$ in. to 1 in. wide, on the rough mills. In the secondary-mill gratings, the slots are 1·5 mm. wide and 4 mm. long; and in the screening mills, the slurry is forced through fine woven-wire screens. In the secondary and screening mills, the full circumference is used for screening the slurry, but in the rough mills only 85 per cent. is used, solid plating being provided below the entry chute to prevent the slurry from being washed out immediately. Below the level of the screens, the concrete walls of the mill tanks are protected from wear by the flints and large lumps of chalk by means of short pieces of bull-headed rail, keyed together. The floor is protected by granite sets.

From the screening mills, the slurry is pumped by two centrifugal pumps to one of four preliminary mixers. These are cylindrical tanks of reinforced concrete, 54 ft. 6 in. high and 23 ft. 7 in. in diameter, with conical bottoms, and are supported on cylindrical walls. In them the slurry is thoroughly mixed by blowing air into each tank in turn from a central air pipe; electrically-operated sequence valves control the distribution of air to each tank. It is the practice to fill one mixer completely with slurry and, when it is full, to alter slightly the proportions of chalk and clay entering the washmills so that a slurry of high-carbonate content alternates with one of low-carbonate content. Samples are taken from the mixers and are analysed in the chemical laboratory on the site. The slurry is then pumped from two of the preliminary mixers to the final mixers by two 8-in. centrifugal pumps, the relative amounts of high-carbonate and low-carbonate slurry being adjusted to give the desired proportion. The two final mixers are of similar design, but are larger than the preliminary mixers,

CEMENT WORKS AT SHOREHAM, SUSSEX.

GENERAL ARRANGEMENT OF 35.0" DIA. HEAVY WASHMILL

Fig. 5. SECTION A-A

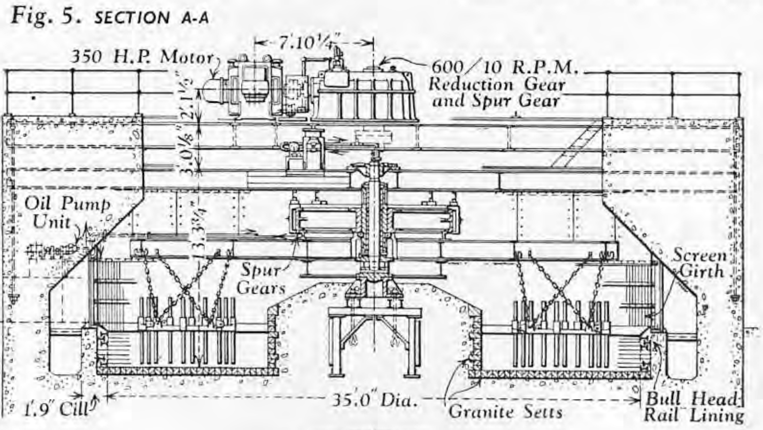


Fig. 7. SECTION B-B-B-B

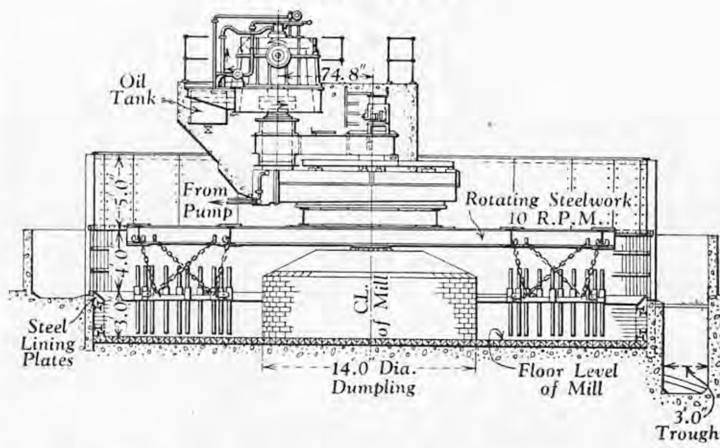
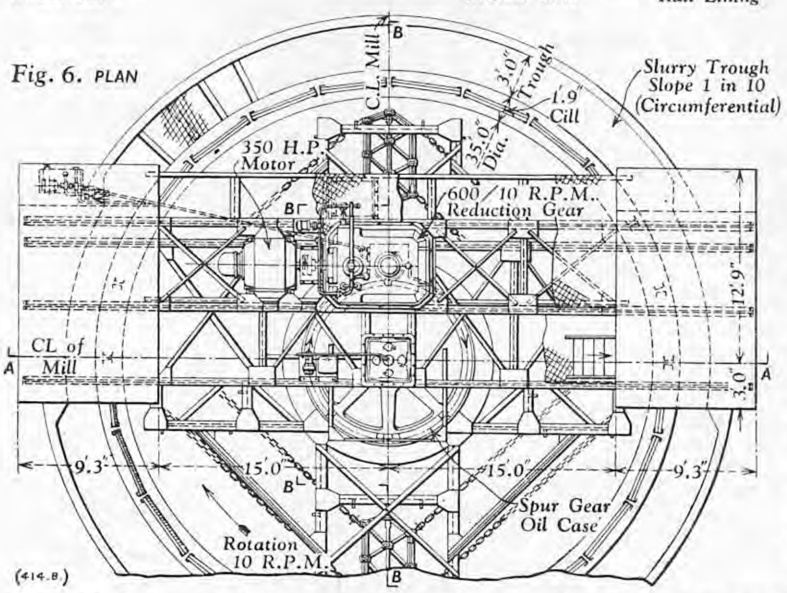


Fig. 6. PLAN



being 76 ft. high and 27 ft. 1 in. in diameter. Further sampling is carried out from the final mixers, and any necessary corrections are then made. From the final mixers the slurry is discharged by gravity to three reinforced-concrete slurry storage tanks, of the same dimensions and fitted with stirring and air-agitation equipment similar to that at the Shoreham clay-slurry tank.

The disposal of the flints rejected by the screens in the washing mills is as follows. In the rough mills, flint-extraction doors are provided at the bottom of the mill floors, through which the collected flints are discharged periodically—about once in each shift—into concrete hoppers, from which they are delivered by jigger-feeders on to sloping belt conveyors which carry them up to a chute feeding a rotary washer. The hopper below one of the rough-mills is illustrated in Fig. 9, on Plate VII, in which may also be seen one of the reinforced-concrete columns supporting the washmills, which form a vaulted chamber of impressive appearance. The flint washer, which is 24 ft. long and 4 ft. 6 in. in diameter, slopes upward at 5 deg.; water enters at the top. The flints are carried up through the water by helical lifters, and any chalk adhering to the stones is removed. At the end of the washer the flints are passed over a 2-in. screen; stones greater than 2 in., which are used in the pottery industry, are delivered by a belt conveyor to a rail wagon or to a stockpile. The flints which have passed the screen are delivered by another belt conveyor to a storage area for rubble.

From the secondary mill, the small flints which have escaped from the rough mills are discharged continuously from a duct in the bottom of the mill to a small elevator which carries them to a ¾-in. mesh rotary screen. The smaller stones are delivered to a washing screw, where any chalk is removed, and thence to a storage dump. The larger stones may be returned to the secondary mill to assist in grinding the slurry. From the screening mills, grit and slurry flows continuously from a duct in the mill floor to a sump from whence it is pumped by a centrifugal pump to a bowl and rake classifier. The rake extracts all the grit exceeding 100 mesh and discharges it to a dump. The slurry is passed to a thickening tank, adjacent to the preliminary mixers, together with the washing water from the flint and beach washers; the solids settle to the bottom and are in this tank pumped back to the roughing mills to mix with the chalk and clay slurry. About 6 tons of thickening slurry are returned to the tank for every 100 tons of chalk passing the wash-mills.

The slurry is calcined in two Vickers-Armstrongs rotary kilns, housed in a steel-framed building 500 ft. long, 67 ft. wide, and 65 ft. high. Fig. 15, Plate VIII, is a view from the top gallery of the kiln house, from the end at which the slurry is introduced, looking down the kiln towards the four coal hoppers at the firing end of the kilns. The illustration shows the comprehensive control and indicator panel for the kilns. Figs. 11 and 12, on Plate VIII, shows the general arrangement of the machines in the kiln house. The kilns, 350 ft. long and 10 ft. in diameter, are set at a slope of 1 in 24; as viewed in Fig. 15, they rotate in a clockwise direction. Each is capable of producing 23 tons per hour of clinker. Slurry from the storage tanks is pumped by three reciprocating pumps to a distribution box at the top of the kiln house, whence it divides to two spoon feeders which deliver it into the upper end of the kilns. The slurry flows down the kilns and the hot gases, produced by burning pulverised coal at the lower end, flow upwards.

The kilns are constructed of 1-in. steel plates over a length of 110 ft. at the lower end, the rest of the kiln plates being ⅞ in. thick. The diameter at the burning zone is increased to 11 ft. 6 in.; the nose-ring castings are of heat-resisting steel. The kilns were constructed in sections at Messrs. Vickers-Armstrongs works, with plate joints welded by the Union-melt process, the kiln sections being connected at the site by riveted butt straps. They are lined with high-alumina bricks. At the upper end of the kiln, curtain chains act as heat exchangers between the hot gases and the slurry, and catch much of the dust that would otherwise escape from the kiln; the flow of slurry down the kilns is assisted by festoon chains. The kilns are supported on six tyres of 45-ton alloy steel, each running on two large rollers, the spindles of which run in water-cooled self-aligning bearings fitted with integral oil lifters for distributing oil on to the bearing surfaces. The bearings are supported on cast-iron bedplates and the side thrust of the rollers is resisted by steel castings, retained by long steel tie-bolts passing through the bedplate. The reinforced-concrete kiln piers supporting the bedplates each carry a vertical load of 200 tons, and are of H-section to resist heavy longitudinal and transverse forces from the kiln.

Each kiln is driven by a Metropolitan-Vickers 150 h.p. motor, with a speed range of 592 to 230 r.p.m., operating on a 3-kV supply. They are driven through a V-rope and a reduction gearbox, and thence through further reduction gearing to the girth gear which surrounds the kiln and is attached to it by tangent plates. The speed at which the kilns rotate ranges between 0·67 and 1·33 r.p.m.

An improved arrangement for resisting the downward thrust of the kilns (as the result of the slope) has been introduced at Shoreham. Hitherto it has been customary to take the thrust partly on a roller mounted on a vertical spindle and engaging with the side of one of the tyres, and partly by "cutting" the rollers which support the tyres, i.e., by inclining the axis of the rollers to the axis of the kiln, so that the rollers tend to force the kiln uphill. This practice resulted in undue wear on the rings and rollers, as their faces were not in contact over their full width and, further, it was difficult to ensure the same amount of cutting on every roller. To overcome this difficulty, a further thrust roller has been introduced on an adjacent bedplate, but to compensate for the expansion of the kiln shell—which amounts to about 10¾ in. for the whole kiln—this second thrust roller is mounted on a counterbalanced slide, so that the roller follows the movement of the kiln and takes its fair share of the thrust at all times. Under certain conditions, there is a tendency for the kiln to creep uphill, and to limit this movement another fixed thrust roller is provided and arranged to operate on the uphill side of a tyre—in the case of Shoreham, No. 5 tyre.

From the lower end of the kilns, the clinker is discharged to two rotating coolers, 90 ft. long and 9 ft. in diameter and sloping at 1 in 20, below the kilns; each cooler is driven by a fixed-speed 50-h.p. motor operating from a 415-volt supply through a drive arrangement similar to that of the kilns. The clinker is cooled to a temperature of 230 deg. F. by drawing through it the air required for combustion in the kiln; thus the heat in the clinker is largely reclaimed to improve the efficiency of the kiln. The coolers are supported on two tyres, the down thrust being resisted by a fixed roller. The upper half, i.e., the hot part of the cooler shell, is lined with firebrick and, except for the first quarter of the length, lifters are arranged around the inside periphery so that the clinker may be lifted up and cascaded down through the cooling air. The first two rows of lifters are of heat-resisting cast steel, the next five of heat-resisting cast iron, and the remainder of mild steel. These last may be seen in Fig. 16, Plate VIII, which shows also the 6-in. mesh grids which direct the over-size material to a hopper-bottom chute from which it is transferred periodically by barrow to a clinker-crusher pit in the store building.

The clinker passed by the cooler screens falls on

CEMENT WORKS AT SHOREHAM, SUSSEX.

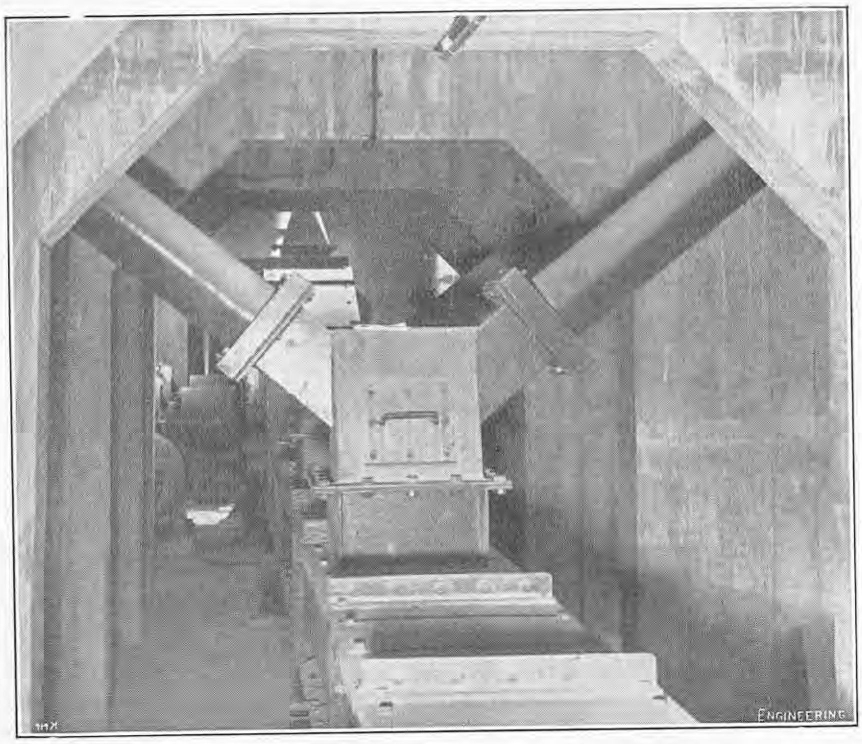


FIG. 21. REDLER CONVEYORS BELOW CEMENT SILOS.

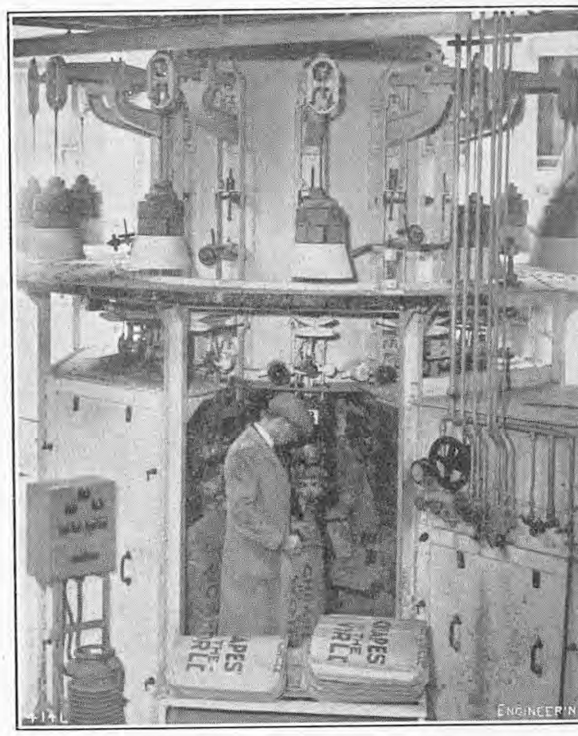


FIG. 22. "FLUXO" PACKING MACHINE.

to two shaker conveyors, towards the end of which is a screen which separates the larger material and passes to to a pit in the store building; as may be seen by reference to Fig. 10, the latter is adjacent to the kiln-house building and is separated from it by a covered annexe 10 ft. wide, which houses the coal, gypsum, clinker and cement conveyor systems. The smaller clinker passed by the shaker screen falls on to a belt conveyor in the annexe; this conveyor delivers on to a travelling shuttle belt conveyor, running on rails, which can deliver clinker to the store bunkers through cylindrical chutes arranged at intervals along the floor of the conveyor annexe. Dust extractors are provided over each chute. In its most forward position, the belt conveyor can deliver clinker on to another conveyor going off at 90 deg. and discharging through a small chute and a Redler conveyor directly to the store hoppers feeding the grinding mills, which are in a building at right angles to the store building (Fig. 17, Plate IX). By using the Redler conveyors to discharge the clinker into the feed hoppers, it is possible to enclose that part of the hoppers which is inside the mill house and thus prevent a dust nuisance. Clinker from the store can be fed to the hoppers by an overhead grab crane. Over-size material from the pit is transferred by the store grab crane to a jaw-type crusher, which delivers the crushed material into another pit, from which it is collected by the store crane and deposited in the main clinker store. The carriage of large lumps of clinker which occasionally occur, and which remain hot for a long time, on rubber-belt conveyors has thus been avoided, and all the clinker in the store, and going directly to the mill house, is of a suitable size for feeding to the grinding mills.

A general view of the store building, which houses the coal, gypsum, and clinker bunkers, and two travelling grab cranes of 5-ton capacity, is shown in Fig. 17. The coal store, which is shown in the background of the illustration, has a capacity of 5,500 tons; in the centre is a small area for storing 1,500 tons of gypsum. The reinforced-concrete retaining walls over this part of the building are 16 ft. high, but forward of this, in the clinker store, which has a capacity of 15,000 tons, the retaining walls are carried up to 40 ft. and consist of cantilever buttresses with the walls spanning between them. The photograph shows clearly the dust-preventing cylindrical chutes, with adjustable ports at various height intervals, through which the clinker is delivered. There is a clear space between the cantilever buttresses of the retaining walls and the steel stanchions of the main frame of the store building; these stanchions carry the crane girders, and it is therefore desirable that they should be independent of deflections of the retaining walls, in order to avoid distortion of the crane tracks. At the forward end of the store building there are four elevated reinforced-concrete hoppers, each pair comprising a clinker hopper of 260 tons capacity and a gypsum hopper of 100 tons capacity, from which clinker and gypsum discharge on to the same belt conveyors feeding the four grinding mills. The speed of the conveyors is controlled by weighing and constant-feed control gear supplied by Messrs. Adequate Weighers Limited, and the British Thomson-Houston Company, Limited; the weighing mechanism weighs the amount of material passing over a given length of belt and records it in tons per hour. A separate weighbeam, which is provided with a poise weight to balance at the desired feed rate, operates electrical switches which control a ratchet mechanism altering the speed regulation of the feeding-conveyor motor, so that a constant flow of material is fed to the mills (Fig. 18, Plate IX).

Fig. 19, Plate IX, shows the grinding mills, consisting of two Vickers-Armstrong 1,200-h.p. mills, one Newell 800-h.p. mill, and a Newell 400-h.p. mill taken from the old works. The clinker is fed into the mills, which are of the tube type, through scroll-drum feeders, and the grinding is effected by steel balls of different sizes. To segregate the different ranges of ball sizes, the mill is divided into compartments by slotted diaphragms. To remove water vapour that may arise from the gypsum and to keep the plant dust-free, air is drawn continuously through the mill and filtered in a dust plant. Each mill is driven directly through a double-reduction gearbox. The motors and reduction gearing are housed in a separate compartment of the mill house to ensure cleanliness. Considerable heat being generated in grinding, the mill shells are cooled by water sprays to keep the temperature of the finished cement within reasonable figures. The 1,200-h.p. Vickers-Armstrong mills have shells 45 ft. long and 8 ft. 4½ in. in diameter, divided into four compartments, the liners of the first two compartments being of hard alloy iron and of the last two of hard white cast iron. The charge of steel balls weighs about 76 tons, and the mills rotate at 20·5 r.p.m. The Newell 800-h.p. and 400-h.p. mills each have three compartments, similarly lined. The shells are 40 ft. and 29 ft. 4 in. long, and rotate at 21 r.p.m. and 25 r.p.m. Auto-synchronous induction motors, shown in Fig. 20, Plate IX, rated at 1,200 h.p. and 800 h.p., drive the three larger mills through reduction gearing. The gearboxes of the 1,200-h.p. motors are fitted with motor-operated barring gears to facilitate maintenance work. The main driving motors are provided with automatic cut-out switches which operate if the pressure of the oil supply to the gearboxes falls below a safe value.

From the grinding mills, the cement is delivered by Redler conveyors to a system of sloping belt conveyors, whence it is carried up and distributed between 12 reinforced-concrete silos. Each silo, of circular cross-section, has an internal diameter of 26 ft. 6 in., and is 60 ft. high, giving a capacity of 1,250 tons of cement. The silo bottoms are some 10 ft. above ground level and below them runs a system of Redler conveyors which carry the cement under the coal bunkers in the store building, on to an inclined belt conveyor in the conveyor annexe. Thence it is carried up the conveyor gantry, across the road and discharged it into the top of one of two 900-ton packing silos, one of which is used for ordinary cement, and the other for rapid-hardening cement.

The cement is drawn from the packing silos as required to the packing plant, which is housed in a five-storey building, approximately square in plan. Into the duct, from the bottom of each silo, air is blown through fabric-wrapped perforated tubes to aerate the cement, which causes it to flow like water. The ducts from the silos discharge into two 24-in. screw conveyors, each feeding an elevator of 125 tons per hour capacity. Each elevator discharges through a revolving screen, in which any air-hardened cement or other foreign matter is removed, into a surge hopper which feeds a 12-spout Fluxo packer, supplied by F. L. Smidth and Company, Limited. They are each capable of loading 120 tons per hour of cement into 1-cwt. paper bags. One of the Fluxo machines is shown in Fig. 22. Each machine comprises a central rotating hopper, into which the cement flows from the pneumatic feeder, in which it has been aerated by compressed air and stirred by a mechanical stirrer. Twelve symmetrically-arranged spouts are connected through short lengths of flexible tubing to the hopper; by means of clamps the flexible tubes are used to control the inlet of cement to the spouts. The spouts are supported on cradles suspended on weighbeams, the fulcrums of which are carried on arms projecting from the rotating hopper. The other ends of the weighbeams carry adjustable balance weights, which are pre-set to the weight to which the bags are to be filled. The paper bags are stored on a floor above the loading conveyors and close to the packing machines. They are delivered by lorry and conveyed to the store by a slat-type elevator.

The machine is controlled by a single operator, who feeds a bag on to a spout as it passes, where it is retained by a clip. As the bag passes away from the operator, a roller on the cradle engages with a fixed cam and releases the clamp on the flexible tube, whereupon cement flows into the bag until the pre-selected charge has been filled. At this point, the weighbeam drops and trips the clamp on the flexible tube, cutting off the cement flow. When the bag reaches the discharge point, another cam and roller cause the clip retaining the bag on the spout to be released, and the spout, which is hinged, drops the bag on to a discharge turntable and thence to a laminated conveyor, returning immediately to its normal position. If, however, the bag has not at this stage filled sufficiently to drop the weighbeam, the discharge roller does not engage with the cam and the bag is carried round for another cycle. A beating mechanism below the feed hopper ensures even filling.

In order to provide the correct weight of cement, it is essential for the head of cement above the spout to be maintained constant. The level of cement in the feed hopper is, therefore, controlled by float-operated solenoids which operate valves shutting off the supply from the feeder. Similar float-operated controls in the surge hoppers shut off the air supply to the packing silos and thus stop the flow of cement when the level in the surge hopper exceeds a certain value. There is inevitably a certain amount of spillage with machines of this type; this is collected in a hopper below the Fluxo machine and conveyed back to the elevator. A fan and air-filtering system on a floor above is also provided for each machine and connected to all points where dust may be produced.

From the laminated conveyor of the Fluxo machines, the filled bags of cement are delivered, either for road or rail transport, by an adaptable system of belt conveyors; three lorry-loading bays are served by retractable-boom conveyors, on to which the cement is delivered through the permanent conveyors. For a rail-wagon loading, the bags are delivered to a turntable on a platform between the two rail-loading lines, whence they are removed and stacked in the wagons by a team of loaders using hand barrows. The packing and loading machinery is interlocked. An average loading rate of 100 tons per hour is regularly maintained.

It remains to describe the way in which the coal and gypsum supplies are carried to the store building, and to trace the combustion of the coal in the kilns. It can be seen in Figs. 2 and 10 that, adjacent to the old works site, there is a system of railway sidings, to which the coal and gypsum supplies are brought. Coal and gypsum are unloaded by a combined wagon tippler and weighbridge into a hopper, on to a reciprocating-tray feeder which discharges on to belt conveyors, passing over the road on the conveyor gantry. A magnetic separator removes any "tramp" iron. The capacity of the coal conveyor system is 120 tons per hour. The wagon tippler is enclosed in a building in which a dust-extraction plant is provided to suppress the spread of coal dust. At the top of the gantry, in an annexe above the coal bunkers at the road end of the kiln building, the coal is delivered either directly to the coal store or through a ¾-in. screen to a Redler conveyor which discharges into the four coal bunkers in the kiln house; the total capacity of these bunkers is 700 tons. The over-size material from the screen in the kiln house is discharged into the coal crusher, and thence to the same Redler conveyor. A return conveyor, fed by the store crane, is provided to carry coal, when necessary, from the store back to the gantry conveyor for feeding to the coal bunkers in the kiln house. The gypsum supply is carried on the same conveyors as the coal up to the point at which the coal is fed down the chute to the coal store. From this chute, the gypsum is diverted on to a band conveyor discharging to the store building.

Each coal bunker in the kiln house feeds a No. 18 Atritor coal pulveriser, supplied by Alfred Herbert, Limited, each being driven by a 150-h.p. English Electric Company motor operating on a 3-kV supply. Two of the Atritors supplying one of the kilns are fed through 5-cwt. batch weighers, to keep a check on the coal consumption. Hot air for drying the coal in the Atritors is drawn from the kiln hoods, through cyclones which remove any clinker dust arising from the discharge of hot clinker down the chute to the coolers. To allow for maintenance work to be carried out on the Atritors, it is possible to operate each kiln on the output from one Atritor, at a reduced rate. Over-size coal rejected by the Atritors travels by an underground screw conveyor and an elevator to the coal store.

Pulverised coal from each pair of Atritors is discharged through pipes into the kiln. The hot primary air, used for drying the coal in the Atritors and transporting the pulverised coal into the kiln, is obtained from the kiln hood, a cyclone in the pipe removing any clinker dust that may be present. The secondary air, as previously mentioned, is preheated in the clinker cooler and mixes with the coal stream at the mouth of the kiln. The combustion gases, together with steam and carbon dioxide from the slurry, pass up the kilns, and are exhausted through flues to two Sturtevant electrostatic precipitators, one for each kiln, in which the fine dust is removed. Each presipitator comprises three electrode chambers, enabling maintenance work to be carried out on any one while leaving the other two in operation; the flue gases are passed through vertical receiving electrode tubes, through the centre of which runs a wire discharge electrode. The potential difference between the discharge and receiving electrodes is about 50 kV, the high-tension supply to the discharge electrodes being provided by mechanical rectifiers. The dust collected on the receiving electrodes is removed by rapping rods, operated by heavy spring-loaded hammers driven by a camshaft; it is discharged through a hopper and removed by a screw-conveyor. By this means, the dust content of the gases passing out of the chimney is restricted to less than 0·4 grains per cubic foot. To reduce the expansion of the reinforced-concrete structures in which the precipitators are housed, under the high temperature of the exhaust gases (400 deg. F.), the walls are lined with brickwork and a 1-in. air cavity is provided between this lining and the concrete. For the same reason, the roofs of the chambers and flues are lined with hollow tiles. In Figs. 11 and 12, Plate VIII, it may be observed that a steel platform, for giving access to the dust-testing points on the exit flues, spans between the precipitator housing and the steel framework of the kiln house. To allow free expansion of the precipitators, the support points on the precipitator are provided with steel roller bearings in grease-filled boxes. From the precipitators, the gases are conveyed through trunking to a 300-ft. chimney, outside the kiln house, by two damper-controlled induced-draught fans, one for each kiln; they are driven by two-speed Metropolitan-Vickers 170/52 h.p. motors operating from the 3-kV supply. For easy servicing and removal of the impellers, quickly-detachable fan doors and panels are provided in the fan casing. The chimney is of reinforced concrete, except for the top 15 ft., which is of brickwork, and tapers in outside diameter and thickness from 23 ft. 1 in. and 9 in. at the base, to 13 ft. and 5 in. at the top. To reduce the temperature of the concrete, it is provided with a protective lining of 4½-in. brickwork and a 4-in. air space between the chimney shell and lining.

The Shoreham works has its own water supply, drawn from two boreholes, each with a capacity of 10,000 to 12,000 gallons per hour, the water being pumped to two 25,600-gallon header tanks, carried on a floor over the coal bunkers. The tanks feed into a ring main supplying the various works services and, when necessary, the lake at Horton. The works has also its own sewage plant. The electrical supply is furnished by duplicate 33-kV lines from a substation of the South Eastern Electricity Board. It is stepped down to 3 kV by two 5-mVA three-phase delta-star transformers. The 3-kVA system to the main substation, and those serving the washmills, the grinding mills, the quarry, and the Horton clay plant, is duplicated to ensure continuous operation of the plant. Many of the principal machines, as has already been recorded, are operated directly from the 3-kV supply; the smaller machines are operated from a 415-volt supply provided by 600-kVA transformers at the various substations. The tariff for the electric power supply includes special terms for off-peak periods, so the cement-grinding mills are run only at night and during week-ends.

LITERATURE.

Winding Alternating-Current Machines: A Book for Winders, Repairmen and Designers of Electric Machines.

By DR. MICHAEL LIWSCHITZ-GARIK assisted by CELSO GENTILINI. D. Van Nostrand Company, Incorporated, 250, Fourth Avenue, New York 3, U.S.A. [Price 8·50 dollars]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 63s. net.]

THIS is a compilation which should be of much value to the class of reader for which it is intended. Its nature is strictly indicated by its title; it is about winding alternating-current machines and about nothing else. It is in no way a general treatise on alternator or electric-motor design. Many "winders" and "repairmen" may think that its price places it beyond their reach, but before reaching a decision on the matter it is desirable that possible purchasers should consider what they will get for their money. It is a book of 766 pages and contains more than 430 illustrations and more than 160 tables. There are a few reproductions of photographs showing formers for winding coils, or the arrangement of end connections, but by far the greater part of the figures are winding or connection diagrams. The thoroughness with which the book deals with its subject is indicated by the fact that the chapter headed "Integral-Slot Lap Windings (Lap Windings with Equal Coil Groupings)" contains 112 connection diagrams, the first showing a two-pole two-phase series connection and the last a 14-pole three-phase 7- or 14-parallel delta connection.

The scheme of the book is, as the author states in his preface, to give at the outset of each chapter the "know how" so that the reader may easily find the answer to his particular problem; the "why" is explained in appendices at the end of the book. Information is given on coil insulation, and the series of tables give all possible series and parallel connections for all pole numbers between two and 30. The "integral-slot, balanced fractional-slot, and unbalanced fractional-slot lap windings" are treated in separate chapters, and it is claimed that "wave windings are treated in detail for the first time." Information is also given on multi-speed windings, single-phase windings and re-connection windings for changed operation conditions. As an example of the detail into which the book enters, there is a section entitled "Reconnecting or Rewinding a Split-phase Motor for a Different Voltage at the Same Performance." Electrical faults and "trouble shooting" are also dealt with, but this part of the book has less novelty. The diagrams and tables are well presented and the whole forms an unusually extensive treatment of a specialised subject.

Fifty Years of British Standards, 1901-1951.

British Standards Institution, 24–28, Victoria-street, Westminster, London, S.W.1.

THE origins of standardisation are often confused, even by engineers, with the beginnings of quantity production and interchangeability, as typified by the introduction of printing by movable type and the classification of warships' guns in the time of Elizabeth: but standardisation, as the term is now used industrially, implies something more than mere uniformity. There is no question that, as an organised activity on a national scale, it had its source in this country, and that the credit for it is due primarily to an iron merchant of London, Mr. H. J. Skelton. The story of how, after he had advocated standardisation of rolled-steel girders in a letter to

The Times in 1895, and a paper read before the British Iron Trade Association in 1900, he won the support of Sir John Wolfe Barry and, through him, of the Institution of Civil Engineers, is well told in this jubilee history of the British Standards Institution. The Council of the Institution of Civil Engineers appointed a strong committee of its members, approaches were made to the Councils of the Institution of Mechanical Engineers, the Institution of Naval Architects, and the Iron and Steel Institute, and, as a result, the Engineering Standards Committee was formed, and met for the first time on April 26, 1901. On May 23, 1918, it was incorporated as the British Engineering Standards Association; a Royal Charter was granted on April 22, 1929; and a Supplemental Charter on November 5, 1931, changed the name to the present title of the British Standards Institution.

This is a very brief and bald summary of a half-century of progress, leaving the hard work to be inferred; but the book adequately reviews that also, without going into any possibly tedious details. No list of current British Standard Specifications is included, but Appendix II comprises an alphabetical list of the Industry Standards Committees—61 of them—accompanied by the dates when work was begun in their respective fields. Biographical notes are given on the men who built up the organisation—at some length in the case of Sir John Wolfe Barry, and more briefly on other pioneers, including Dr. W. H. Maw, of ENGINEERING; and a special tribute is paid to the late Director, Mr. Percy Good, who had done much of the preliminary work for the book when he died on December 2, 1950.

NOTES ON THE HISTORY OF HAYLE FOUNDRY.

By T. R. HARRIS.

THE Hayle Foundry of Harvey and Company was founded in the late 1770's by John Harvey, a blacksmith of Carnhell Green, near Camborne, to supply the neighbouring mines with iron castings. From very small beginnings, the foundry developed into one of the foremost engineering works in England during the middle decades of the Nineteenth Century. The story of this remarkable undertaking has never been fully told, though there have been a number of details published at various times.* The purpose of the present article is to record some further information collected over a period of years.

At first, the products of the foundry were of a simple nature, the earliest reference to these known to the writer being in a manuscript book once belonging to the Tehidy estate of Lord de Dunstanville, in which is recorded a payment in August, 1779, of 3*l*. 18*s*. 4*d*. to "John Harvey for a cast iron kittle for the Kennels." In December, 1783, also, John Harvey was paid 1*l*. 9*s*. 2*d*. for "cast iron stoves for Tehidy Kitchen."

From the correspondence of Boulton and Watt† it appears that, quite early in their history, the Birmingham firm entrusted some of their work to the Hayle foundry. In March, 1781, Watt sent to Henderson, at Redruth, an engraving of the balance bob for the United mines, with a request to get a pattern made and cast. Instructions were given that the "cradle should be very truly formed to the circle and the bed quite smooth and flat." It is possible that this job may have been a little too difficult for the young firm, as, later in the year, Watt, writing from Cosgarne to Boulton at Soho, said "I Must draw this (Wh Virgin) balance bob and cradle gudgeon which we must get cast with you, as Harvey takes a most unreasonable time to his jobs and charges high."

Miscellaneous castings for the mines formed the major portion of the products of the foundry, as reference to mining cost books of the period show. For example, Dolcoath paid Harvey 54*l*. 5*s*. 1*d*. in August, 1786, and 33*l*. 18*s*. 8*d*. in May of the following year. In October, 1788, a Cook's Kitchen entry reads, "John Harvey for a working piece 18*l*. 10*s*. 0*d*.," and in March, 1789, "John Harvey for 3 working pieces 76*l*. 0*s*. 10*d*.," while in February, 1789, 9*s*. was paid for the carriage of two working barrels from "J. Harvey's Foundry, Hayle." By degrees, the skill of the workmen increased and, by the late 1790's, nozzles, condensers and air pumps were being made. The former were for Trevithick's engine at Ding Dong, and the latter for an engine that Murdock was erecting at Wheal Jewel West.*

The castings for Trevithick's first road locomotive were made in 1801, and in 1803 William West was at Hayle "about the new cylinder and boiler" for another locomotive. Engines were being manufactured by 1806; in this year, a 12-in. engine was in hand for Crenver and a 14-in. for Perran Sands. In 1812, Trevithick ordered castings for an engine of "12 mule-power" for St. Kitts, but, owing to a dispute among the partners, the order was cancelled. By the following year, cylinders were again being ordered from Hayle, as the founders of Bridgnorth were not keeping their delivery promises.†

An engine for rock boring was constructed in January, 1813, by Trevithick and was probably the first power-driven rock drill in the world. Arthur Woolf, who joined the firm about 1820, did much to develop the small concern into an engine works of the first magnitude, and gradually, under his superintendence, larger work was undertaken. In 1824,‡ one of Woolf's compound engines was constructed with cylinders of 70 in. and 40 in., and in 1827 Samuel Grove's Wheal Towan engine, with an 80-in. cylinder, was built.

During 1833, Woolf retired from the active direction of the works at Hayle, where he was followed by N. O. Harvey, who, in 1834, exhibited at the Royal Cornwall Polytechnic Exhibition "cast iron figures" which, in the opinion of Davies Gilbert, the President, "equalled the productions of Berlin." These figures, representing a Grecian and a Roman warrior, "elicited universal admiration." In 1836, at another exhibition of the Society, it was reported that "The beautiful and delicate specimens of sand castings from the foundry of Messrs. Harvey & Co., of Hayle, attracted, as it merited, general attention. Chains of a similar kind, it is well known, form a staple article of manufacture at Berlin, when they are usually constructed by casting the rosettes first and then uniting them by wrought iron links. The mode of formation of those exhibited at the Polytechnic Hall was peculiar. The rosettes were first cast, each separately and the small adjoining links were afterwards cast, each in its present position, probably the first specimen of a similar process ever attempted." These art castings were probably the work of a German workman, brought over by N. O. Harvey from the Continent.

An engine of some historical interest was made in 1836§; this was the first of the Sims compound engines. After working on two mines in Cornwall, it was transferred to the Lincoln Water Works in 1848, where it remained until scrapped in 1903. The engine consisted of a 25-in. cylinder fixed on top of a 50-in. cylinder, the two pistons being on one piston rod and the space between them being open to the condenser. The length of the stroke was 8 ft. and the 12-in. plunger pump, at the other end of the beam, had a stroke of 7 ft. The Haarlemmermeer engines of the 1840's were based on Sims' principle, the small cylinder being placed inside the large one, to save head room, and an annular piston used. The introduction of the Cornish engine into London, for waterworks pumping, occurred in 1837, and was largely due to the efforts of N. O. Harvey and William West. Harvey and Company supplied numerous engines to the various water companies.

The 1840's were a great period in the history of Hayle Foundry; during this decade, some of the heaviest work was produced, the most noteworthy being the Haarlem engines. These have been described elsewhere,‖ but a few notes on the various stages of their manufacture may be of interest. In March, 1843, it was reported that¶ "an enormous steam engine, by far the largest ever constructed, is now in process of manufacture at Harvey & Co.'s Hayle Foundry. The piston rod, which was forged last week, is 19 ft. long, 13 in. diameter in the middle and 16 in. in the cone, and weighs 3 tons 16 cwt. It will work in an 84-in. cylinder which will stand in the middle of another cylinder 144 in. in diameter. The 84-in. cylinder was cast last week and the large one will be cast soon."

The successful casting of the 144-in. cylinder was duly noted as follows by the *Mechanic's Magazine*, quoting from *The West Briton*: "An enormous cylinder of 144 in. diameter for the great engine, designed to drain the Haarlem Lake, has been cast at the Foundry of Harvey & Company, of Hayle. It is the largest cylinder ever cast entire for any purpose. A blast cylinder of 144 in. has, indeed, been constructed at the same works, but this was cast in parts. The largest cylinder ever made for mining purposes was of the diameter of 90 in. and a fraction. It was boasted a few days since that the cylinder for Her Majesty's steam frigate 'Penelope' was the largest ever cast, being 92 in. diameter. The cylinders of the 'Penelope,' however, are only two-fifths the size of that cast at Hayle, the piston of one containing 6,647 sq. in. and that of the other 16,286 sq. in. The operation was completely successful; more than 25 tons of iron were melted for the occasion, and the whole of that mass of liquid fire ran out into the mould in less than six minutes in a manner that afforded the highest satisfaction to a great number of intelligent visitors who were kindly allowed to be present, without a single casualty having occurred. The iron founders of Hayle may now justly boast that they have executed by far the greatest work in their line which has ever been attempted."

A note in the *Mechanic's Magazine*,* two years later, refers to a letter from Haarlem announcing that the mammoth steam engine had been put to work to everyone's satisfaction, and that an order was expected to be placed for two engines of the same size and similar construction. The same note also recorded that "Messrs. Harvey & Co. have nearly executed an order for six flywheels for the South Devon Railway measuring 20 ft. in diameter and each weighing nearly 14 tons. Two of them have been sent to their destinations and the other four are in a great state of forwardness." [Presumably, these were for the air pumps which exhausted the atmospheric tube.—ED., E.]

An 80-in. engine at Par Consols, built in 1846, was described "as a most complete and perfect piece of mechanism" and was admitted to be unrivalled in the country, or even in the world. The whole weight of iron of which it was constructed was said to be about 200 tons. Engines for other parts of the country were equally satisfactory. *Gore's General Advertiser*,† early in 1847, reported the starting of the engine at the Green Lane Water Works, Liverpool; "such is the excellence of the machine," reads the report, "that not a single joint was found to be defective, nor was there the slightest appearance of leakage."

The second of the large engines for Haarlem was built in 1847, and early in the year a 144-in. cylinder was cast at Hayle. "There were 36 tons of iron melted for the occasion," said a contemporary report in the *Penzance Gazette* (evidently written by the same reporter as on the former occasion), "and near 30 tons of that mass of liquid fire ran into the mould in one minute and a half. The remainder of the metal was used in some other articles for the engine."

Another example of the large work undertaken at this period was noted‡ in November of the same year. "A set of monstrous blocks," it was recorded, "consisting of 4 treble and 3 sheave and 3 single sheave blocks have lately been manufactured by Messrs. Harvey & Co., at Hayle Foundry for the purpose of lifting the stupendous suspension bridge over the River Danube, the longest in the world. The sheaves, which are of cast iron, are 3 ft. in diameter and $7\frac{1}{4}$ in. wide, but the shells are wrought iron. The main or cog pin that goes through the

* *Rept. of Royal Cornwall Polytechnic Soc.*, 1936; and *Trans. Newcomen Soc.*, vol. xxiii, page 24 (1942-43).

† *Boulton and Watt MSS.*, Birmingham City Library.

* *James Watt and the Steam Engine*, by H. W. Dickinson and Rhys Jenkins (1927).

† *Life of Richard Trevithick*, by Francis Trevithick (1872).

‡ *Proc. Inst.C.E.*, vol. xxi, page 558 (1861-62).

§ *Proc. I.Mech.E.*, 1887, page 124.

‖ *Trans. Newcomen Soc.*, vol. xv (1934).

¶ *Penzance Gazette*, March 29, 1843.

* August 23, 1845.

† Quoted by *The West Briton*, February, 1847.

‡ *Penzance Gazette*, November 3, 1847.

sheaves to connect them to the shells is 7 in. in diameter and the swivel work for one block weighed 14 cwt. The weight of the blocks complete was 21 ton 1 cwt. 1 qr. 11 lb. and the chain to work in them or connect them is 2 in. in diameter and 3,000 ft. long, weighing nearly 100 tons. The blocks are considered to be the largest in England and calculated to lift 450 tons. They have been sent from Hayle to London to be forwarded to their place of destination, the Persth in Russia."

No description of the premises occupied by the Foundry, or means of effecting work there, known to the writer, is earlier than 1812. In the particulars of a law suit* of that year, reference is made to "a Boring Mill . . . and the newly erected Iron Foundry," suggesting that the original moulding shop of the 1770's had been rebuilt to cope with the increasing business and a boring mill added to enable the firm to produce engine cylinders.

In October, 1825, Simon Goodrich† visited Hayle, referring in his journal to "The extensive Iron Foundry and Steam Engine Manufactory," in which he was "surprised to see the extent of the work and the number of tools and means for doing work considering what is doing in other parts of the country." John Brunton, in his biography, gave a vivid account of his apprenticeship at Hayle, a short while after the visit of Goodrich.

Because of the varying demands of the local mines and the uncertainty of the foreign market, the number of workmen fluctuated considerably. In 1841, N. O. Harvey, in evidence before a Royal Commission,‡ said that the number was as great about 1824 as at any time. During the same examination, he gave the following information regarding working hours and the conditions of labour. The hours for the indoor workmen were from 6 a.m. to 6 p.m. from March 1 to November 1, and from 7 a.m. to 7 p.m. for the rest of the year, the outdoor labourer leaving with daylight. Breakfast was from 8 a.m. to 8.30 a.m. in summer, and from 8.30 a.m. to 9 a.m. in winter. In summer, the dinner hour was from 12 noon to 1 p.m., and in winter from 1 p.m. to 2 p.m. This arrangement illustrates an early form of "daylight saving" on a local scale.

The greater part of the work was done as piecework, being set to a party; but the management fixed the minimum wages of those under them. Apprentice boys of 14 years of age were paid 4*d.* a day and their wages were gradually raised to 2*s.* a day up to the age of 21 years. The labouring boys, however, received higher wages at first, commencing with 8*d.* or 10*d.* a day, according to their usefulness, and when big and strong they earned 1*s.* 9*d.* a day, being the full labourer's wage. Indoor tradesmen earned, on the average, 15*s.* to 18*s.* per week, though, when work was brisk, some of them received 2*l.* or 3*l.* in the week by the piece. It was seldom that work was continued later than 8 p.m. or 9 p.m.; that was two hours overtime, which was reckoned as a quarter of a day, though, when occasion demanded, as in the case of a breakage at a mine, men were required to work on through the night to complete the job.

From the same report, it appears that, at this period (1841), the employees at the Foundry numbered 464, being composed of 344 men above 18 years of age, 75 between 13 and 18 years, and 45 under 13 years. No details were given of the men, but the youths were employed in a variety of ways and were classified. Sixteen were returned as being engaged in moulding and iron casting; of these, three were entered as "stove and grate makers" and 12 as "founders." Moulding and brass casting employed two only. Out of 11 entered as carpenters and patternmakers, five were styled "house carpenters," while the remaining six were "engine patternmakers." Nine were engaged in the chipping and cleaning shop, and, of the 23 returned as blacksmiths, 18 were designated "engine smiths." Masonry—the building of furnaces—engaged 14 youths, while 11 were employed in boiler building and six in ropemaking.

* Public Record Office, *Chancery Proc.*, C.13, Bundle 65, Blewett *v.* Harvey.

† *Goodrich Papers*, Science Museum, South Kensington.

‡ *Royal Commission on Employment of Children*, vol. xv (1843).

Some 30 years after the visit of this Royal Commission, a description of Hayle Foundry was written for the *Western Morning News*.* Unfortunately, the original is not in the present files of that newspaper, but a number of extracts were reprinted in the *Cornish Telegraph*. They are much too discursive and popular in style to be worth quoting *in extenso*, but they show what a mixture of ancient and modern equipment the works contained. "There is a continual roar," observed the visitor, "from the steam-driven fan supplying air to the different fires. This forms a sort of droning undertone, above which rises the sharp clatter of countless small hammers, the measured beat of the sledge and the earth-shaking thuds of the steam hammers . . ." "In one corner, you may see men making bolts and nuts with a neatness and dexterity that at once suggest mechanism and bespeak long practice (in fact, they do nothing else), while in another part a gigantic forging of, perhaps, eight or nine tons weight or heavier is rapidly brought to the required shape by the aid of the steam hammer. These ponderous masses are moved with the greatest of care by the aid of huge cranes. . . . In this building, too, are some of the old-fashioned tilt hammers . . . used for welding scrap into wrought iron. This is the way which the best wrought iron is produced and Messrs. Harvey & Co. always make their own."

Later in the same year (1875) a report of some heavy forging was noticed in a local paper: "One of the heaviest pieces of wrought iron work ever made at the factory of Messrs. Harvey & Co. was turned out of the Hammer Mill on Friday last. The work under notice is a flywheel shaft for a large winding engine and weighs nearly nine tons. It took seven horses to draw it from the Hammer Mill to the fitting shop . . ."

Reverting to the description of the works in the *Western Morning News*, this continued: "Not many years ago, comparatively speaking, nearly the whole of the work in the fitting shop was done by hand. Now the shop is full of ponderous machines which relieve the workman of nearly all the manual labour, and leave him nothing to do but to superintend the working of those steady-going quick-working steam-actuated tools . . . little is left to be done in the vice after the planing machines and the steam lathes and the 'shapers' and their kindred have wrought their will. At the end of the fitting shop is a department devoted to the manufacture of Mr. Husband's patent pneumatic stamps, which are doing excellent work at several mines in the country and have been largely exported. . . ." . . . "At the time of our visit there was in hand a large pumping engine for the Metropolitan Water Works. . . . Newcastle-on-Tyne is looked upon as a kind of engineering metropolis; but Messrs. Harvey have sent several large pumping engines into that district for the collieries and have now in hand a couple of engines of very large size for the Newcastle and Gateshead Water Works. And so in London, the majority of the pumping engines of the London Water Companies were made at Hayle. There are others too at Liverpool, Manchester, etc."

William Husband (1822-1887), who is mentioned above, had been an apprentice at Hayle. In 1843, though only 21 years of age, he was sent by the firm to Holland to supervise the erection of the big engine for Haarlemmermeer and learned to speak Dutch with such fluency that the Dutch Government appointed him as mechanical engineer in charge of the whole of the drainage plant of the Meer. He returned to England after an absence of six years and, in 1852, became London manager for Harvey and Company, and eventually managing partner. He was one of the chief promoters of the memorial window to Richard Trevithick in Westminster Abbey, but died before it was unveiled.†

In 1883, a short time before Husband's retirement, the business of Harvey and Company was converted into a limited liability company. Twenty years later, in 1903, the Hayle Foundry closed down; but the name of Harvey and Company is still to be found in Hayle, where they carry on business as coal and iron merchants.

* March 25, 1875.

† See memoir, *Proc. Inst.C.E.*, vol. 89, page 470 (1887)

BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

(*Concluded from page* 43.)

CONTINUING our description of the exhibits at the British Instrument Industries Exhibition at Olympia, which closed on Saturday, July 14, the British Internal Combustion Engine Research Association showed, on the stand of the Department of Scientific and Industrial Research, an improved version of their test flowmeter for measuring quickly and accurately the mean rate of fuel flow in compression-ignition engines, for which orifice-type meters are unsuitable because the viscosity of the fuel varies appreciably with changes of temperature. The method adopted is to time the passage of a weighed quantity of fuel while maintaining a constant pressure head. Fig. 8, on page 104, illustrates the meter. The vessel shown on the left is filled with fuel from the service tank through the flexible pipe at the top. This vessel is carried on two light arms attached to a block, supported in ball bearings, to which are also attached two counter-balancing weight arms, shown on the right. (The original Bicera flowmeter carried only one weight arm; the addition of the horizontal arm facilitates adjustment.) As the vessel is filled, the increase in weight causes the balanced system to rotate, the vessel descending and the lower weight moving outwards to give an increased balancing torque. To measure the fuel flow, the service tank is shut off and the metering vessel is connected to the engine fuel system; fuel flows out of the same pipe line by siphoning action, and the vessel rises as fuel is consumed by the engine. The time interval between the passage of two reference points on the vessel past a fixed mark is observed with a stop-watch. An optical system is used which magnifies the movement of the vessel about 30 times; the fixed reference graticule is illuminated by a lamp and condenser system. (In the earlier meter, a hair wire was used in place of the graticule and there was no condenser.) The reference points on the fuel vessel comprise two lenses of short focal length, mounted on a strip attached to the side of the vessel. As each lens, in its upward journey, passes the illuminated graticule, an image of the graticule moves rapidly past a well-defined datum line on the ground-glass screen seen on the right of Fig. 8. This arrangement is free from parallax errors. It will be observed that the fuel pipe carries a plate at its open end, which serves to damp any oscillations set up in the vessel. When setting up a new meter, the horizontal balance weight, which is mounted on a screw on the weight arm, is adjusted to balance the vessel, including the over-run allowance of fuel, in its mid-position. The second weight arm is placed vertically when the metering arm is at the end of its travel, and its balance weight is adjusted to give the desired rotation when a given quantity of fuel enters the vessel.

Messrs. Evershed and Vignoles, Limited, Acton-lane Works, Chiswick, W.4, showed a range of equipment for industrial-process control, including their new Centroller: a console in which are grouped all the controllers and recorders for operating an industrial processing plant. The instrument exhibited was designed for operating a chemical plant, and contains five flow controllers, six liquid-level controllers and two pressure controllers, three six-point multi-pen recorders, a multi-point temperature indicator, and 25 miniature indicators; these show the level, pressure, flow and temperature in various parts of the plant. All measurements are transmitted to the Centroller as small direct-current signals; the various components are carried on easily-removable trays supported in racks. The firm also showed their electronic process controller which can provide proportional control or a combination of proportional, integral and derivative control, and is used in conjunction with a signal transmitter and a final element, usually an electro-pneumatic relay actuating an air-operated valve, an example of which was also on view; both components are housed in aluminium-alloy casings and are suitable for installing in inflammable atmospheres.

Messrs. Evershed and Vignoles also showed their

EXHIBITS AT THE BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

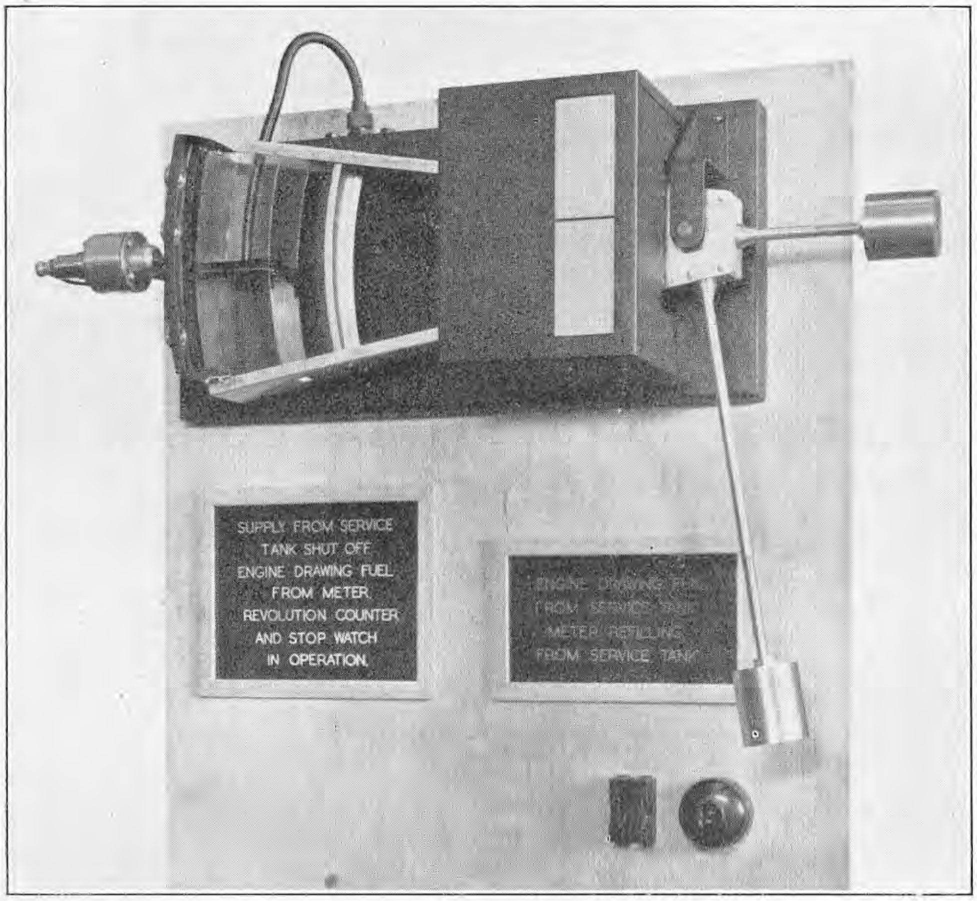


FIG. 8. FUEL-FLOW METER; BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION.

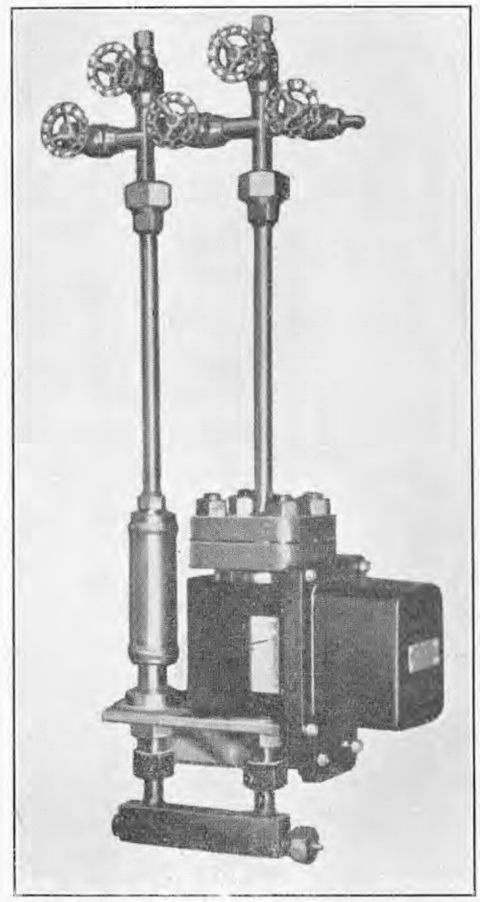


FIG. 9. TRANSMITTING FLOW METER; EVERSHED AND VIGNOLES, LIMITED.

Rollflow transmitting flow-meter, a photograph of which is reproduced in Fig. 9. It consists of an ordinary stainless-steel glandless mercury manometer, suitable for use with volatile and corrosive liquids, designed to withstand a working pressure of 1,500 lb. per square inch, and available in a pressure range of 20 in., 50 in., 100 in. and 200 in. water gauge. One limb of the manometer houses a cage surrounding a cylindrical floating magnet which rolls up or down as the mercury level changes. The transmitter unit, which can be removed easily for servicing, is clamped over this limb. It consists of a pivoted strip magnet, which is repelled by the floating magnet, the latter being polarised along its horizontal axis while the strip magnet is polarised across its width. In the zero position, the cylindrical magnet is opposite the pivot of the strip magnet, and hence there is no turning moment on the strip magnet. As the mercury level changes, a torque proportional to the change of level will be generated; any deflection of the strip magnet is, however, opposed by a torque generated by a coil, carried on an arm attached to the strip magnet and working in a pot magnet. The current in the coil then gives a measure of the differential head of the manometer. The coil is in the cathode circuit of a thermionic valve, the circuit being completed through the remote indicators, recorders or controllers, which are connected in series. The coil arm also carries a disc contact lying between two fixed contacts which carry, respectively, positive and negative biasing voltages, so that when the coil arm deflects, as the floating magnet rises or falls, the disc contact touches one of the biasing contacts until the torque exerted by the coil balances the deflecting torque. The current in the transmitting circuit is, therefore, always proportional to the differential head; that is, to the square of the flow, in the manometer. Variations in line resistance or in mains voltage or frequency are automatically compensated by the biasing contacts. Direct measurement of flow can be obtained by replacing the pot magnet by a fixed coil connected in series with the moving coil. Zero adjustments are carried out by lowering or raising the strip-magnet and moving-coil assembly; the manometer need not be altered. Also on view on the stand of Evershed and Vignoles was a displacement-level electronic transmitter for detecting the liquid level or the interface between the liquids in a pressure vessel.

A variety of industrial electronic control equipment was shown by Messrs. Elcontrol Limited, 10, Wyndham-place, London, W.1, including process timers, photo-electric units, a fluid-level controller, furnace-safety equipment, and an instrument for controlling butt welding by the colour temperature of the weld. The latter instrument consists of two units: a photo-electric cell housed in a cast-aluminium case fitted with a glass window and a tubular light shield, which is mounted close to the weld. There is also a photo-electric amplifier and relay unit, which includes a photo-electric pyrometer circuit of adjustable sensitivity and an adjustable timing circuit, which is set for a period slightly greater than the weld time. Normally, the correct temperature will be reached before the end of the pre-set timing period, and a signal from the photocell will cause the contactor of the welding circuit to open. In the absence of such a signal, the timing circuit controls the welding time.

The furnace-safety equipment consists of three units: a flame-sensing element, a relay control unit, and an electrically-actuated fuel-supply valve operated by the relay contacts in the control unit. Two forms of sensing element are available: for oil burners, a flame viewer is used consisting of a photo-electric cell of adjustable sensitivity, which views the flame through a window in the front of its cast-aluminium casing; it is protected by a heat-absorbing glass filter. For detecting the flame failure of gas burners, the electrical conductivity of the flame is used. A heat-resisting steel probe is inserted in the flame close to the burner; when the flame goes out, an electronic circuit is broken and the relay in the control unit closes the fuel valve.

The exhibits of the British Scientific Instrument Research Association, illustrating aspects of various research activities, did not form part of the display organised by the Department of Scientific and Industrial Research, but were shown on a separate stand. Among them may be mentioned a constant-current source of direct current, developed in the course of work on magnetic amplifiers; a photograph of the unit is reproduced in Fig. 10, opposite. The stabiliser shown, which utilises the inherent properties of a transductor in producing a sensibly constant output current over a range of alternating-voltage input, has been designed to provide the heater supply to several thermionic valves at about 6·3 volts. Output currents up to 0·9 ampere can be obtained with a stability of 0·1 per cent. for a 10 per cent. change in mains input. For such purposes as heating valve cathodes, a constant root-mean square value of the current is required. To obtain this, the output of the transductor is rectified and smoothed before being applied to the load. A constant direct reference current is supplied to the control winding of the transductor from a stabilised high-tension supply unit used for the anode supplies of the amplifier valves. Also on view was a mains-operated experimental thermionic direct-current amplifier which has achieved a long-term stability of the order of 40 microvolts per hour.

The mechanical department of the British Scientific Instrument Research Association showed a pneumatic gauging system for detecting deviations in the radius of curvature of large spherical surfaces, presenting them as variations in the reading of a manometer. The gauge is operated at a pressure below atmospheric, to provide a suction which will hold the instrument firmly in contact with the surface under test. The department also had exhibits relating to researches being carried out on the flow characteristics of sharp-edged metering orifices in small mains pipes of less than 2 in. diameter, which are affected considerably by the surface roughness of the pipe walls. The investigations are carried out on pipes in which the surface has been roughened to a known degree by an internal diamond knurling operation, and on commercially smooth pipes. The exhibits on view consisted of samples of roughened pipes leading to and from a pipe-orifice fitting, designed to ensure a concentric arrangement of the orifice and the bore of the main; and a discharge metering nozzle, with a traversing

INSTRUMENT INDUSTRIES EXHIBITION.

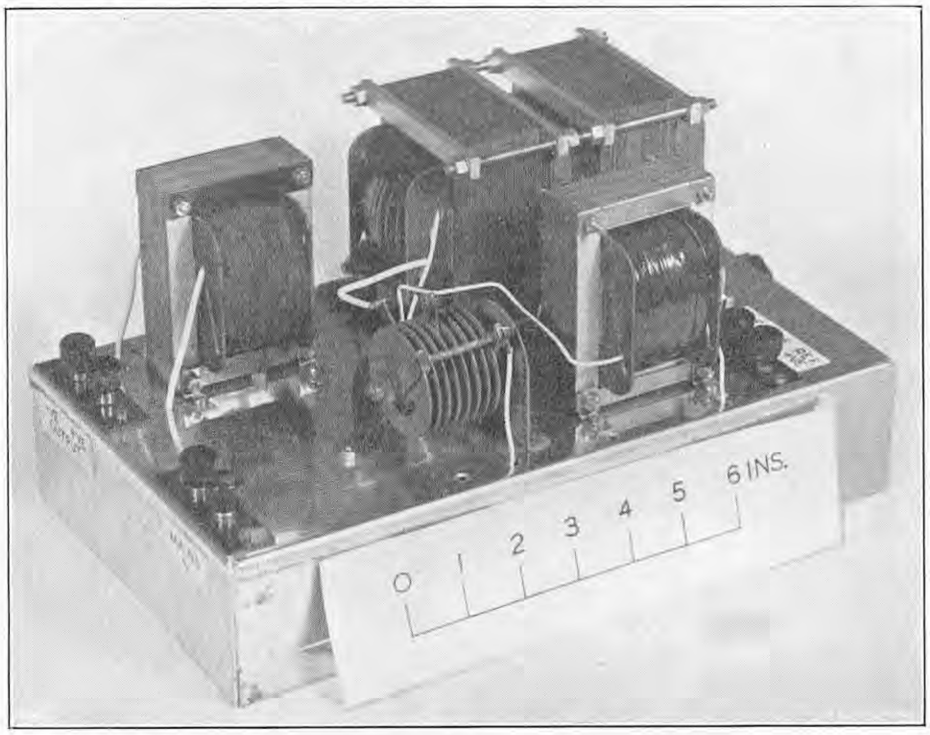


FIG. 10. CONSTANT DIRECT-CURRENT SOURCE; BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION.

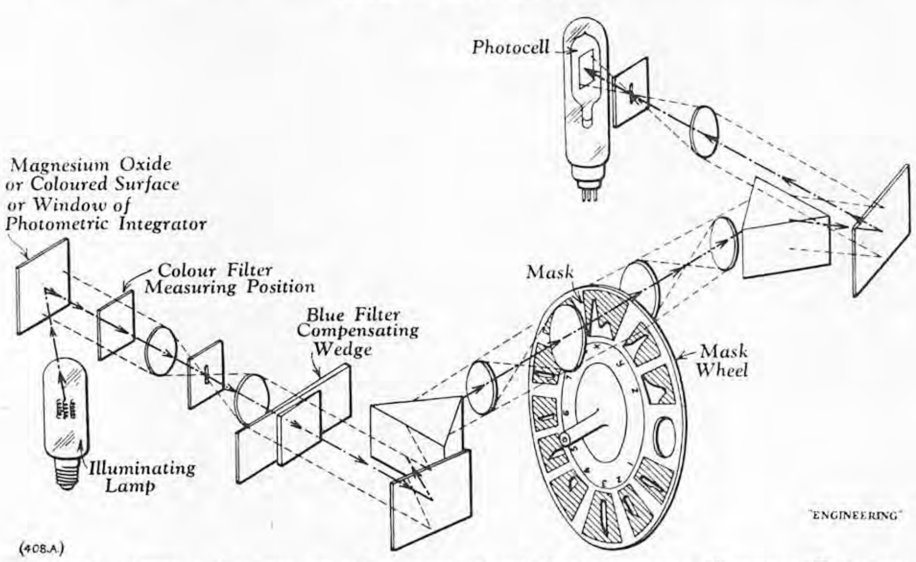


FIG. 11. OPTICAL SYSTEM OF "PHYSICAL EYE" COLORIMETER; GENERAL ELECTRIC COMPANY, LIMITED.

impact tube, used as a flow standard in air calibrations of the pipe-orifice being tested.

The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, showed their new "physical eye" colorimeter and spectrophotometer, which is based on the standard observer as defined by the International Commission of Illumination in 1931, and is suitable for measuring luminous intensity, luminous flux, chromaticity co-ordinates, colour-rendering properties, spectral-reflection, transmission and distribution, and colour temperature, in conjunction with the universal photo-electric photometer. To achieve the desired spectral response of the photo-electric cell to correspond with that of the standard observer, the light to be measured is dispersed into a spectrum; a series of specially-shaped masks, arranged around the periphery of a wheel, can be located in turn in the plane of the spectrum so that they attenuate the coloured light in the various parts of the spectrum in suitable proportions. A diagrammatic representation of the optical system is shown in Fig. 11. When a lamp is to be tested, it is arranged to illuminate a white magnesium-oxide surface which acts as a diffuser; the instrument can be calibrated by a tungsten-filament standard lamp, and can then be used to measure light from sources of any colour. For measuring the luminance factor of a coloured surface, the latter can be set up in the position occupied by the magnesium-oxide surface and its luminance compared with that of the magnesium-oxide surface when illuminated by the same lamp. For measuring luminous flux, the lamp is set up in a photometric integrator arranged so that its window occupies the space normally occupied by the magnesium-oxide surface. To compensate for the ageing of the white integrator paint, which tends to go slightly yellow with age, an adjustable blue-filter compensating wedge is built into the instrument.

Messrs. Hilger and Watts, Limited, Watts Division, 48, Addington-square, London, S.E.5, showed a wide range of their precision surveying instruments and metrological equipment, among which may be mentioned a new gauging projector known as the T.600, in which the projection system has been arranged parallel to the front of the instrument allowing the controls to be grouped conveniently close to the observer's hands and facilitating loading. The Hilger division of Messrs. Hilger and Watts, Limited, 98, St. Pancras-way, Camden-road, London, N.W.1, showed a recording photo-electric microphotometer for measuring continuously the relative intensity of separate lines on spectrum photographs over a wide range. The recording element is a high-speed potentiometric ratio recorder coupled through an amplifier system to a photomultiplier. To keep the record independent of fluctuations in the mains supply to the light source, impulses from a photo-electric cell, placed close to the light source, are fed to the ratio recorder in opposition to those of the photo-multiplier. The photographic plate is held in a slightly sloping carriage, in an accessible position, with a rack and pinion adjustment normal to the direction of travel. The plate-holder is traversed by a long micrometer screw, and the speed and direction of traverse can be varied by a press-button operated gearbox between the micrometer screw and the motor drive. In addition to recording the spectrum intensity, a visible projection of the spectrum and the image of the measuring lamp is thrown on to a circular grey screen at the foot of the instrument. To guard against light from this projection system filtering into the measuring system, a dichroic beam splitter is used and, in addition, the light from the projection source is plane polarised by a sheet polariser; in the measuring system there is another sheet polariser, the plane of polarisation of which is crossed with that of the projection polariser and effectively shuts off light from the projection system. The electronic power supplies, amplifier and recorder are housed in a vertical rack which stands in a convenient position beside the instrument.

The Electroflo Meters Company, Limited, Abbey-road, Park Royal, London, N.W.10, showed for the first time their pneumatic transmitter, developed originally by the parent company in the United States. The transmitter converts rates of fluid flow, liquid levels, pressures, or liquid densities into equivalent air pressures varying proportionally with the quantity being measured, and the pressures may be transmitted to remote or local indicators or recorders. In the Electroflo pneumatic transmitter the force exerted by the variable being measured is transmitted by a pivoted weighbeam to a pneumatically-loaded diaphragm; the compressed-air supply to the diaphragm, admitted through an orifice, bleeds through a nozzle, the flow through which is restricted by a throttle tip mounted on the weighbeam beyond the diaphragm. As the force produced by the variable tends to move the weighbeam, the throttle tip tends to close the nozzle, and the pressure is built up on the diaphragm, which moves the weighbeam to open the throttle until balance is restored. The total movement of the throttle tip is less than 0·004 in., and the movement of the diaphragm is less than this; the effective area of the diaphragm, therefore, remains sensibly constant over the operating range. The pressure is conducted through copper tubing to the indicating instrument, which is graduated directly in terms of the measured variable. The standard transmitting pressure is 3 lb. to 15 lb. per square inch, and the air consumption is 0·20 cub. ft. per minute.

Electroflo Meters also showed their new electronic recording and controlling potentiometer, in which the sensing and balancing actions are performed continuously and simultaneously with great precision. A pivoted galvanometer movement, connected in the standard potentiometer circuit, carries a small aluminium wire loop, the path of which is parallel to two small fixed coils connected respectively in the anode and grid circuits of an oscillator-amplifier valve. When the instrument is balanced, the relative positions of the coils and the loop corresponds to a pre-determined degree of magnetic coupling between the grid and anode circuits. A change in the position of the loop causes a simultaneous increase or decrease of the anode current, which operates a relay energising an electro-magnetic clutch which causes a continuously-running motor to shift the sliding contact and thus re-establishes balance. The instrument has automatic cold-junction correction, automatic self-standardisation, and protective devices for the electronic circuit, the measuring circuit and the standard cell. The manufacturers consider it to be particularly suited, in conjunction with their hydraulically-operated regulator, for the automatic control of furnace temperature, pressure and fuel-air ratio.

Messrs. Elliott Brothers (London), Limited, Century Works, Lewisham, London, S.E.1, showed a supervisory console for the central monitoring of a completely automatic control system for process plant, with facilities for manual adjustment in addition. Information on the primary control points is displayed upon a flow diagram on the front of the unit, and chart records of selected variables are provided by multi-point recorders. The automatic controllers are accessible from the rear of the cabinet.

The Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1, showed, for the first time, a high-speed multi-point recorder which imprints dotted records in six different colours on a single recording chart, which is driven by a gearbox giving a range of six chart speeds from ½ in. to 6 in. per minute. The Foster Instrument Company, Limited, Letchworth, Hertfordshire, showed a foundry pyrometer for measuring the temperature of molten metals, such as cast iron, steel and the cupro-nickel alloys, up to a maximum of 1,650 deg. F., in which the measuring element is a platinum/platinum-rhodium thermocouple housed in a calorised sheath with a replaceable vitreosil tip. A large-scale illuminated Teloscale indicator enables the instrument to be read from a considerable distance. The firm also showed a low-range radiation pyrometer employing a magnetic amplifier in conjunction with a thermocouple, for the measurement of surface temperatures down to 100 deg. C. Messrs. Unicam Instruments (Cambridge), Limited, Arbury Works, Cambridge, showed a new spectrocomparator which is suitable for the continuous analysis of liquid or gaseous products. It combines repeated scanning of a given spectral region with a system by which the difference between the absorption spectra of two samples is displayed on a cathode-ray screen. The difference may be adjusted to zero by varying the proportions of the reference mixture.

ENGINEERING IN THE FESTIVAL OF BRITAIN.*

VIII.—EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

(*Continued from page* 86.)

THE Hall of Power for Industry, which, following a logical sequence, the visitor is intended to inspect after the Hall of Steel, is arranged to show the part that steam has played, and is playing, in the national economy. Near the entrance there are models of Hero's Aeolipile, the Florence flask and steam ball, Papin's digester, and Savery's and Newcomen's engines, while Watt's separate condenser and Trevithick's high-pressure engine also find a place. The principal methods of raising steam in modern boilers, with their associated equipment, are then illustrated, as are the reciprocating compound engine and the turbine, in which steam is converted into mechanical power. The internal-combustion engine is represented by one of the latest designs of oil engine, equipped with turbo-charger, and the picture is completed by a full-scale model of a gas turbine.

The principal exhibit in the Hall has been arranged by the Combustion Engineering Association, 6, Duke-street, London, S.W.1, to illustrate the technique of steam raising. It consists of a full-scale section of a 9-ft. diameter Lancashire boiler with the shell plate cut away to show the internal arrangements. The flue tubes are also sectioned so that the mechanical stoker and ash extractor can be seen in operation; and the brickwork has been left incomplete, so that the superheater and economiser can be examined. The economiser is of the vertical-tube cast-iron type and is fitted with scraper gear for cleaning the tubes. It contains 48 9-ft. tubes arranged in one group six tubes wide, and has a mild-steel front casing, and vertical and horizontal gas baffles. It is capable of evaporating 12,250 lb. of water per hour with gas inlet and outlet temperatures of 850 deg. and 557 deg. F., respectively.

THE EXHIBITION OF INDUSTRIAL POWER.

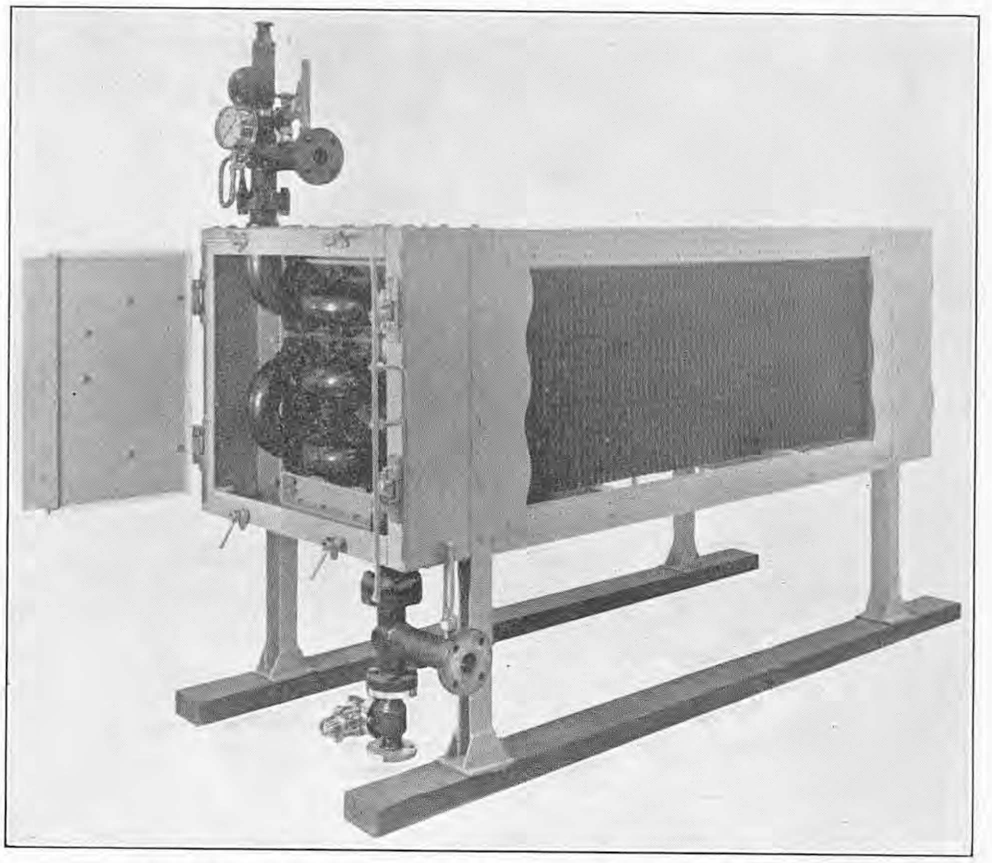


FIG. 129. CAST-IRON ECONOMISER; COMBUSTION ENGINEERING ASSOCIATION.

A second economiser exhibited is the 475-sq. ft. cast-iron unit depicted in Fig. 129, herewith. This consists of 12 tubes 6 ft. 7 in. long, arranged four tubes in width and three rows in height. The two ends are fitted with swing doors to afford access to the return bends. A by-pass is fitted, so that the boiler can be operated without the economiser. The heating surface consists of straight gills on tangential plates, which are cast on opposite sides of the tubes. When the tubes are assembled, the adjacent gills almost touch and form rectangular gas passages of uniform cross-section. A minimum draught loss for a given rate of heat transfer is thus ensured and access for cleaning by rods or brushes is facilitated. The economiser has been designed for a working pressure of 650 lb. per square inch.

Methods of steam raising are also illustrated by a vertical cross-tube boiler. This is 12 ft. 3 in. high over the crown and 5 ft. in diameter, and is capable of generating 1,250 lb. of steam per hour at a pressure of 100 lb. per square inch. The heating surface is 120 sq. ft. and the grate area 15·4 sq. ft. The automatic stoker is fitted with a Perspex cover to show the mechanism. The boiler is equipped with both electrically-driven and steam-driven feed pumps, the former being of the plunger type and having a stroke of 3 in. The steam-driven pump is of the horizontal duplex type. The operation of the pumps is automatically controlled by a feed regulator. Draught is provided by a fan.

An Economic boiler is also shown as an example of a design intended to combine high operational efficiency, maximum heating surface in minimum space, and an absence of external brickwork. The boiler is of the double-pass type, with an economiser between the boiler and the chimney. The coal is delivered by an elevator to the mechanical stoker. A coal meter, an automatic feed-water regulator and soot blowers are fitted.

The story of steam generation may be said to be completed in the exhibit of the Water Tube Boiler Makers' Association, 8, Waterloo-place, London, S.W.1. This consists of a model, about 40 ft. long, of a modern boiler designed to generate 200,000 lb. of steam per hour at a pressure of 645 lb. per square inch and a temperature of 840 deg. F. with a feed-water temperature of 350 deg. This boiler is designed to use pulverised brown coal with a moisture content of 66·5 per cent., a high ash content, and a calorific value as fired of 3,710 B.Th.U. per pound. The combustion chamber is of the water-lined radiant type with a bank of convection tubes before the superheater. Associated with it are three beater mills, each with a capacity of 15 tons per hour, a plain steel-tube economiser and a tubular air heater, the cold end of which is formed of corrosion-resisting cast-iron tubes. Draught is provided by two electrically-driven forced-draught fans with an output of 60,300 cub. ft. of air per minute at a temperature of 70 deg. F. and a pressure of 6·35 in. water gauge, and two electrically-driven induced-draught fans with a delivery of 123,600 cub. ft. of flue gases per minute at a temperature of 380 deg. and a pressure of 12·9 in. water gauge. The gases pass to the chimney through an electrostatic precipitator.

The fuel, air and water-steam circuits on the model are distinguished by different colours. The passage of the coal from bunker to burner can thus be traced, as well as the flow of air from the forced-draught fans through the preheater to the primary and secondary ducting, and the path of the gas from the combustion chamber to the superheater, economiser, grit separator, air heater, dust precipitator and, finally, through the induced-draught fans to the stack. The same exhibit includes a number of photographs of parts of actual installations, arranged as colour transparencies which can be illuminated by pressing a button. At the same time, a pilot light on the main diagram shows the position of the component in the system.

The stokers exhibited separately from the boilers include a coking stoker with a self-cleaning grate, which has been designed to facilitate even distribution of fuel. For this purpose, the height of the fire door can be adjusted within fine limits and the thickness of the bed adapted to the output required

* Previous articles in this series on the Dome of Discovery, the Royal Festival Hall, the temporary bridges, the "Skylon," the civil engineering works and the exhibits at the South Bank Exhibition appeared in the previous volume of ENGINEERING (vol. 171) in the issues of April 13 and 20, May 4, 11 and 18 and June 1, 8, 15, 22 and 29, 1951.

EXHIBITS AT THE EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

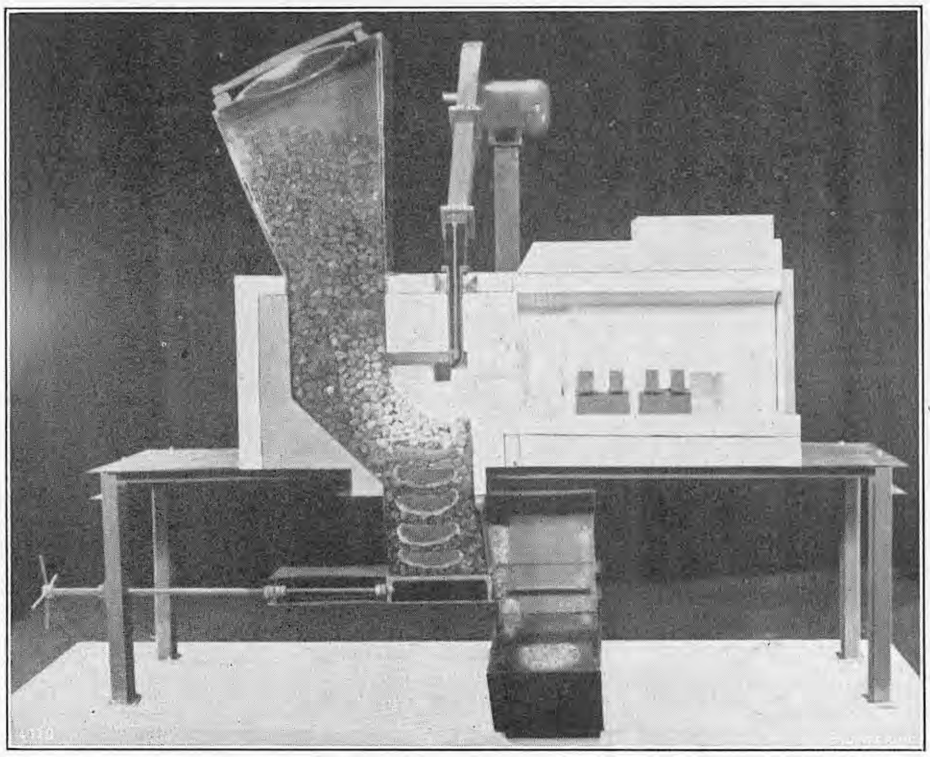


FIG. 130. MODEL OF DOWN-JET COKE-FIRED FURNACE; BRITISH COAL UTILISATION RESEARCH ASSOCIATION.

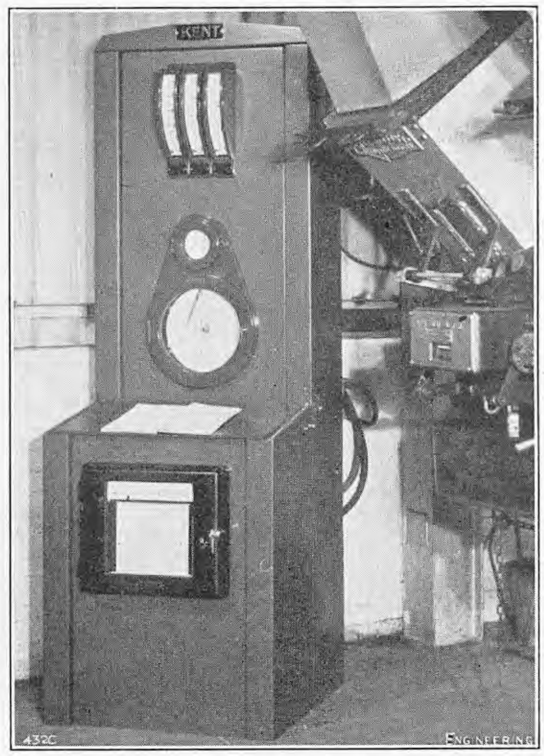


FIG. 131. BOILER CONTROL PANEL; COMBUSTION ENGINEERING ASSOCIATION.

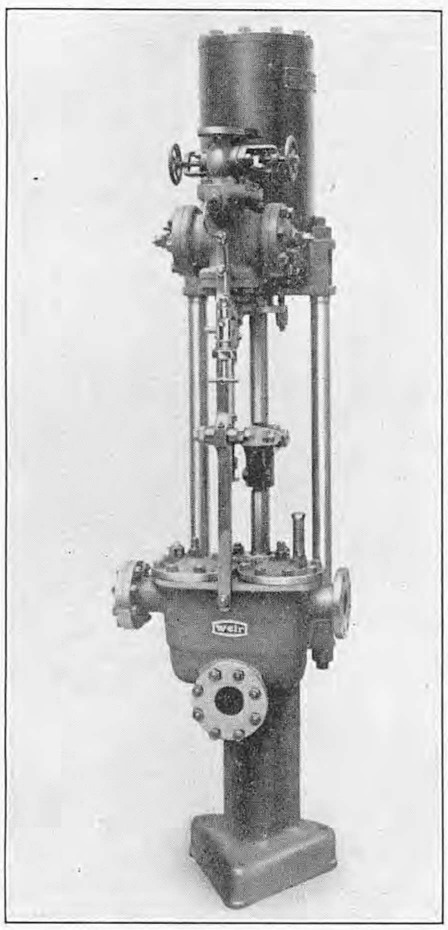


FIG. 132. DIRECT-ACTING BOILER FEED PUMP; COMBUSTION ENGINEERING ASSOCIATION.

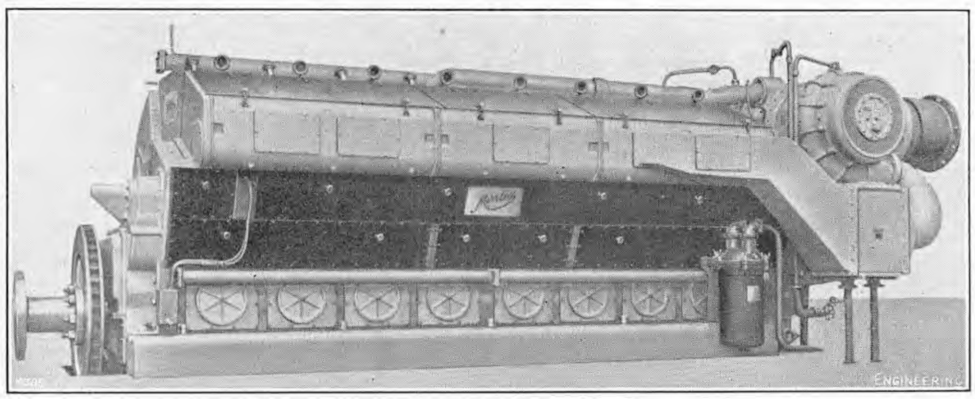


FIG. 133. 2,270-H.P. TURBO-CHARGED DIESEL ENGINE; MIRRLEES, BICKERTON AND DAY, LIMITED.

and the characteristics of the fuel. When the door is in its lowest position, it acts as a seal between the grate and the hopper, an arrangement which is useful when the boiler has to be banked. The feeding ram extends across the whole width of the reciprocating grate, the speed of which is also adjustable. Ash and clinker are deposited in a chamber formed between the end of the grate and the bridge wall. A spreader stoker is also exhibited, consisting of a reciprocating feed plate and a set of revolving distributor blades. The movement of the feed plate causes the fuel to work down on to a table, integral with the stoker, along which it is pushed on a curved throw-plate. At this point the distributor blades, which run at 300 to 400 r.p.m., pick up the fuel and scatter it to right and left on to the fire, the distance it is thrown being determined by the position of the plate.

An example of the control devices which, it is now being realised, are essential to the satisfactory operation of a boiler plant, is provided by the "Stoker's Mate" equipment. This has been designed for use with small installations and consists of means for measuring the feed water and steam flow, the temperature at various points, the CO_2 and the draught pressure. The instruments for this purpose are grouped on the panel illustrated in Fig. 131, the draught gauges being shown at the top with the steam-flow recorder in the centre and the CO_2 and temperature meters below. Other examples of control equipment are provided by a number of coal meters for stoker-fired water-tube and Lancashire boilers, float-operated switches for regulating feed pumps, and a complete switching and indicating panel of the type now common in power-station boiler houses.

The Lancashire boiler and Economic steam generator mentioned above are both supplied with feed water by direct-acting pumps, an example of which is illustrated in Fig. 132. The first of these pumps has a normal duty of 660 gallons per hour, and that of the second is from 1,450 to 1,725 gallons per hour. They have been designed to be economical in steam consumption by reducing the clearance spaces; and, as there is no dead centre, the pump will start at any point on the stroke. The steam stop-valve is of stainless steel, so that it is light and resistant to superheat.

Another method of utilising fuel is illustrated by the quarter-scale model in longitudinal section of a refractory-testing kiln fired by a down-jet coke burner. This model, which is being exhibited by the British Coal Utilisation Research Association, Leatherhead, Surrey, is illustrated in Fig. 130, and serves to demonstrate the operation of the burner by which all the air for combustion is projected in a jet on to the surface of the fuel bed. The rate of burning and the composition of the productions of combustion are controlled by adjusting the quantity and velocity of the air supplied, the result being that working temperatures of over 1,650 deg. C. and a CO_2 content of 18·5 to 19·5 per cent. have been obtained without preheating the air. The ash fuses and runs down in droplets to form a solid layer in the lower part of the coke bed, whence it can be removed mechanically. This burner is now being manufactured by Joshua Bigwood and Son, Limited, Wolverhampton, for the high-temperature firing of refractories and, with water-jacketed nozzle, for firing central-heating and other low-pressure boilers.

An example of steam-operated plant is provided by the two-crank compound steam engine with inclined piston valves, exhibited by Belliss and Morcom, Limited, Birmingham. This engine is designed to operate on dry saturated steam at a pressure of 180 lb. per square inch with a back pressure of 5 lb. per square in. and to run at a speed of 500 r.p.m. The cranks are set opposite to each other and steam is admitted simultaneously to the top of one cylinder and the bottom of the other. The high-pressure and low-pressure slide valves are in separate chambers between the cylinders and are operated by separate eccentrics. The high-pressure valve cuts off on the inner edges and exhausts directly to the low-pressure valve, so that the use of outside receiver pipes is avoided. The engine is directly connected to a 150-kW 400-volt three-phase alternator constructed by Lancashire Dynamo and Crypto, Limited, Trafford Park, Manchester.

A double-flow low-pressure turbine rotor is being exhibited by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. This rotor, which weighs $19\frac{1}{2}$ tons, is for one of the two 52·5-MW three-cylinder sets for the Carmarthen Bay power station of the British Electricity Authority. The turbines are designed to run at 3,000 r.p.m. when supplied with steam at a pressure of 900 lb. per square inch and a temperature of 900 deg. F. and to exhaust into a 52,000 sq. ft. surface condenser operating at a vacuum of 29 in. The low-pressure rotor has three stages and ten discs. Its maximum diameter is 6 ft. 9 in., so that the peripheral speed of the stainless-steel blading is 1,050 ft. per second.

The production of power from oil is illustrated by the 2,270-h.p. turbo-charged compression-ignition engine exhibited by Mirrlees, Bickerton and Day, Limited, Stockport, the appearance of which will be seen from Fig. 133. This engine, which is the most recent product of the firm, has 16 cylinders arranged in V formation and runs at 900 r.p.m. The brake mean effective pressure is 160 lb. per square inch and the boost pressure is 7·5 lb. per square inch. The bedplate and the monobloc cylinder of this engine have been fabricated from mild-steel plate, the welds being stress-relieved. The cast-iron cylinder heads have the injector spaced centrally between the two exhaust and two air-inlet valves. There is also a starting non-return valve. The cylinder liners are of chrome-hardened cast iron and are arranged to expand downwards. The valve gear is pressure-lubricated and totally enclosed. It is operated through push rods from high-tensile steel ground camshafts, which have chill-cast cam profiles. The crankshaft is a forging of 45-50 ton steel, hardened and tempered, and the connecting rod is also a steel forging, of H-section. The pistons are of aluminium alloy with a dished crown. The bore and stroke are $9\frac{3}{4}$ in. and $10\frac{1}{2}$ in., respectively, and the piston speed is 1,578 ft. per second. Fuel is supplied to each cylinder by individual pumps and starting is effected by compressed air at a nominal pressure of 3,000 lb. per square inch. The brake thermal efficiency of the engine is 38 per cent. and the dry weight of the engine is 17·2 tons.

As an indication of the power of the future, Ruston and Hornsby, Limited, Lincoln, are showing a full-scale model of their industrial gas turbine, the operation of which is explained by a diagram of the working cycle, on which temperatures and pressures are indicated. The set is made up of four major units: a gas generator, consisting of a two-stage high-pressure turbine driving a 13-stage axial-flow compressor; a heat exchanger, flexibly supported from the main turbine frame; combustion chambers, arranged symmetrically on each side of the plant; and the combined power turbine and reduction gear. These units are connected by flexible ducts and any section can be dismantled without interfering with the others. Among the special features of the turbine are the cooled stator with segmental shrouding in the turbine driving the compressor, and there are overhung disc rotors on both the compressor and output turbines. High-temperature ducting of thin section is employed and is housed in an external pressure-carrying casing. The reduction gearing is of the epicyclic type. The turbine, which is coupled to a 750-kW alternator, was first run under its own power in 1946 and was subjected to endurance tests with the alternator in 1950. The fuel consumption of the complete unit on full load was found to be 0·59 lb. per b.h.p., and the thermal efficiency 23·4 per cent.

(To be continued.)

SEAWEED RESEARCH IN SCOTLAND.

THE annual report for 1950 of the Scottish Seaweed Research Association shows that the five-year research and development programme published in the 1946 report was nearing completion. It covered a survey of Scottish seaweed resources from the biological, chemical and economic points of view, the development of harvesting and processing techniques (a matter of considerable engineering interest) and the investigation of uses to which seaweed could be put. It has now been established that the mechanical harvesting of brown seaweed from beds fringing the coastline is technically feasible, and the survey of the weed beds has been extended to cover 85 per cent. of the Scottish coast. In addition, the Gulland Laboratory (named after the late Professor J. Masson Gulland, F.R.S.) was officially opened in December by the Rt. Hon. Hector McNeil, M.P., Secretary of State for Scotland; this is described as a "semi-technical" laboratory, equipped for experimental work on drying, filtration, separation, distillation and other chemical operations leading to the design and erection of pilot plants for seaweed processing. The layout of the laboratory is such as to permit the erection of complete pilot plants.

Of the 4,500 miles of coastline surveyed to the end of 1950, 1,652 miles were found to support sublittoral seaweed in concentrations and densities of growth likely to prove of potential industrial significance. The weight of weed found ranged from 10·5 to 18·3 tons per acre; but the interesting fact emerged that, round the southern half of the Isle of Arran, there was an abnormally high density of growth at all depths to 6 fathoms, amounting to 40·7 tons per acre. As a result of the survey, it has been estimated that the "total weed potential" of Scotland is some ten million tons (wet), of which four million tons is sufficiently concentrated to be industrially significant when suitable means of harvesting have been developed. The engineering staff of the Association have achieved considerable success in developing suitable means and have established that the continuous grapnel method of harvesting, described in the 1949 report, is practicable. Experiments were continued, also, with the method of cutting by reciprocating reaper-type blades and entertained in a stream of water.

CONCRETE OIL-STORAGE TANK.

FIG. 1. CASTELLI TYPE OF OIL TANK.

OIL-REFINING CAPACITY IN ITALY.

As in most other countries, the consumption of petroleum products in Italy has shown a steady increase since the war, and has now exceeded by a considerable margin the figures for the last pre-war year, 1938. In that year, the consumption of petrol was 455,000 metric tons, of gas oil 261,000 tons, of kerosine 100,000 tons, and of fuel oil 1,587,000 tons. Even in 1946, when conditions were still far from normal, the corresponding quantities were 202,000, 275,000, 151,000 and 1,048,000 tons, in round figures; but in 1949 they rose to 547,000, 586,000, 148,000 and 1,910,000 tons, respectively, and 1950 greatly exceeded these totals, reaching 664,000 tons of petrol, 750,000 tons of gas oil, 188,000 tons of kerosine, and 2,341,000 tons of fuel oil. During the year, the Italian refineries processed over 4,000,000 tons of crude oil, an increase of more than a million tons on the 1938 total, in spite of war-time damage which included the total destruction of the large refinery at Leghorn. Schemes for the expansion of the industry, with the backing of the Italian Government and considerable investment of American money, contemplate an increase of processing capacity to 9,000,000 tons a year in the course of 1952, to meet the requirements of public and private transport, and the rapid conversion of industrial power plants of all kinds from coal to oil.

Of the existing refineries, the largest is that of the Socony-Vacuum Company at Naples, with a capacity of 1,600,000 tons of crude oil a year. Next come the rebuilt plant of the Stanic company (Esso Italiana e Anic) at Leghorn, which can process 1,080,000 tons a year, and the same company's Bari refinery, with a capacity of 960,000 tons. At Venice there is the 750,000-tons plant of "Irom"—Industria Raffinazione Olii Minerali; and the Aquila Oil Company have one of 600,000 tons capacity at Aquilinia, Trieste. Only one other can process as much as 500,000 tons a year, this being the refinery of the Raffineria Siciliana Olii Minerali at Augusta, near Syracuse.

An important new refinery, now in an advanced stage of construction, is that of the Condor Oil Refining Company at Milan; it is expected to be completed by the end of 1952. It occupies a site of 1,000,000 sq. m. at Rho, on the highway between Milan and the Simplon, and will be connected with the port of Genoa by a pipeline 305 mm. in diameter and 135 km. in length, to be operated at a pressure of 60 atmospheres by a single pumping station. At Genoa, an oil dock is being built, with accommodation for four 30,000-ton tankers, and pumping plant capable of handling 4,000 tons an hour. Storage at the Rho refinery will be in steel tanks, the aggregate capacity of which will be 400,000 cub. m. Half of the tanks will have floating roofs. Steel is scarce in Italy, however, and therefore many storage and distribution depots are being equipped with concrete tanks of the type introduced by Ing. Stefano

OIL REFINERY AT LEGHORN, ITALY.

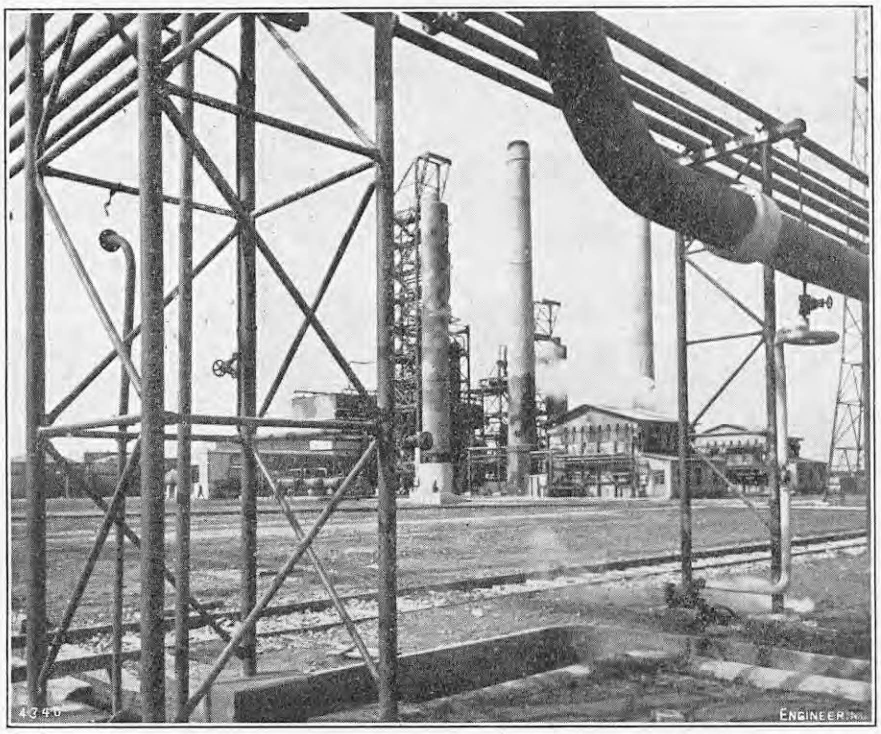


FIG. 2. NEW REFINERY AT LEGHORN.

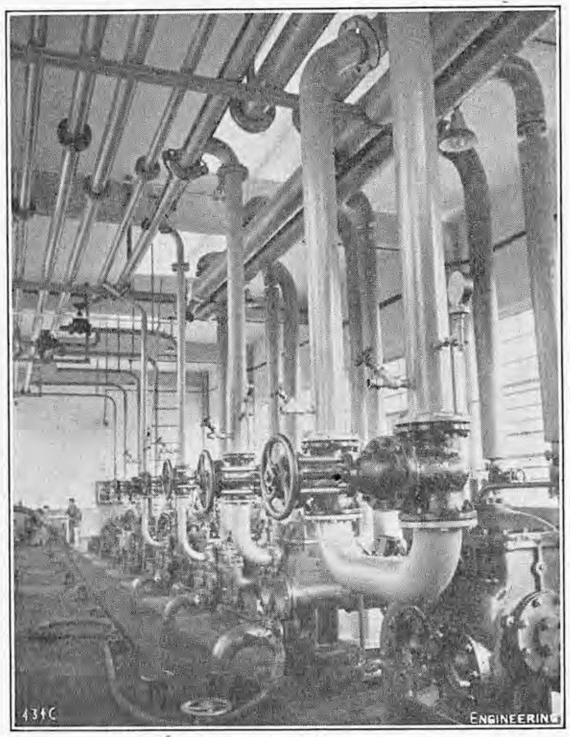


FIG. 3. TANK PUMPS.

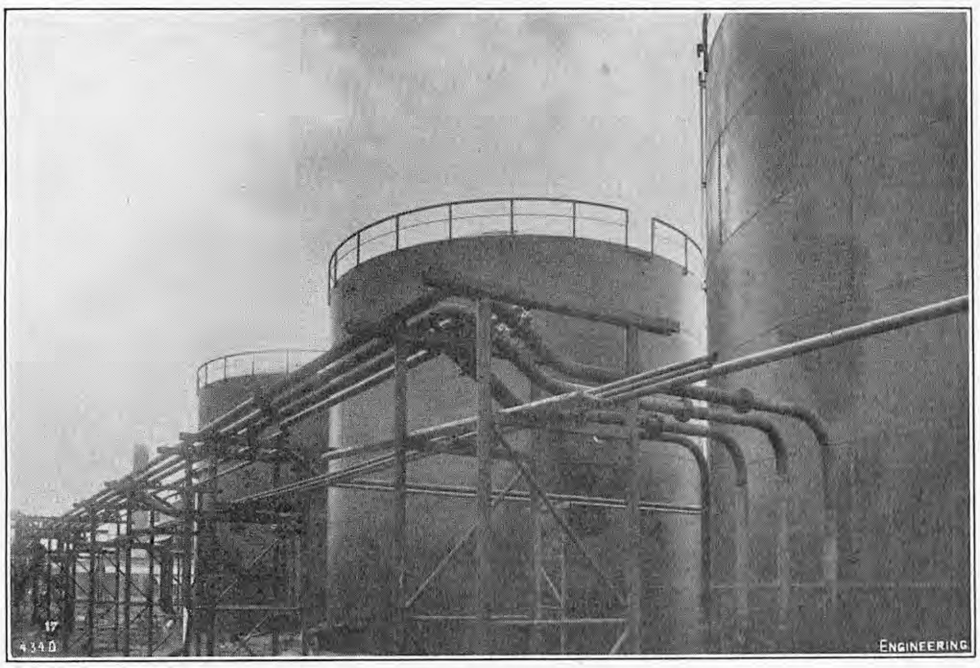


FIG. 4. STORAGE TANKS AT LEGHORN REFINERY.

Castelli, of Milan; a tank of this type is illustrated, under construction, in Fig. 1, opposite.

Another important new refinery is that of the Petrocaltex Company with which the Fiat Company are associated. It is situated at San Giorgio di Trecate, near Novara, on the road between Turin and Milan, and is practically identical in type with that of the Condor Company, though ultimately to be larger; the eventual annual processing capacity is expected to be 1,800,000 tons. It will be connected with an oil port at Vado Ligure, to the east of Genoa, by a pipeline 155 km. long, operating at a pressure of 80 atmospheres. A further refinery, with a designed capacity of 300,000 tons of crude oil yearly, is under construction at Mantova under the auspices of a group formed by the Perdomini Company and the Omnium Français des Pétroles.

Meanwhile, the Stanic Company have made considerable progress in reorganising and enlarging their refineries at Bari and Leghorn, which were built between 1936 and 1938 to process Albanian oils. Their original capacity was about 400,000 tons a year each. In 1940, the Leghorn plant was extended to produce a greater output of lubricating oils and paraffins, in the proportion of 60,000 tons of lubricating oil to 14,000 tons of paraffin. During the war, the Bari refinery was only slightly damaged, but the Leghorn refinery, as stated above, was completely destroyed. In 1946, production was resumed at Bari, and in the following year various extensions were completed. At present, the throughput there is up to 80,000 tons a month as a result of the installation of new equipment obtained in the United States by means of funds placed at the disposal of the Stanic Company by the Standard Oil Company of New Jersey. An oil dock is to be constructed at Bari to take tankers of 35,000 tons deadweight capacity.

At Leghorn, which was brought into production again towards the end of 1947, the repair of the topping unit restored the capacity to 50,000 tons of crude oil monthly, and this figure has now been raised to 90,000 tons. With the aid of the dollar credits provided by the Standard Oil Company of New Jersey, the construction has begun of a new lubricating-oil equipment. Figs. 2, 3 and 4, herewith, show portions of the Leghorn refinery; it will be noticed that the tanks are of riveted construction. It is intended also to modernise the plant for the production of petrol, to supply high-octane spirit and fuel for jet-propelled aircraft. Five new tanks with floating roofs, having a capacity of 20,000 cub. m. each, are to be added for storage purposes, and a pipeline 5 km. long will connect the refinery with a new oil dock, designed to berth tankers up to 28,000 tons deadweight.

Further plans for the expansion of Italian oil-refining capacity, on several of which work is now proceeding, include an extension to the Shell refinery at Spezia; the addition of 50 per cent. to the capacity of the Falconara refinery of the Societa Anonima Petroli Italiana, to bring it up to 600,000 tons a year; a proposal of the same company to extend their refinery at Fiorenzuola d'Arda; and a similar project of the Societa Anonima Lombarda Petroli. The programme of the S.A. Petroli Italiana is designed with a view to developing the production of lubricating oils from crude obtained from the Piacenza fields. The Permolio Company, of Milan, have obtained permission to increase the processing capacity of their plants at Rome, Genoa and Milan to 500,000 tons yearly, with the aid of American capital; and negotiations are in progress between the Italian Government and the Socony-Vacuum Company with a view to increasing the capacity of that company's refinery at Naples to 2,200,000 tons a year, with particular emphasis on the production of lubricating oils. Discussions are proceeding also between the Italian Government and Sardinian industrialists who wish to obtain American financial aid to establish a refinery at Cagliari, with a projected throughput of 500,000 tons of crude oil annually, to produce aviation spirit and fuel oils. A refinery at Cagliari is necessary, it is claimed, to serve the growing air traffic and the increasing demands of industry in Sardinia.

PROPOSED SERVICE RESERVOIR FOR WOLVERHAMPTON.—The construction of a service reservoir of 5,000,000 gallons capacity at Goldthorn Hill, together with the necessary additional water mains, at the cost of 107,440*l.* is recommended by the Water Committee of Wolverhampton Town Council. The existing service reservoir at Goldthorn Hill was constructed a century ago to hold 1,500,000 gallons, but since 1936, when it was found not to be watertight, its maximum capacity has been limited to 1,200,000 gallons. This reservoir and the one at Bushbury Hill, of 2,000,000 gallons capacity, have together to balance the hourly variations of demand against the supply from the various pumping stations; the total daily demand is more than 9 million gallons. The capacity of the existing Goldthorn Hill reservoir is now inadequate and, because of its age, it cannot be relied upon to maintain its stability or watertightness. The site for the new reservoir was acquired in 1931, but the war interfered with the proposed project. The committee propose to build the reservoir of reinforced concrete, partly below and partly above the surface.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

BELT CONVEYOR FOR MINE USE.—A conveyor in which the belt is supported by two travelling steel ropes and carried along by friction through rubber shoes has been installed experimentally at the Frances Mine, East Fife. The removal of much of the strain from the belt by this arrangement is expected to increase its life considerably, while the longer single stretches of belt which it is possible to employ reduce the number of driving motors. The makers are Cable Belt, Ltd., Rose-street, Inverness.

CHEMICAL INDUSTRY.—Trade in the Scottish chemical industry maintained its progress during 1950, according to a statement by Dr. E. A. Balfour Birse, Chief Inspector of Alkali, etc., Works for Scotland, in his annual report to the Secretary of State. The shortage of sulphur, however, was a discouraging feature, as only two plants in Scotland were manufacturing sulphate of ammonia, and large quantities of ammonia produced by the country's gasworks, as a by-product, went to waste. At the same time, the use of ammonia for the manufacture of nitrogen fertilisers had proved promising.

NEW FERRY SERVICE.—The Ministry of Transport has made a grant of 18,296*l*. towards an expenditure of 30,493*l*. for the construction of slipways for the proposed vehicular ferry service between the island of Luing, near Oban, and the mainland. Luing is a centre of the West Highland slate industry.

GASWORKS CONSTRUCTION.—The Scottish Gas Board has sanctioned the expenditure of more than 325,000*l*. during the past three months, according to a report made at a meeting of the Scottish Gas Consultative Council in Edinburgh on July 18. Of that sum, about 132,000*l*. has been allotted to the Glasgow and West Division, including 42,000*l*. to be spent on the Dawsholm Gasworks at Maryhill. The chairman of the Board, Mr. A. T. Morrison, announced that a sub-committee would consider the most appropriate standard of calorific value.

SCOTTISH INDUSTRIAL ESTATES, LTD.—Reviewing the progress made by Scottish Industrial Estates, Ltd., Glasgow, since the organisation was established 14 years ago, Mr. W. C. Kirkwood, the general manager, stated on July 18 that 52,000 men and women were now employed by their tenants, and that the company's income exceeded 1,000,000*l*. annually. Mr. Kirkwood said that the company's work now was to help all essential types of businesses which fitted into the Government's policy for the distribution of industry.

PAISLEY SPINNING MILL.—Plans for a new spinning mill to be constructed at Ferguslie, Paisley, which is estimated to cost over 500,000*l*., were passed at Paisley Dean of Guild Court on July 18. The application was made by United Thread Mills, Ltd., Bolton and Paisley, for the erection of a building of three storeys, with provision for a fourth storey later. The new mill will form the largest unit so far undertaken in connection with the long-term reconstruction scheme being carried out at Ferguslie.

EXHIBITION OF INDUSTRIAL POWER, GLASGOW.—The Cunard motorship Britannic arrived at the Tail of the Bank, on July 19, on the second of the three calls she is making in connection with the Festival of Britain. Nearly 500 American and Canadian passengers landed at Greenock, in response to an invitation by the Scottish committee of the Festival inviting the ship's passengers to visit the Exhibition of Industrial Power in Glasgow.

CLEVELAND AND THE NORTHERN COUNTIES.

THE UPWARD MOVEMENT IN STEEL PRICES.—For some time past, the interest of North-East Coast commercial circles has centred very largely on likely trends in the recognised market values of steel. Recent announcements indicate that the export price of small bars and sections has been advanced by 7*l*. 11*s*., raising the quotation 40*l*. 10*s*. Heavy steel export prices have risen by 5*l*. a ton. The increases are, however, no greater than were generally expected and they leave the cost of Tees-side products well below the general level, at which the manufactures of their Continental competitors are quoted. The outputs of all steel-producing areas between the Tees and the Tyne have been fully booked and great activity by the plants concerned for some time to come is assured. Offers of new business are not eagerly sought after at present. The general situation, in fact, still occasions considerable anxiety.

DECLINE IN COAL CONSUMPTION.—The output of saleable coal in the North Eastern Division of the National Coal Board declined sharply during the first two weeks of this month, mainly owing to the incidence of the summer holiday period. Production, which amounted to 875,300 tons for the week ended June 30, and totalled 842,100 tons for the week ended July 7, declined to only 828,800 tons for the following week. The Board estimated that the amount of coal lost, owing to holidays, strikes and similar causes, was 8,120 tons during the week ended June 30. For the following two weeks, however, the quantities of coal lost in this way increased to 16,960 tons and 32,730 tons, respectively.

SHORTAGE OF RAILWAY WAGONS.—Complaints are being made that the efficient handling of goods traffic at West Hartlepool docks is being jeopardised by the growing shortage of railway wagons. Imports of timber through the port are increasing, as is usual at this season, and the docks are working at full pressure. The shortage is considered to be due, in some measure, to the lack of trained railway staff, and this, in turn, is aggravated by the calling up of railwaymen for national service duties. Railway officials claim to have the matter in hand and it is hoped that representations made to the Railway Executive will lead to more wagons being diverted to the port.

LANCASHIRE AND SOUTH YORKSHIRE.

SHEFFIELD STEEL PRODUCTION.—In Sheffield, February was the peak month this year for the production of steel ingots and castings, with an average of 49,900 tons a week. The average for June was only 40,300 tons, owing to the closing of five open-hearth furnaces, for which the necessary scrap metal was not obtainable. The average weekly output of steel ingots and castings during May and June was 11 per cent. lower than that for the first four months of the year.

MINERS AND THE SATURDAY SHIFT.—The realisation that special steps will be necessary to avoid another coal crisis, during the coming winter, has led miners at ten Yorkshire collieries to indicate that they are willing to resume immediately the working of voluntary Saturday shifts. Saturday working was suspended at all collieries for the months of June, July and August to give the men a rest. At some Nottinghamshire pits, Saturday shifts have been worked recently, with encouraging results.

THE WORKING OF IRONSTONE IN RUTLAND.—During the course of an inquiry into ironstone mining at Rutland and Kestevan, the county planning officer for Rutland advised that the ironstone should be worked, but without damaging agriculture, which was the county's principal industry. The ironstone operators had applied to work an area of approximately 18,000 acres, or about one-fifth of the total acreage of the county. They had also deposited plans showing projects to extend their operations at a later date to about two-thirds of the county's area.

THE POSITION OF MEDICAL OFFICERS IN INDUSTRY.—Mr. Gerald Steel, joint managing director of the United Steel Companies, Ltd., has pleaded for works' doctors to be given increased responsibility in management. He suggested that they might pay greater attention to accident prevention and to what was technically known as neurosis, but which he regarded as extreme unhappiness. The financial loss to industry caused by avoidable accidents was frightening, and, from the humanitarian point of view, Mr. Steel considered that there was too much unnecessary suffering and distress.

THE MIDLANDS.

THE AUSTIN MOTOR COMPANY.—The new assembly plant of the Austin Motor Co., Ltd., at Longbridge, Birmingham, was officially opened by the Minister of Supply, Mr. George Strauss, M.P., on July 19. The plant has been designed to utilise modern methods of mechanical handling and mechanisation to the greatest possible extent, and has cost 2,000,000*l*. Mr. L. P. Lord, chairman and managing director of the Austin Company, said at the opening ceremony that, during the company's present financial year, which would end in two weeks, the output of the works had again risen; it was about 3 per cent. higher than that of the previous year. In that period, they had despatched 157,000 vehicles of all types, 75 per cent. being exported.

WARNING OF POWER CUTS.—With the inevitability of power cuts for some years to come in mind, the Midlands Electricity Board are considering the possibility of using short-wave radio to give warning of impending cuts. Experiments are being carried out at present by the British Electricity Authority in Yorkshire, and if they are successful, it is likely that something similar will be done in the Midlands. The M.E.B. consider that the district most in need of such a warning system is the highly-industrialised area between Birmingham and Wolverhampton.

SATURDAY WORKING IN MIDLAND COLLIERIES.—Miners in the West Midlands Division of the National Coal Board have expressed a wish to begin voluntary Saturday shift-working before September 1. It was agreed in April that Saturday working should be suspended between June 2 and September 1, but, because of this demand for an earlier start, a ballot is being held among Midland members of the National Union of Mineworkers with a view to setting aside the previous decision.

PROPOSED NEW POWER PLANT.—A proposal by the British Electricity Authority to seek planning permission for the building of a new power station at Hams Hall, near Coleshill, Warwickshire, has been considered by the local authority. The authority, Meriden Rural Council, had before it a suggestion that a protest should be made, but decided to take no action until further details were available. There are already two large power stations at Hams Hall, and the objection to the erection of a third was based on the ground that atmospheric pollution would be increased.

UNDERGROUND FIRES.—The old Black Country problem of underground fires has cropped up again, this time at Willenhall, Staffordshire. A fire has been discovered in the garden of a Council house which is built on an old colliery site. Willenhall Urban District Council have taken test borings to discover the extent of the fire, and it will probably be necessary to excavate a trench to prevent the burning area from spreading.

INDUSTRIAL DEVELOPMENT AND EMPLOYMENT IN THE MIDLANDS.—The Midland Regional Board for Industry state that applications for building licences during the first six months of 1951 increased by 24 per cent., compared with the same period of last year. Birmingham and Coventry are the centres of greatest demand. Unemployment figures for the Midlands, issued by Mr. J. W. Eldridge, Deputy Regional Controller, Ministry of Labour, are :—Birmingham 2,200, Coventry 890, North Staffordshire 1,150, Wolverhampton and the Black Country 1,380, and the rest of the Midland Region 1,195.

SOUTH-WEST ENGLAND AND SOUTH WALES.

ANTHRACITE MINE AT LLANELLY.—The National Coal Board have approved, during the past week, a scheme for sinking a new anthracite colliery at Cynheidre, five miles north of Llanelly, which will cost 7,500,000*l*. It is expected to come into production in 1956, and its maximum output, 1,000,000 tons of the highest grade anthracite per annum, should be reached in 1962, when about 3,450 men will be employed. Reserves of workable coal in the vicinity have been calculated as sufficient to keep the colliery fully employed for more than a century. The Board confirmed last week that the estimated expenditure at the new colliery was "extremely high" in relation to its output, but explained that, owing to geological faults, mining conditions were far from favourable. In spite of the heavy cost involved, however, the anthracite obtained would be gained at a lower cost than that from neighbouring pits. Horizontal mining will be employed and the new colliery will be an "all electric" undertaking.

NANTGARW COLLIERY.—The first battery of coke ovens to be erected at Nantgarw Colliery, near Cardiff, was lighted last week. The temperature will be increased gradually for eight weeks, prior to the insertion of the first charge of coal in September or October next. They have cost 3,000,000*l*. During periods of full production, the ovens will consume 1,500 tons of coal daily and will have a daily output of 1,100 tons of coke.

PONTYPOOL TOWN-PLANNING SCHEME.—Pontypool has drawn up a plan for the development of the town which it is estimated to cost 1,300,000*l*., and to require twenty years to complete. The schedule includes the provision of a civic centre. The plan will form part of the Monmouthshire County Council's development scheme, which has been divided into an immediate five-year programme and a long-term 15-year programme.

RURAL ELECTRICITY SUPPLIES.—The estimated two-year programme for developing electricity supplies in rural Wales may have to be curtailed. A meeting of the South Wales Electricity Consultative Council in Cardiff on July 17, was informed that the South Wales Electricity Board considered that projects, such as rural development, with a low rate of priority, would have to be deferred, owing to the commitments of the Board to industry and to the need for building up the electricity-industry.

NOTICE OF MEETING.

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.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS. —*South-West London Branch:* Tuesday, August 14, 8.15 p.m., St. George's Hall, St. George's-road, Wimbledon. "Carbon Brushes for Electrical Machines," by Mr. C. T. Lawrence.

TRADE PUBLICATIONS.

V-Belt Drives.—J. H. Fenner & Co., Ltd., Hull, have issued a leaflet showing the uses to which their V-belt drives are being put in connection with the heating and air-conditioning plant in the new House of Commons.

Aluminium Wire.—A file, containing four data sheets on the characteristics and properties of aluminium and aluminium-alloy wire, has been sent to us by the Aluminium Wire and Cable Co., Ltd., 37, Thurloe-street, South Kensington, London, S.W.7.

Industrial Safety Goggles, Helmets and Respirators.—A catalogue of their many types of safety goggles and other face and eye protectors, dust respirators and other safety equipment, has been received from J. and R. Fleming, Ltd., Safety Goggle Division, 146, Clerkenwell-road, London, E.C.1.

Chemical and Iron and Steel Plant.—A selection from the gas and chemical plant, blast-furnace and other installations erected and equipped by the Power-Gas Corporation, Ltd., and Ashmore, Benson, Pease and Co., Stockton-on-Tees, are contained in a folder recently issued by these associated firms.

Reinforced Asbestos.—British Reinforced Asbestos Co., Ltd., 24, New-street, Worcester, have sent us a sample of their woven asbestos sheeting with a metallic insertion. The material, which is flexible and intended for exacting conditions, is made up in sheets $\frac{1}{16}$-in. and $\frac{1}{8}$-in. thick, and is also obtainable in the form of tape.

Refractory Cement.—A folder relating to Durax No. 3 refractory cement has come to us from General Refractories, Ltd., Genefax House, Sheffield, 10. This material, it is claimed, makes strong durable joints in firebrick walls, an advantage being that it shows little or no shrinkage on drying and firing.

Metal-Faced Plywood.—A booklet dealing with Plymax metal-faced plywood has been issued by Venesta, Ltd., Vintry House, Queen Street-place, London, E.C.4. It is entitled "Facts about Plymax," and deals with such matters as design data, methods of working and of finishing the material, the construction of complete units, and lead Plymax for X-ray protection.

Chains and Wire Ropes.—Information on the manufacture of wrought-iron and mild-steel chains, together with their safe working, proof and test loads, is contained in a booklet prepared by Edge and Sons, Ltd., Shifnal, Shropshire, makers of chains for over 150 years. Some particulars of double-leg chain slings, hooks, shackles and steel-wire ropes are also included.

Coal Washing.—Simon-Carves, Ltd., Cheadle Heath, Stockport, have produced a brochure describing their "Simcar" froth-flotation and flocculation plants. Froth flotation is used to recover a comparatively low-ash fuel from washeries, which is saleable after mixing with washed slack. Flocculation plant is solely for cleaning washery circuits, but can be used in various ways.

Lubricants.—Acheson Colloids, Ltd., 18, Pall Mall, London, S.W.1, have sent us the first three of a series of leaflets to be issued by them on industrial applications of their products. The subjects covered are: lubrication of glass moulds, prevention of screw-thread seizure, and conveyor and chain lubrication. These leaflets are numbered U.1, X.1 and P.1.

Cold Rolling Mill.—The English Electric Co., Ltd., Queen's House, Kingsway, London, W.C.2, have sent us a publication describing some of the cold rolling-mill equipment installed at the Falkirk works of the British Aluminium Co., Ltd. It has been written by Mr. G. R. Wilson, B.Sc., A.M.I.E.E., chief engineer of the firm's metal-industries division, and is a reprint from the *English Electric Journal.*

Air and Gas-Drying Apparatus.—Birlec, Ltd., Tyburn-road, Erdington, Birmingham, 24, have sent us two leaflets in which are set out particulars of their Lectrodryers containing a solid, granular adsorbent material. The first leaflet, No. 49, refers to laboratory drying apparatus and the second, No. 80, is concerned with the removal, on an industrial scale, of moisture from air, gases and organic liquids.

Bronze Castings.—The composition, manufacture and application of their Taurus bronze castings for engineering purposes are dealt with in an attractive manner in a publication issued by David Brown and Sons (Huddersfield), Ltd., Park Gear Works, Huddersfield. The effect of casting methods on the macro- and micro-structure of phosphor bronze, and the microstructures of various bronzes, are shown in a series of 24 microphotographs in colour. The control and testing of bronze castings are dealt with.

Watchman's Recording Clock.—As a result of suggestions made by Scotland Yard, the Blick watchman's clock has been improved by the makers, Blick Time Recorders, Ltd., 188-190, Grays Inn-road, London, W.C.1. The watchman carries the clock with him on his rounds, visiting selected stations and recording the time at, and the code letter of, each station. The sealed record thus obtained is a means of ensuring that the watchman does not adhere to a routine which can be detected by a burglar. The makers have issued a leaflet on the new model of the clock.

Steels, Tools and Tool-room Work.—Darwins, Ltd., Fitzwilliam Works, Tinsley, Sheffield, 9, have issued a comprehensive catalogue of their products. It is in five sections dealing, respectively, with tool, alloy and other special steels; castings; permanent magnets; hacksaw blades and tool-holder bits; and machining facilities. Each section is a separate publication and the binding makes possible the addition of further sheets. All the sections are well illustrated and contain data of scientific and technical interests, as well as details intended for purchasers.

CONTRACTS.

PHILIP AND SON, LTD., Dartmouth, have received a contract from the Mersey Docks and Harbour Board, Liverpool, for the construction of a Diesel-electric pilot vessel, similar to the M.S. Sir Thomas Brocklebank, previously built by the firm for the same owners. As in the case of the former vessel, the GENERAL ELECTRIC CO., LTD., Birmingham, are the main contractors for the propelling machinery, which will consist of two 640-b.h.p. Diesel engines (to be constructed by the NATIONAL GAS AND OIL ENGINE CO., LTD., Ashton-under-Lyne, Lancashire), each driving 375-kW and 80-kW generators in tandem. These will provide power for the single-armature propulsion motor.

Among other contracts, BRITISH POLAR ENGINES, LTD., 139, Helen-street, Govan, Glasgow, S.W.1, obtained orders for twelve marine engines during June, including one of 1,500 b.h.p. for the Grangemouth Dockyard Co., Ltd., and another, of 450 b.h.p., for Cleland's (Successors), Ltd. The firm's Australian agents and Alexander Stephen and Sons, Ltd., placed orders for auxiliary engines, and the Caledon Shipbuilding and Engineering Co., Ltd., for three 300-b.h.p. 600-r.p.m. engines. An order for two engines, of 800 b.h.p. at 330 r.p.m., was received from William Denny and Brothers, Ltd., for the Diesel-electric packet boat Loch Fyne.

The BURNTISLAND SHIPBUILDING CO., LTD., Burntisland, Fife, have secured contracts for the construction of two cargo vessels, each of 10,500 tons deadweight, for the Fomentador Compania Naviera S.A., Panama. The company have also obtained an order for the building of a cargo vessel of similar deadweight carrying capacity for the Tramp Chartering Corporation, Panama. The propelling machinery in each case will consist of Kincaid-B. and W. Diesel engines of 5,500 b.h.p., to be constructed by JOHN G. KINCAID & CO., LTD., Greenock.

NEW ROOF FOR DERBY MIDLAND STATION.—The roof of Derby Midland station, which is of the overall type and remains much as it was erected to the designs of Robert Stephenson in 1839, was badly damaged by enemy action during the war. British Railways (London Midland Region) have now decided to replace the old roof by individual platform roofs of the awning type, constructed of prestressed precast concrete sections. On the two island platforms, the roof will be carried on two rows of columns, spaced at about 60-ft. centres longitudinally. The area between the columns and the edges of the platforms will be covered by a solid concrete slab about 10 ft. wide, and the space between the rows of columns will be spanned by another concrete slab at a higher level, connected to the lower slabs by glazing to form a clerestory. The main platform, No. 1, will have no columns, the cantilever roof extending from the line of the buildings to the edge of the platform, a width of about 30 ft. As the new roof would obstruct the view of the signalman in the box now situated in the centre of the station, a new signalbox will be provided. The present old type colour-light signals are to be replaced by modern equipment. It is expected that the work will be begun in the autumn. The estimated cost is about 200,000*l*.

PERSONAL.

SIR FREDERICK LEITH-ROSS, G.C.M.G., K.C.B., and MR. JEAN LOUIS, President of the Société Française des Constructions Babcock et Wilcox, Paris, have been elected directors of Babcock and Wilcox, Ltd., Farringdon-street, London, E.C.4.

MR. FRANK ARNOLD HURST has been elected chairman of SAMUEL OSBORN & CO., LTD., Clyde Steel Works, Sheffield, to fill the vacancy caused by the death of Mr. S. Eric Osborn. An obituary notice of Mr. Osborn appears on page 116.

DR. P. F. SOPER, B.Sc. (Eng.), M.I.E.E., has been appointed head of the electrical-engineering department of the Northampton Polytechnic, St. John-street, London, E.C.1, in place of Dr. J. S. Tait, whose appointment as Principal of the Woolwich Polytechnic was announced in our issue of May 18, page 595. Dr. Soper is at present head of the electrical-engineering department of the Nottingham and District Technical College.

MR. KENNETH J. HUME, B.Sc. (Eng.), at present metrology superintendent of the de Havilland Engine Co., Ltd., has been appointed head of the National College of Horology and Instrument Technology, which is situated at the Northampton Polytechnic, St. John-street, London, E.C.1. The present head of the College is Mr. R. A. Fell, who is taking up an industrial appointment.

MR. G. C. R. MATHIESON, B.Sc. (Glas.), D.R.T.C., has been appointed by Power Jets (Research and Development), Ltd., 25, Green-street, London, W.1, to be senior lecturer at the School of Gas Turbine Technology, Farnborough, Hampshire. Mr. Mathieson was formerly a senior scientific officer in the Aerodynamics Department of the National Gas Turbine Establishment, Pyestock.

MR. R. J. B. WOODHAMS, B.Sc. (Lond.), A.F.R.Ae.S., M.I.A.S., has been appointed assistant chief designer to Air Service Training, Hamble, Hampshire, which is one of the Hawker Siddeley group of companies. He will be responsible to Mr. H. W. Sidwell, O.B.E., A.F.R.Ae.S., the chief designer, for the design section of the firm's aircraft division.

MR. E. ARCHER has been elected a director of Brampton Fittings, Ltd., Brandwell-road, Oldbury, Worcestershire, which is associated with Walton and Brown, Ltd., Downing-street, Birmingham. Mr. Archer and MR. T. WATSON, the company's works director, have been appointed joint general managers.

The Consett Iron Co., Ltd., Consett, County Durham, have announced the appointment, as local directors of the company, of MR. F. B. GEORGE, manager, works development, MR. H. V. TOMLINSON, manager, works production, MR. G. M. NAVE, manager, coke, by-product and brick works, and MR. S. BATES, secretary.

MR. A. J. C. MACLEOD, A.M.I.E.E., Assoc.M.C.T., has been appointed export manager of the Lancashire Dynamo and Crypto (Mfg.), Ltd., and will operate from the company's London office, 94, Petty France, Westminster, S.W.1. He was previously the sales manager for the products of the firm's Willesden works. MR. V. W. PRESS has been appointed the company's sales manager for the London area.

MR. BARRY KAYE, Midland regional controller for the Board of Trade, has been appointed to act in the Midlands for the newly-formed Ministry of Materials. Mr. Kaye's office is at C.M.L. Building, Great Charles-street, Birmingham, 3.

MR. F. J. ERROLL, M.A., A.M.I.Mech.E., A.M.I.E.E., M.P., has removed his office to 21, Alexander-square, London, S.W.3. (Telephone: KENsington 9543.)

Appointments made recently by the London Transport Executive in the department of the chief mechanical engineer (road services) include that of MR. J. W. WICKS, M.I.Mech.E., previously assistant engineer for the development of 'buses and coaches, as works manager ('buses and coaches). MR. J. SCHOFIELD, M.C., formerly works engineer at Charlton, has been made works manager (tramways and trolleybuses). He will be responsible for the overhaul of trams and trolleybuses at the Executive's Charlton and Fulwell works. MR. N. H. CHARLES, B.Sc., M.I.Mech.E., A.M.I.E.E., formerly planning and methods engineer ('buses and coaches) has been appointed to the position of planning and methods engineer (road services-works). MR. W. D. D. BREWER, M.Com., has been appointed an officer of the Executive with the title of progress and materials superintendent ('buses and coaches). MR. L. F. HOENISS, A.M.I.P.E., has been made chief inspector (road services) and will be responsible for all engineering inspections throughout the Executive's workshops. In the department of the chief mechanical engineer (railways), MR. R. I. D. ARTHURTON, B.Sc. (Eng.), A.M.I.Mech.E., A.M.Inst.T., has been appointed a principal executive assistant in the development division and will control all work connected with contracts for rolling stock and associated equipment.

NORTH TEES "C" POWER STATION.

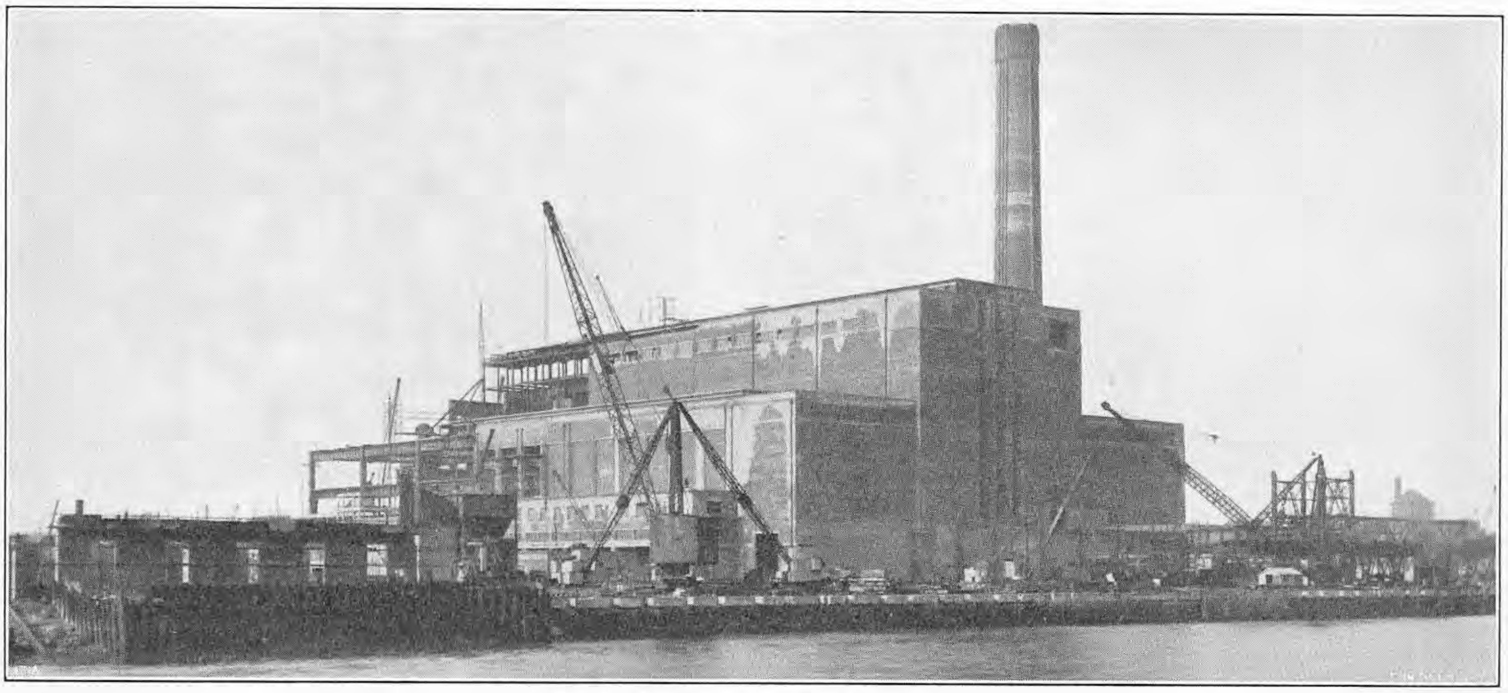


FIG. 1. GENERAL VIEW OF STATION.

NEW POWER STATIONS FOR THE B.E.A.: XXII.—NORTH TEES "C."

THE North Tees "C" station of the British Electricity Authority is situated on the north bank of the River Tees, near Billingham, County Durham, adjacent to the existing station, and is the first to be commissioned in the North Eastern Division since the war. It lies near the load centre of a large industrial area where there are good coal and water facilities. It is hoped that the first section will be in commission in the autumn; completion of the station is scheduled for 1953. The appearance of the exterior of the station is shown in Fig. 1.

Durham and Northumberland coal will be brought in by water, and provision has been made for discharging ships up to 5,000 tons burden. The coal will be conveyed either to the boiler house or to a coal store, the capacity of which will be 85,000 tons. The steam-raising plant will consist of seven Babcock and Wilcox boilers, each supplied with pulverised coal from three mills and delivering 360,000 lb. of steam per hour to the turbines at a pressure of 900 lb. per square inch and a temperature of 925 deg. F. A view of the front wall of one of these boilers under construction appears in Fig. 2. In this connection it is interesting to recall that, when the North Tees "A" station was opened in 1920, the pressure used—450 lb. per square inch—was considered high. An initial temperature of 700 deg. F. was adopted, as this appeared to be about the maximum with the materials then available; and it was regarded as a striking departure from normal practice at the time that the steam was reheated to 650 deg. F. between the high-pressure and low-pressure turbines, integral reheaters being incorporated in five of the boilers. A non-reheat cycle is, however, to be used in the "C" station.

The boilers are fitted with Ljungstrom regenerative air heaters, and the gases are cleaned in electrostatic precipitators. The ashes will be loaded into barges at the jetty, shown in Fig. 1, and taken out to sea for dumping. The generating plant will consist of four turbo-alternators, constructed by C. A. Parsons and Company, Limited, Heaton, Newcastle-on-Tyne. Each of these sets, two of which are shown under construction in Fig. 3, will have a continuous maximum rating of 60 MW and an economic rating of 48 MW, the heat rate being 9,236 B.Th.U. per kilowatt-hour. The turbines will exhaust into Vickers-Armstrongs three-pass condensers with a surface area of 57,000 sq. ft., which will be cooled with water from the river and provide a normal vacuum of 29 in.

As in the original station, generation will be at 11 kV. The three-phase alternators are to be hydrogen-cooled, and the main and auxiliary exciters will be driven through gearing. The alternators will be solidly connected to 11/66-kV Parsons transformers, and all the switching will be carried out at the latter voltage by air-blast switchgear, supplied by A. Reyrolle and Company, Limited, Hebburn, Co. Durham.

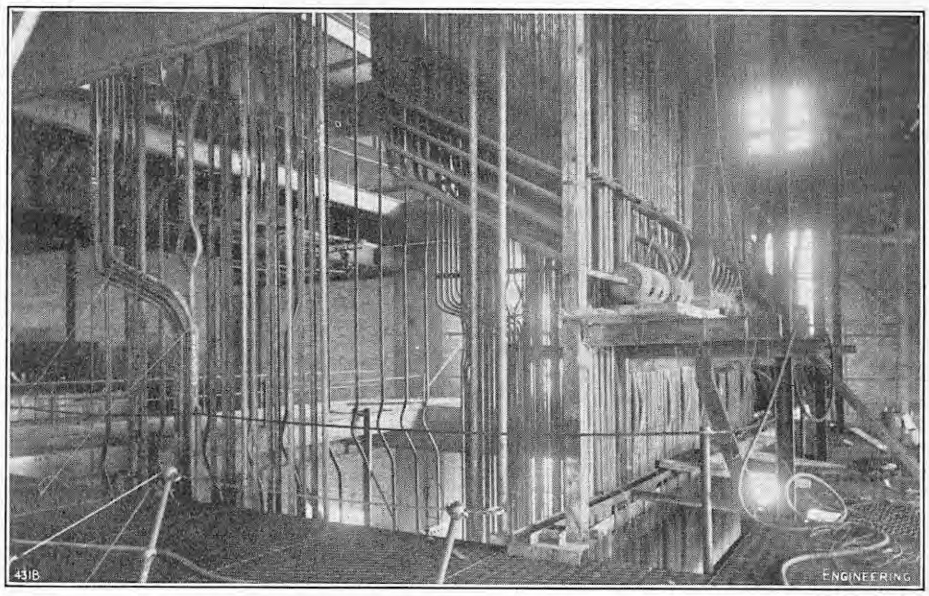


FIG. 2. CONVECTION TUBES OF NO. 1 BOILER.

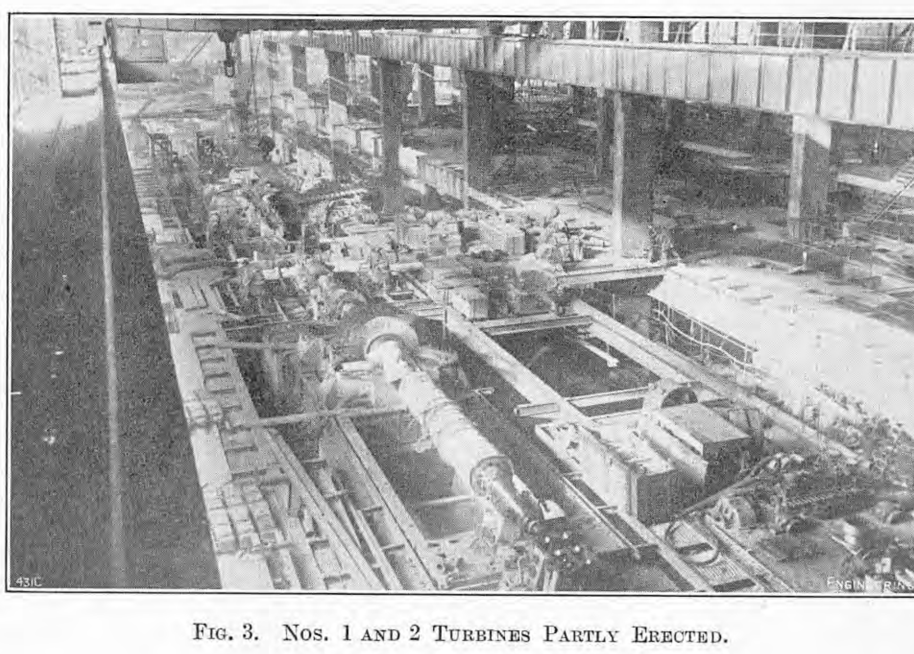


FIG. 3. NOS. 1 AND 2 TURBINES PARTLY ERECTED.

CEMENT WORKS AT SHOREHAM, SUSSEX.

(*For Description, see Page 97.*)

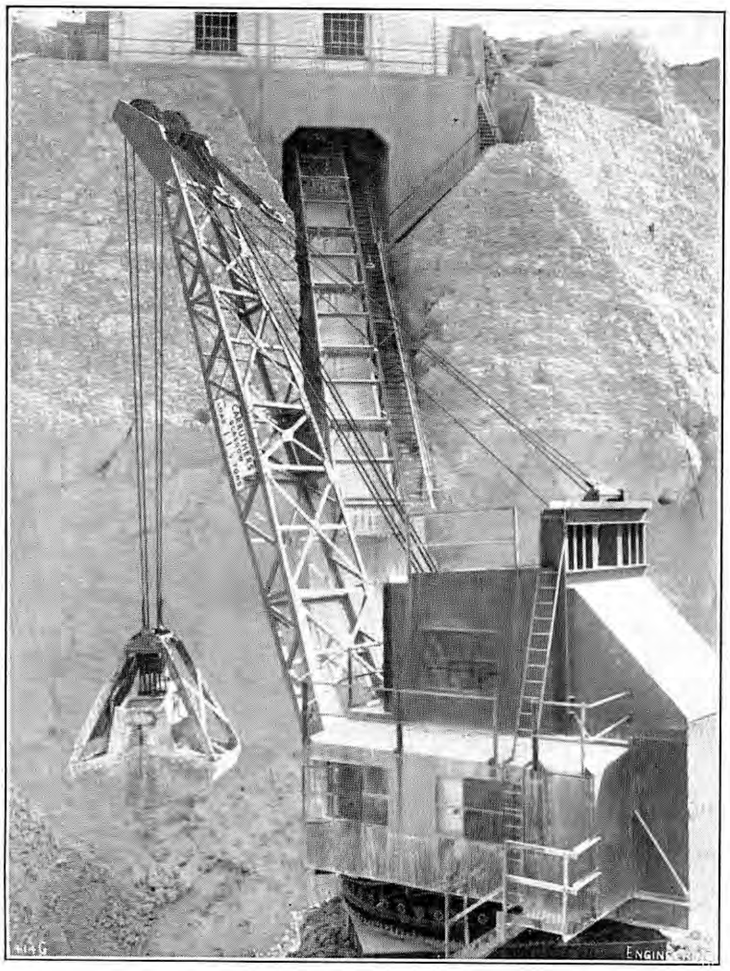
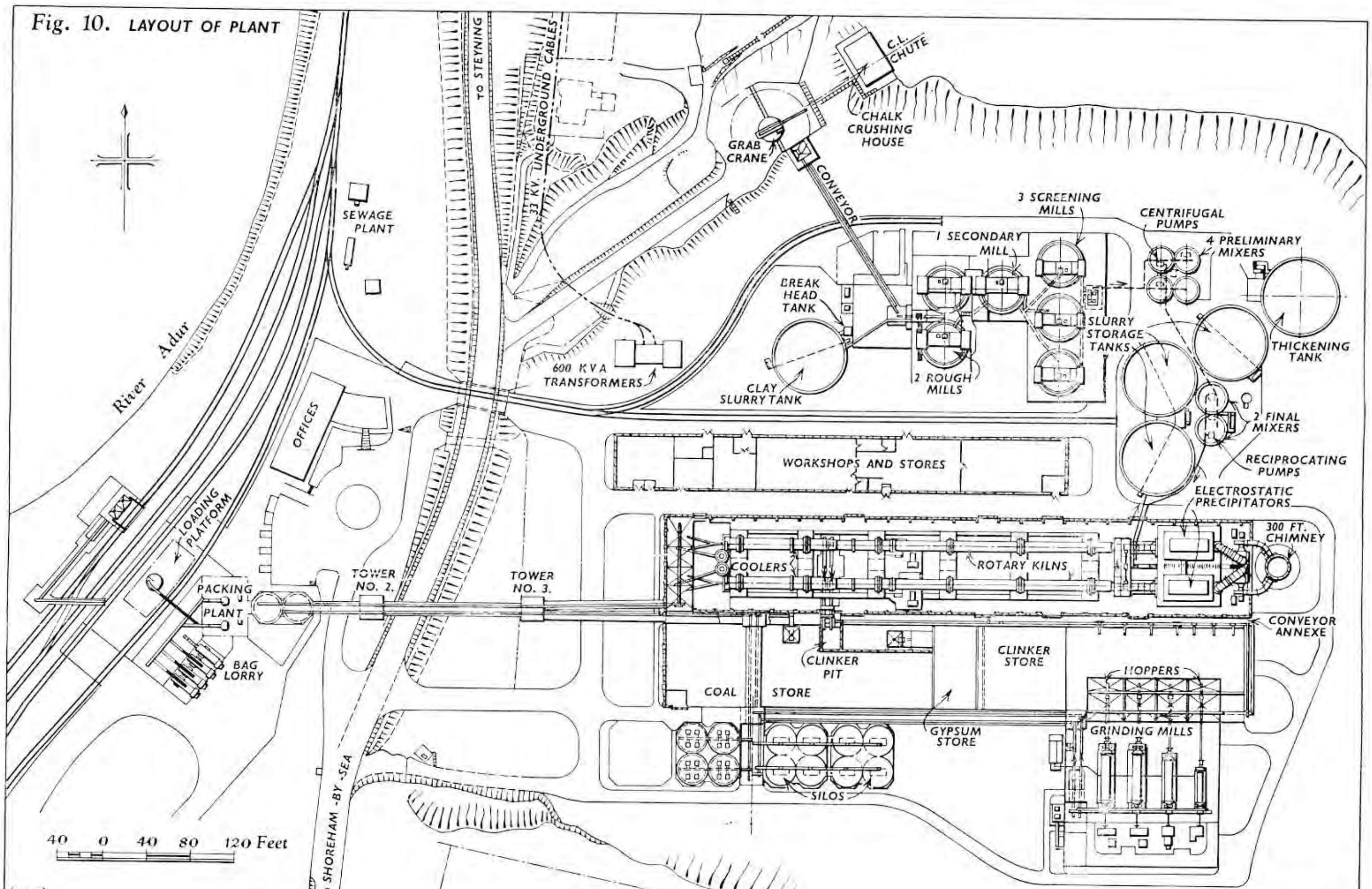


Fig. 8. Chalk Chute and Jib Crane.

Fig. 9. Hopper Below Rough Mills.



CEMENT WORKS AT S

(For Descri

Fig. 11. GENERAL ARRANGEMENT OF MACHINERY IN KILN HOUSE

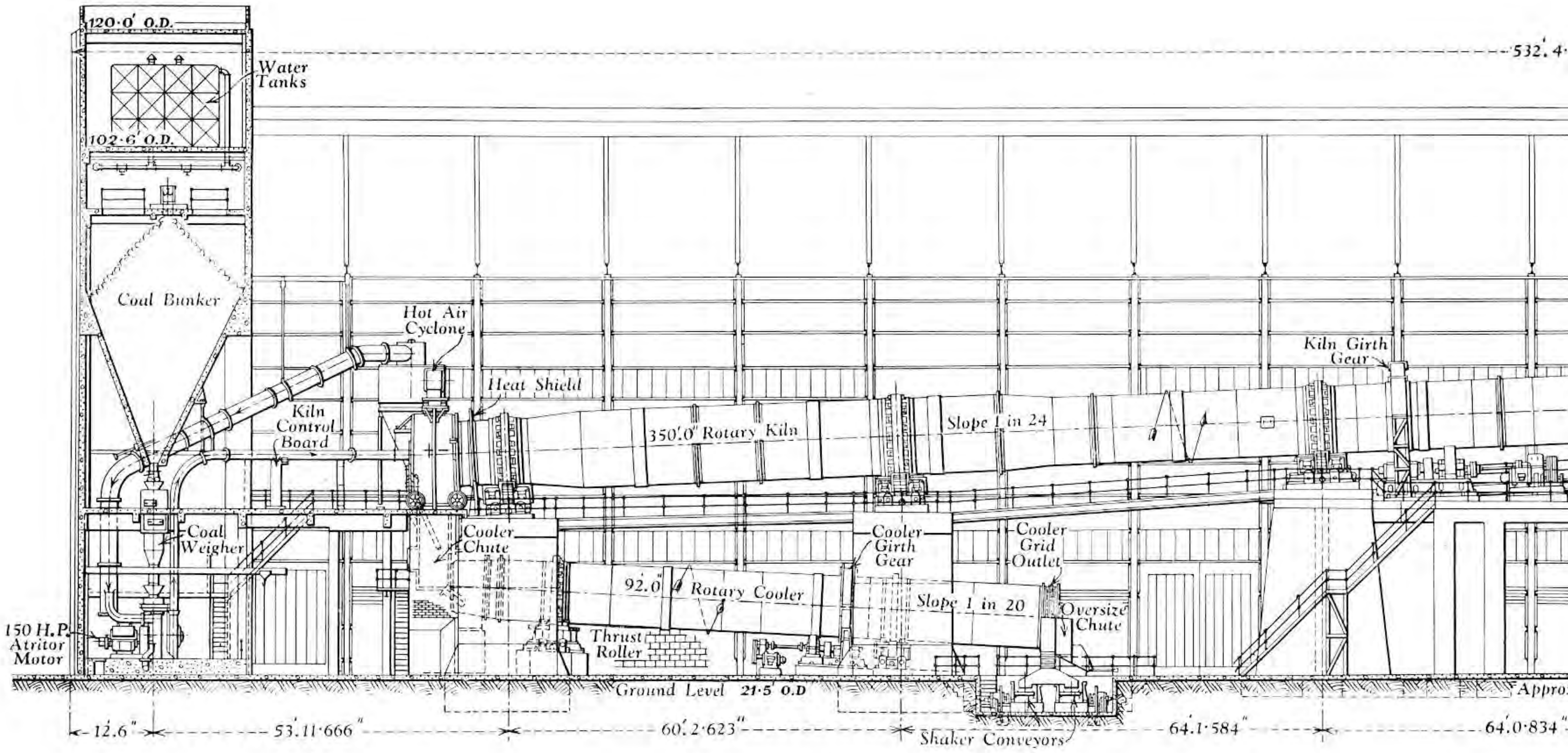


Fig. 12.

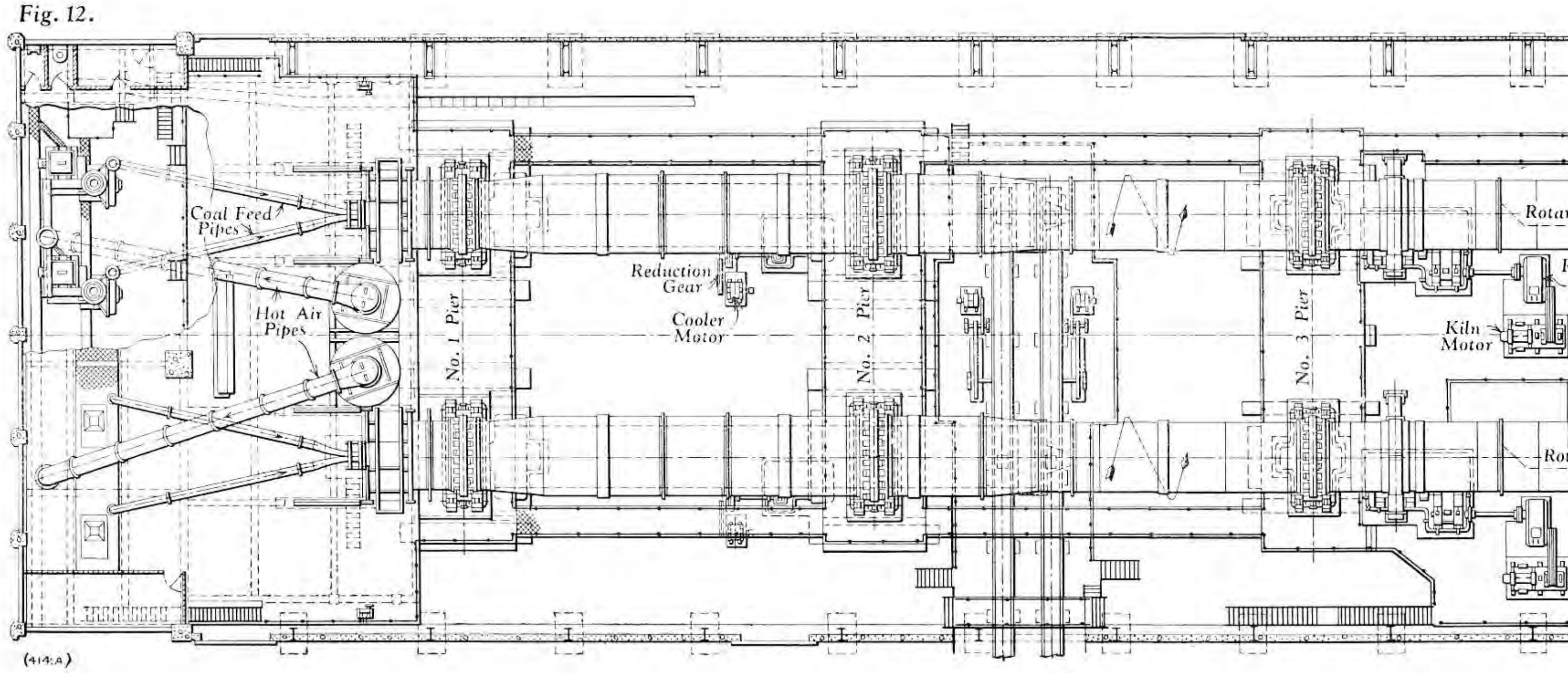
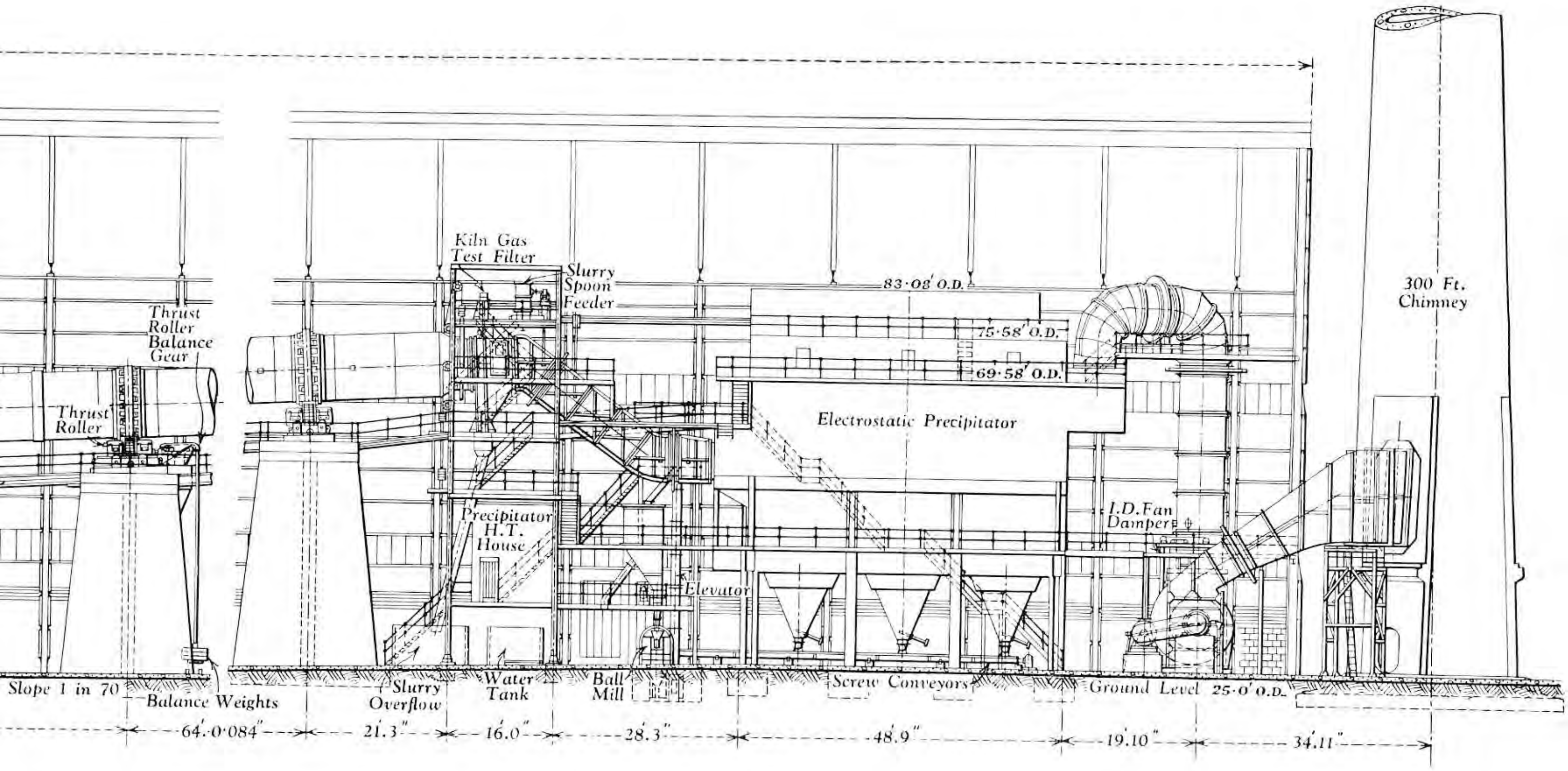


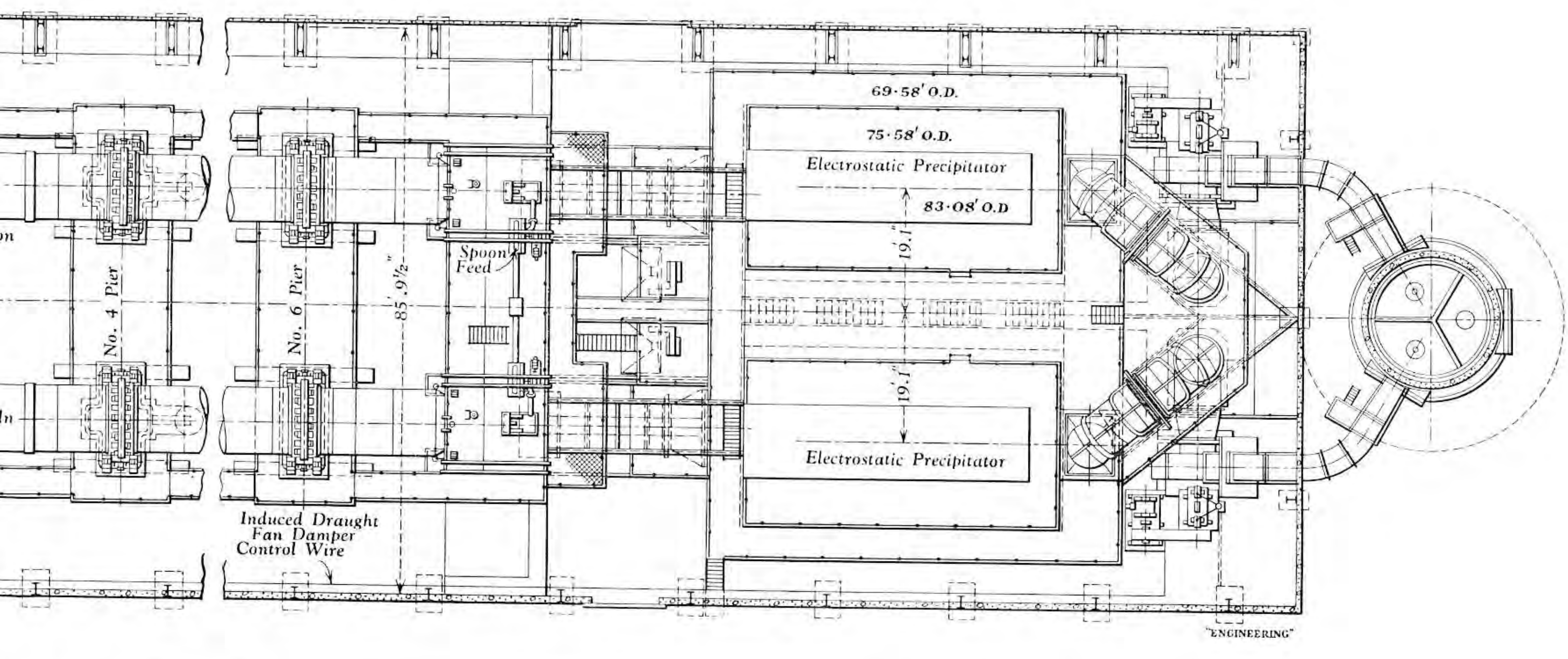
Fig. 13 Clay Excavator.

Fig. 14. Chalk Washmills.

OREHAM-BY-SEA, SUSSEX.

(...n, see Page 97.)





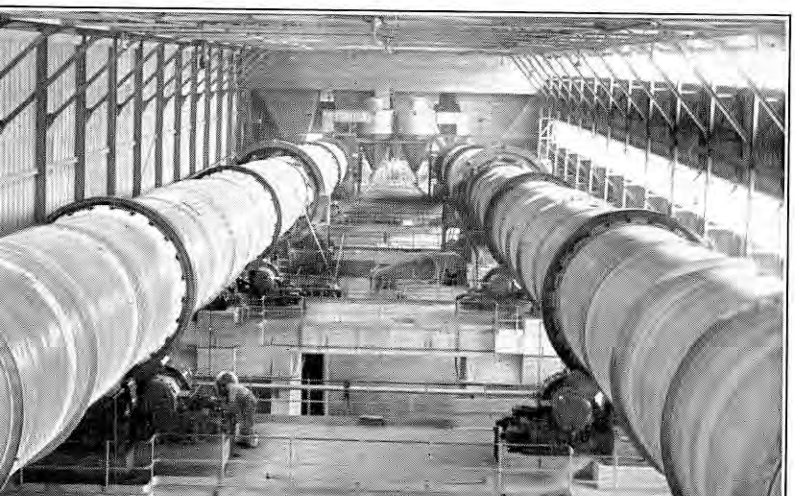


Fig. 15. Interior of Kiln House.

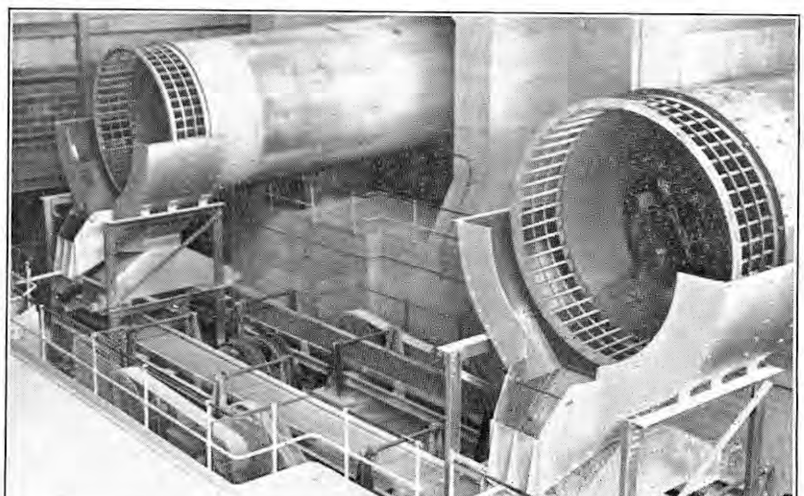


Fig. 16. Clinkers and Shaker Conveyors.

CEMENT WORKS AT SHOREHAM, SUSSEX.

(For Description, see Page 97.)

FIG. 17. INTERIOR OF STORE BUILDING.

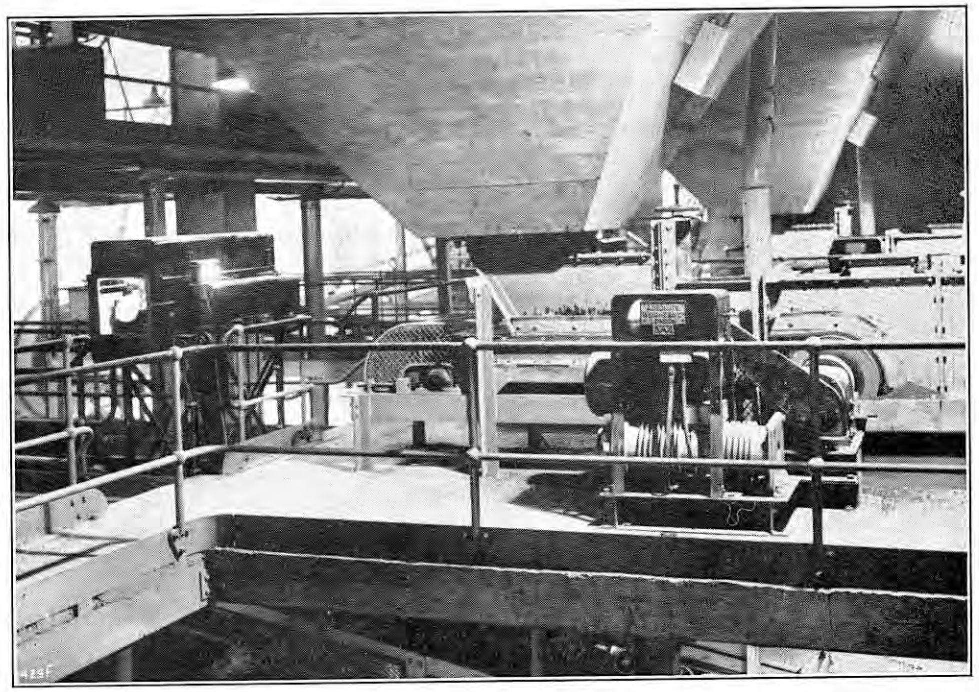


FIG. 18. GRINDING-MILL HOPPERS AND CONSTANT-FEED GEAR.

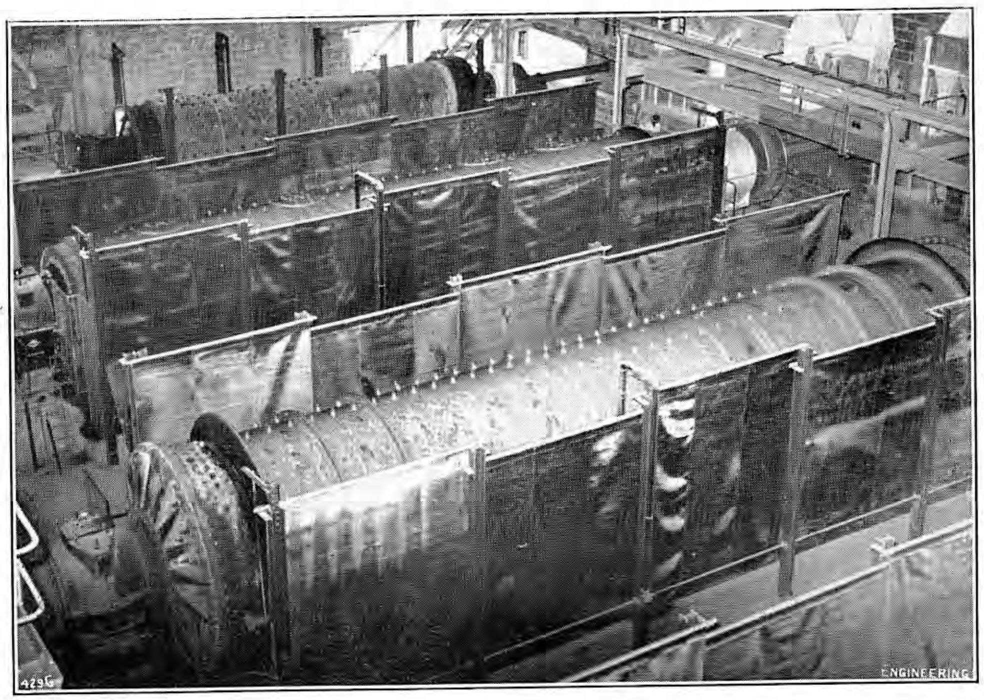


FIG. 19. GRINDING MILLS.

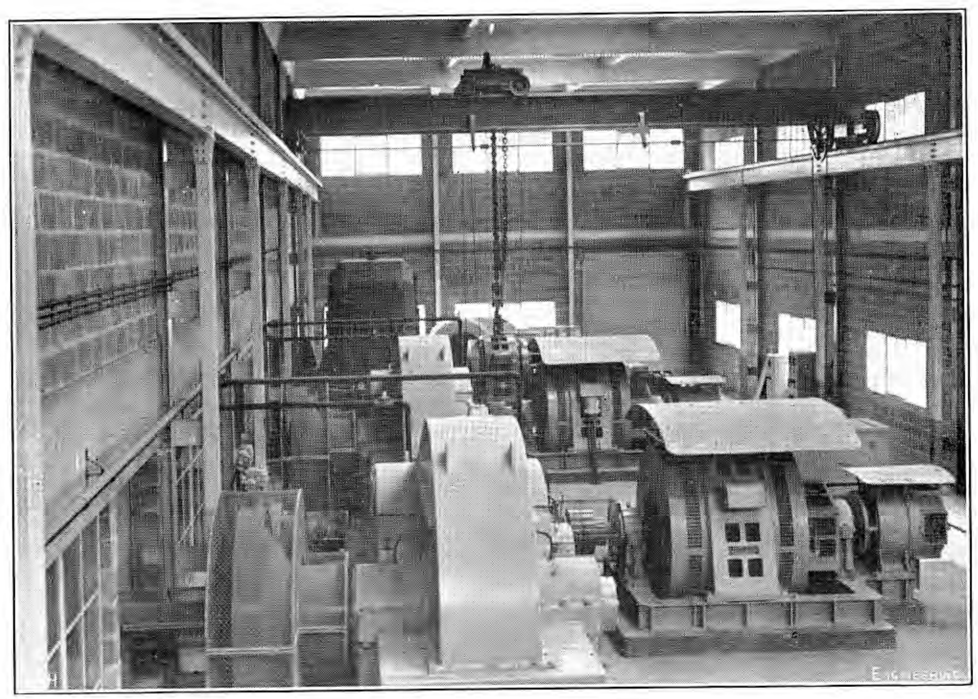


FIG. 20. GRINDING-MILL POWER HOUSE.

(*To face page* 99.)

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.

Telegraphic Address:
"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers:
TEMPLE BAR 3663 and 3664.

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

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

CONTENTS.

ENGINEERING

FRIDAY, JULY 27, 1951.

VOL. 172. No. 4461.

ATMOSPHERIC DUST AND FUMES.

THE annual reports of the Chief Inspectors appointed to carry out the provsions of the Alkali, etc. Works Regulation Act, 1906, and the Alkali, etc., Works Orders, 1928-1950, are divided into sections dealing, respectively, with registered works and unregistered processes. The former section is necessarily largely concerned with matters of interest to chemical engineers and, although gas scrubbers and other types of plant referred to are of importance in a wider field than that of chemical engineering, the section dealing with unregistered processes is probably of greater interest to engineers generally. As the Act does not apply to unregistered works, the inspectors have no power to enforce any recommendations they may make with a view to abating causes of complaint which have been referred to them. It is recorded in the report* for the year 1950 that more than 500 visits were paid to unregistered works and that owners of works seldom failed to co-operate satisfactorily in carrying out recommendations. These all concerned methods of reducing atmospheric pollution.

Although intense local interest is naturally taken in the production of dust, or offensive odours, by works engaged on processes difficult to control, it is probable that emissions from electricity generating stations have been the subject of widest public concern. Many large stations are situated in closely built-up areas in important towns, in which local opinion has ready means of expression. It is pointed out in the report that power stations in Great Britain consume annually about 30 million tons of coal, much of it of poor quality, and that the rate of consumption is increasing. There can be no doubt that, taken as a whole, the electricity-supply industry has a good record in the matter of atmospheric pollution as compared with industry generally. Matters are continually being improved by the building of stations of modern design, and, as the report says, complaints are mainly due to the older and more inefficient stations. The rate at which these are replaced is controlled by the Government's capital expenditure policy.

It is stated that, although the total weight of sulphur dioxide discharged annually from fuel-burning appliances throughout the country is very great and cannot be viewed with equanimity, the proportion contributed by power stations averages only 17 per cent., being a maximum, at 28 per cent., in the London region and a minimum, of about 5 per cent., in the South-Eastern region. Moreover, it is not established that power stations are responsible for similar proportions of sulphur dioxide in the atmosphere at ground level. A survey is being carried out under the auspices of the Department of Scientific and Industrial Research with a view to assessing the effect of power-station emissions. In view of their situations, much attention has been directed to the Battersea and Fulham stations in connection with the matter of atmospheric discharge. It is stated that at Battersea trouble was experienced by reason of the choking of sprays and in controlling the distribution of water and chalk between the two washers at the north-west and north-east chimneys, but that, during the last four months of 1950, the removal of sulphur dioxide was "more uniform and satisfactory." At Fulham, gas washing, suspended during the war, had not been resumed; but grit-arresting plant has been installed; this "has brought about a great improvement in local conditions."

The manufacture of cement is presumably a chemical process, although many of the problems connected with it fall within the province of the mechanical engineer. Cement works are registered under the Alkali Act, and the Works Order of 1950 extended registration to "works in which cement clinker is ground or cement is packed." It is stated, in fairness to the industry, that this aspect of cement manufacture had been given attention before the Order was drafted. Electrical precipitators are favoured as the most suitable means of dealing with dust-laden kiln gases. They are, however, expensive, a unit for a kiln with an output of 15 tons to 20 tons per hour now costing about 40,000*l*. Considerable supervision and maintenance are necessary and it is stated that "there is still much that is obscure regarding the behaviour of high voltage electricity when applied to gases containing nearly 50 per cent. of moisture." Works records, however, indicate fairly continuous operation, and, as far as practicable, major overhauls are reserved for periods when the kiln concerned is shut down for overhaul.

It was recorded in the Alkali Works Report for the year 1949 that high production, coupled with the difficulty of obtaining and installing new plant, resulted in unsatisfactory atmospheric conditions in the cement-producing Thames-side area. It is now stated that considerable improvement has been effected. At works on the south bank of the river the programme of improvements had been completed by the end of 1950, except for one works at which the four precipitators were out of action for complete overhaul. On the north bank, the work is completed as far as the installation of electrical precipitators for kiln gases is concerned. At one of the works in this area, a precipitator has been installed to deal with dust arising from the grinding mills; this is the first application of this kind in Great Britain. Complaints about cement works in the Medway towns have related to both smell

* *Eighty-Seventh Annual Report on Alkali, etc., Works by the Chief Inspectors. Proceedings during the Year 1950.* H.M. Stationery Office. [Price 1s. 9d. net.]

and dust. The waste gases from cement kilns have a characteristic odour to which neighbouring residents probably become inured, but the smell is greatly intensified if sulphur compounds, associated with the appearance of hydrogen sulphide in the gases, are present. The production of these offensive constituents is favoured by low oxygen content of the kiln gases and low back-end temperatures. With the legitimate object of saving fuel, chain systems are introduced into the kilns in order to recover as much as possible of the sensible heat n the gases. At times, the attempts have been "too successful" in the sense that they have brought the back-end temperature below the smell threshold. It is implied that the Medway area has had to take second place in the provision of dust-arresting plant owing to the claims of the larger Thamesside area.

The whole question of atmospheric pollution was discussed at a conference convened by the United States Ministry of the Interior in Washington in May of last year. The Alkali Works inspectorate and the Fuel Research Station were represented. There is no Federal legislation on atmospheric pollution in the United States and each city, county or State is free to make such regulations as seem appropriate for local conditions. It is clear that a system of this kind may result in the efforts of one authority being nullified by the negligence of a neighbour. This aspect of the matter is not referred to in the account of the conference given in the report. Although regulations may vary between authorities, it is stated that most of them are based on a common pattern. If carried out rigorously they impose fairly drastic controls. Dense smoke-emission from either industrial or domestic premises is prohibited. The sale, transportation or use of solid fuel other than smokeless fuel, is prohibited unless it is to be burned in a mechanically operated plant for approved design, smokeless fuel being defined in relation to its volatile content, 23 per cent. being a usual figure. Building of new furnaces or reconstruction of old are subject to prior approval of plans by a Smoke Commissioner. Emission of fly ash in greater concentration than 0·8 lb. per 1,000 lb. of waste fuel gas is prohibited. The report states that, although effective administration of these regulations obviously requires a large staff and entails substantial costs, the general impression obtained was that attempts to deal with smoke had the support of both ratepayers and industrialists.

The large section of the report which deals with chemical works of many kinds contains the statement that the whole of the chemical industry is in a very healthy state and that a wise policy of ploughing back a good proportion of its profits has placed it in a good position to meet future competition. In all, 65 infractions of the Alkali Act were recorded during the year, but in no case was it found necessary to institute legal proceedings. Suitable action by responsible owners was taken on formal recommendations being made. Considerable attention has been paid to the problems created by oil refining, an industry in process of considerable expansion in this country. Odours from oil distillation and cracking are very objectionable. The best way of dealing with the malodorous gases is by combustion, by means of which evil-smelling sulphur compounds are converted to sulphur dioxide, which is relatively harmless when discharged in a sufficiently diluted state. Such discharge must be carried out a considerable height above ground and, depending on local conditions and the relative situations of the various chimneys of a works, chimney heights ranging from 100 ft. to 300 ft. are considered to give the most satisfactory results. This seems, on the face of it, to afford a very wide margin; but it can be appreciated that much depends on individual circumstances, such as the nature of the surroundings and the direction of prevailing winds.

PAMETRADA IN 1950.

FEW research organisations can have received a more generous tribute of praise than was accorded to Pametrada in the paper on "Boiler and Turbine Testing," which Captain L. F. Ingram and Captain L. A. B. Peile contributed to the recent International Conference of Naval Architects and Marine Engineers. In the paper, the reference was chiefly to the instrument laboratory—"one of the greatest assets which Pametrada possesses . . . superlative in the production of electronic test equipment," and in which "a fine team of technicians is rapidly making a name for itself in diagnosis"; but the trend of the discussion, reported in this issue, left no doubt that the high opinions entertained of the instrument section (which Dr. T. W. F. Brown, the Director, described as the Cinderella of his organisation) extend also to the rest of the establishment. It may be of some topical interest, therefore, to summarise briefly the work of Pametrada during 1950, as recorded in the annual report for that year; prefacing the summary, for the benefit of those readers who are not directly concerned with the design of marine turbine machinery, with the explanation that the word "Pametrada" represents the initials of the Parsons and Marine Engineering Turbine Research and Development Association.

Nothing can be said, of course, of the considerable amount of work undertaken for the Admiralty, apart from the tests of a complete set of machinery for a destroyer of the Daring class; the results of those tests provided a great deal of the material in the paper by Captain Ingram and Captain Peile, and, indeed, make that paper one of the most important communications on the subject of marine steam turbines that have appeared for many years. There are, however, plenty of other items of technical interest in the report, one being the clear indication, at the outset, of the increasing extent to which member firms of the organisation are making use of it; an extension to the research house, completed in October, was fully occupied by additional test rigs before the end of the year, and, even so, some work had to be transferred to the adjacent test-bay of the Parsons Marine Steam Turbine Company. The design department prepared turbine and gearing designs for new ships to the extent of more than two-thirds of the total horsepower of geared-turbine machinery put into commission by the member firms, including such well-known vessels as the Chusan, for the P. and O. Company, the Tasmania Star for the Blue Star Line, the 28,000-ton tanker Velutina and her sister ships, and the Eva Peron and 17 De Octobre for the Argentine State Merchant Fleet. The destroyer which Messrs. Vickers-Armstrongs are building for Venezuela will have machinery based on Pametrada designs.

Two investigations of machinery troubles were also undertaken during 1950. One concerned a new set of double-reduction gearing in which "a peculiar knocking noise" was noted; it was traced to a fault in the hobbing machine on which the gears had been cut, and was duly rectified. The other investigation related to a series of large tankers, in which the one-node torsional critical speed occurred higher in the power range than had been expected, and with great severity. The design department developed a new form of torsiograph to deal with this problem, and traced the trouble to the low torque, and consequent reduced inertia effect, in the low-pressure turbine. The department was also actively engaged in the theoretical examination of improved forms of reduction gearing.

Research work undertaken or continued during the year included tests on an experimental condenser to ascertain the heat-transfer rate, the distribution of effectiveness of the tubes, and the effect of varying the velocity of the circulating water, and an examination of the flow on the steam side. A rig was being made, also, to test some small condenser elements developed by Professor T. R. Cave-Browne-Cave, in which secondary surface is provided on the water side and the flow paths on the steam side are tapered to maintain the velocity of the vapour as condensation takes place. An investigation of considerable potential importance to turbine designers related to the deflection under steam load of the diaphragms in an impulse turbine, and the stresses caused thereby. In the test rig, the diaphragm was loaded by hydraulic pressure, the deflections being measured by clock gauges and the stresses by electrical strain gauges. Most of these tests were made with diaphragms having the nozzles attached in the manner standardised in designs issued to member firms; but, arising out of this inquiry, a new type of diaphragm was developed and tested, using nozzle segments with a serrated fixing in the turbine casing. The tests showed this method of fixing to be superior to that previously used; it is expected, too, that it will be appreciably cheaper to construct. One other steam-turbine inquiry which may be mentioned, though no constructional work was done on it, sought to determine how much water could be removed from steam towards the end of the expansion in a turbine, and with what effect on the efficiency of the turbine and the erosion of the final blades.

Gas-turbine research also continued during the year with the 3,500-h.p. marine experimental unit. Fuel was first burned in the combustion chambers in the middle of April, but various modifications proved to be necessary, and these involved a month's delay. Preliminary short runs, undertaken on several occasions during the summer, indicated directions in which further detail improvements could be made, and the compressors were tested, under power from the starting turbine, in early September. In late October, the high-pressure line was brought to the self-running state. Testing continued, with intervals for further modifications, to the end of the year; and, of course, still continues. Much experimental work was also done on the design of fuel sprayers for gas turbines; on the optimum shape of vortex chambers; on control gear for gas turbines; on refractory linings; and on heat exchangers, and methods of analysing the gases of combustion. The effect of ash on gas-turbine blades received considerable attention, and preparations were put in hand to test some "very promising" refractory blading materials.

Tests of gearing and couplings form an important part of the research programme, and work was done, *inter alia*, on apparatus for investigating the pitting of discs and on problems of low-speed "scuffing," which had been causing trouble in marine reduction gears. An experimental study which made progress during the year, also, was concerned with the design of a torsio-axial pick-up apparatus for shafting. An electronic instrument was constructed for applying to a pen recorder a voltage proportional to the torsional vibration in a shaft, so as to enable the frequency and amplitude of the vibrations to be measured on either the turbine shafts, the secondary shafts, or the main shafts of marine machinery. It is stated that the device was used on the trials of the tanker Volsella "with great success." At the end of the year, a final model was in process of construction, together with a calibrating machine. Miscellaneous work included a wide variety of investigations on bearings, the conformations and materials of gland-sealing strips, and impulse and reaction blading; and the design of a single stage high-speed air turbine was completed and the first steps taken towards its construction. Developments in the instrument section included the installation of a photo-elastic analyser, work on strain-gauging equipment, modifications to electromagnetic torque-meters, and a preliminary design of a hydraulic torque-meter for a maximum torque of 5,000 lb.-ft. at a speed of 9,000 r.p.m.

NOTES.

THE TYNE TUNNEL.

ON Tuesday, July 24, the escalators which communicate with the pedestrian tunnel under the River Tyne between Howden and Jarrow were formally started by the Minister of Transport (the Rt. Hon. A. Barnes). This inauguration marks a first stage towards the completion of a scheme, initiated just over four years ago, also by Mr. Barnes, to improve road communication in a densely populated area of Northumberland and Durham. It was described in an illustrated article on page 493 of our 163rd volume (1947). The new pedestrian tunnel is 900 ft. long and has a finished diameter of 10 ft. 3 in. Its construction is generally similar to that of the London tube railways, although it is lined with concrete, covered with glazed tiling. Particular attention has been paid to the lighting and ventilation, and drainage spaces have been provided under the footway. The gradient in the main control section of 545 ft. is 1 in 500, falling towards the south, and at each end there are short lengths on a rising gradient of 1 in 15, which terminate in a level concourse 30 ft. long. The escalator shafts rise at an angle of 30 deg. from these concourses, where there are also cross connections with the 11 ft. 9 in. cyclist tunnel and with lift shafts. The entrance buildings are circular and have been erected close to the Jarrow and Howden landing stages. The main vehicular tunnel, which also forms part of the scheme, is designed to have an internal diameter of 29 ft. 3 in. and to contain a 22-ft. wide roadway, but work upon it is unlikely to be begun at an early date. It will be reached by an approach road on each side about four miles long so as to ensure easy gradients. These roads have also been planned to serve a second vehicular tunnel, if one should become necessary. They will each consist of two 22-ft. carriageways, two 9-ft. cycle tracks and two 6-ft. footpaths. The work has been carried out by the Tyne Tunnel Joint Committee of the Durham and Northumberland County Councils, the consulting engineers being Messrs. Mott, Hay and Anderson.

INTERNATIONAL WELDING CONGRESS.

A congress organised by the International Institute of Welding, at which 17 countries were represented, opened in London on July 14 with a Government reception at Lancaster House. The first of a series of technical meetings took place at Oxford on Monday, July 16, under the presidency of Professor H. E. Jaeger, President of the International Institute of Welding, when a number of interesting papers were read and discussed. In particular, a meeting at which Professor J. F. Baker was in the chair dealt with welding in bridges and structures, the communications including one by Mr. C. I. M. Cottrell, Mr. M. P. Jackson and Mr. J. G. Whitman on "Control of Cracking in the Metal Arc Welding of High Tensile Structural Steel," and one by Professor W. Soete on "Possibilities of Pre-stressing Metal Constructions." At a later meeting the welding of the wrought light alloys was dealt with under the chairmanship of Sir Arthur Smout, a paper on "British Experience in the Argon Arc Welding of Aluminium" being presented by Dr. E. G. West and another on "Recent Advances in the Technique of Electric Spot Welding of Aluminium Alloys in the French Aircraft Industry," by Messrs. J. Herenguel and M. Hollard. Recent developments in welding in Great Britain were discussed at a meeting presided over by Sir Donald Bailey, at which Mr. H. E. Lardge read a paper on "Welding on Gas Engines for Aircraft"; Dr. J. M. Robertson, one on "Welding in Relation to Gas Turbines for Use on Land"; and Mr. W. S. Atkins and Mr. E. M. Lewis one on "Developments of Design and Fabrication in Recent British Structures." On Friday, July 20, the reports of the commissions of the International Institute were presented, and on the following day the delegates were entertained to a banquet by the British Reception Committee. This was held at the Savoy Hotel, London, under the presidency of Sir William Larke, and the toast of "The International Institute" was proposed by the Lord Privy Seal (the Rt. Hon. R. R. Stokes).

THE BRISTOL "BRABAZON" AIR LINER.

On Wednesday, July 25, a number of guests, invited by the Bristol Aeroplane Company, Limited, had the privilege of travelling as the first passengers in the Brabazon Mark I air liner, which has recently had its special-category Certificate of Airworthiness extended to cover the carriage of non-fare-paying passengers. It may be recalled that the Brabazon, which was designed to a specification of the Brabazon Committee for the direct London to New York route, was described in detail in a series of articles in our 168th volume (1949). From London Airport, the Brabazon made five half-hour flights over London. The passengers were accommodated in a well-furnished cabin aft of the wing; most of the interior space of the aircraft, which is still under development, is occupied by flight-testing instruments and recording cameras. Since its first public appearance at London Airport in June last year, certain modifications have been carried out which have improved both the performance and the appearance of the aircraft. The long air-speed indicator tube on the nose of the aircraft, which was fitted to allow the air speed to be measured in a region of undisturbed airflow, has been removed, in order to facilitate the installation of a Decca Navigator system. The external mass-balance weights, said to be equivalent to the weight of three passengers, on the rudder and elevator, have been removed, and the handling qualities of the aircraft have thereby been improved considerably. The Brabazon Mark I has now completed nearly 300 hours' test flying; preliminary testing of the cabin air-conditioning and pressure system has begun, but it was evident that the system was not in operation during the demonstration flights on Wednesday. A gust-alleviating mechanism is being developed; a gust-detecting vane has already been installed in the side of the fuselage, and is undergoing response tests in flight before being linked to the ailerons. Construction of the Mark II Brabazon, which will be driven by four double Proteus propeller turbines, is proceeding; this aircraft will be fitted with a retractable eight-wheel bogie undercarriage. A fixed version of the undercarriage is to be fitted in the near future to the present Brabazon for take-off and landing tests.

THE INSTITUTION OF MINING ENGINEERS.

The annual dinner of the Institution of Mining Engineers was held this year at the University of Nottingham, on Thursday, July 5, the President, Sir Andrew Bryan, D.Sc., being in the chair. The toast, "The Institution of Mining Engineers," was proposed by the Rt. Hon. P. Noel-Baker, M.P., Minister of Fuel and Power, who thanked the President for accepting the invitation to join the National Coal Board as a full-time member. The new Coal Board, he felt, was strong and well balanced and would enter on its task with confidence. Speaking of the coal position, the Minister said that in the 'twenties the average internal consumption of coal was 167 million tons a year; in the five years before the Second World War, the average was 175 million tons, but in 1951, if the present rate of consumption continued, it would be 210 million tons. Fuel economy of every kind both at home and in industry was, therefore, an urgent public duty. In his reply, the President said that he would be leaving his present post of Chief Inspector of Mines with much regret, for he was deeply attached to the subject of health and safety in mines. Mining accidents had been decreasing for some years and, while the necessity for safety must be urged as strongly as ever, problems regarding health were emerging which also required emphasis. The problem was mainly an engineering one, namely, that of bringing down the coal in such a way that the least possible dust was made initially and of suppressing the dust inevitably made. Sir Andrew then referred to education and stressed the fact that the more use that was made of the universities and the more men who went from them into mining, the better for the industry. The toast of "The Guests" was proposed by Mr. Alan Hill, vice-president of the Institution. In reply, the Vice-Chancellor of the University of Nottingham, Mr. B. L. Hallward, M.A., said that the University welcomed the Institution, and pointed out that the new scholarship scheme of the National Coal Board had been a means of bringing new blood to the mining-engineering department of the University. Engineering, however, should, in his opinion, be developed within the universities and he thought it would be unwise to establish a purely applied-science university in this country after the pattern of the Massachusetts Institute of Technology. After praising the students who were coming into the mining-engineering department, the Vice-Chancellor said that he was disappointed that more were not coming from the public schools; the headmasters of some did not appear to know of the department's existence. He felt that this was a matter to be brought to the attention of parents, teachers and careers masters.

OBITUARY.

COL. FRANK HIBBERT, C.B., C.B.E.

WE regret to record the death, on July 12, of Colonel Frank Hibbert, C.B., C.B.E., a past-President of the Institution of Water Engineers and of the Liverpool Engineering Society, and, since June, 1934, water engineer to the city of Liverpool. He was 62 years of age.

Colonel Hibbert, who was born on June 17, 1889, was educated at the New Mills Technical School, Marple, Cheshire. His first engineering appointment was as a junior assistant on the Kinder water scheme of the Stockport Corporation, in whose service he spent ten years, eventually becoming assistant water engineer. In 1915, he was commissioned in the Royal Engineers and, by the end of the war, was in command of a Field Company, with the rank of major. For his war services, he was awarded the Military Cross. On demobilisation in 1919, he was appointed deputy water engineer to the Swansea Corporation and, five years later, succeeded Mr. G. R. Collinson, M.I.C.E., as chief engineer. In 1934, he was selected as successor to Colonel (now Sir) Jonathan Davidson as chief engineer of the Liverpool water undertaking, in which capacity he was responsible for the construction of the third pipeline from Lake Vyrnwy and a number of service reservoirs and filter installations.

In all matters connected with the development of public water supplies, Colonel Hibbert was an active participant. He was a Fellow of the Geological Society, and a member of the Institution of Civil Engineers, of the Executive Committee of the British Waterworks Association, of the National Joint Industrial Council of the Water Industry, and of the Central Advisory Water Committee to the Ministry of Local Government and Planning. He also served on the committee which prepared the report on "The Organisation of the Water Supply Industry"; and, at the recent conference of the International Union of Local Authorities, at Brighton, he presented a paper on "Water Supply from the Local Authority Angle." A keen Territorial for some 30 years, he was promoted to the substantive rank of colonel in 1935, and awarded the Territorial Decoration in the same year. In the Birthday Honours, last month, he received the C.B. for his services to the Territorial Army. He had been a Deputy Lieutenant of Lancashire for the past five years; and in 1948 was awarded the degree of Master of Engineering, *honoris causa*, by the University of Liverpool.

MR. W. LITTLEJOHN PHILIP, O.B.E.

THE Institution of Mechanical Engineers has lost a member of very long standing, and of exceptional ingenuity, by the death of Mr. W. Littlejohn Philip, O.B.E., a pioneer in the application of hydraulic power to the operation of machine tools. Mr. Philip, who was 88, had been living in retirement at Bournemouth for a number of years, and it was there that he died on July 20.

William Littlejohn Philip was born in 1863 and received his education in Aberdeen, subsequently serving an apprenticeship to engineering with the firm of McKinnon and Company. On completing his apprenticeship in 1885, he left Aberdeen for London, serving as a draughtsman with Masson, Scott and Bertram, millwrights (now Masson, Scott and Company) and afterwards as foreman in their works. Twelve months later, he was appointed manager of the engineering works of Spencer and Company, of Melksham, Wiltshire. There he spent the rest of his working life, except for four years in Glasgow, from 1898 to 1902, when he was managing director of the Mirrlees Watson Company. He had been previously managing director for four years of Spencer and Company, and resumed that position when he returned to them in 1902. Twenty years later, he retired, but was persuaded to take up his former position in 1925 and continued to hold it until 1939.

Mr. Philip's interest in the hydraulic operation of machine tools dated back to 1915, when he was engaged on the production of medium and heavy shells, and eventually he developed machines which produced an 18-pounder shell from the black bar in as little as $15\frac{1}{2}$ minutes, and a 9·2-in. shell, with a screwed-in base, in $2\frac{1}{2}$ hours. For his work during the 1914-18 war, he was awarded the O.B.E. in 1919. In 1938, when re-armament was in progress, he designed and equipped for the War Office a new factory for the production of 3·45-in. shells, in which he so far perfected his methods that the major operations could be carried out on four machines, if the interior of the shell was tooled, and only three if the interior machining was not required. In these machines, the only mechanism that was not hydraulic was the electric motor which provided the drive to the spindle. Mr. Philip gave a full description of the plant in a paper which he contributed to the Institution of Mechanical Engineers in April, 1943; he had then just completed 50 years' membership of the Institution. The paper, which was entitled "The Hydraulic Operation of Lathes for the Production of Shells," and for which he was subsequently awarded a Water Arbitration Prize, was printed in vol. 151 of the *Proceedings* (1944); an abridgment of it appeared in vol. 155 of ENGINEERING, pages 396 and 418 (1943). As an instance of Mr. Philip's ingenuity in a somewhat different direction, it may be mentioned that he designed and constructed the mechanical devices to produce the "effects" in the play, *The Ghost Train.* For a number of years after his retirement, and until comparatively recently, Mr. Philip was a member of the Benevolent Fund Committee of the Institution of Mechanical Engineers, where his shrewd judgment and genial personality will be greatly missed.

MR. S. E. OSBORN.

IN our issue of November 17, 1950, we reported the death of Mr. F. M. Osborn, chairman of Messrs. Samuel Osborn and Company, Limited, Clyde Steel Works, Sheffield; and it is with much regret that we have now to record that of his nephew, and successor in the chairmanship, Mr. Samuel Eric Osborn, who died in London on July 19, following an operation. Mr. Osborn, who was 59 years of age, was the only son of William Fawcett Osborn and a grandson of the founder of the company. He was educated at Rugby and, after serving in the 1914-18 war, returned to the family firm, which he had joined in 1910, becoming a director in 1919. He was concerned chiefly with the commercial side of the business and had travelled extensively in India and Canada in its interests. Mr. Osborn was a member of the Council of the Sheffield Chamber of Commerce and, earlier this year, was elected President of the File Manufacturers' Association. He was also active in many social and philanthropic causes and, like his father, grandfather and maternal grandfather, had served the office of Master Cutler, in which he was installed in October, 1945.

DR. J. T. BATEY.

As we close for press, we have learned of the death, on July 23, of Dr. John T. Batey, formerly managing director of Messrs. R. and W. Hawthorn, Leslie and Company, Newcastle-on-Tyne, and for many years one of the leaders of Tyneside shipbuilding. He was nearly 89 years of age. We hope to publish a notice of Dr. Batey's career in our next issue.

THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

(*Continued from page* 88.)

THE fourth paper in the Conference programme, which, with the third paper, occupied the technical session on the morning of Wednesday, June 27, dealt with "Boiler and Turbine Testing." The joint authors were Captain (E) L. F. Ingram, R.N., and Captain (E) L. A. B. Peile, D.S.O., M.V.O., R.N. Captain Peile presented the paper. Mr. James Turnbull, O.B.E., was in the chair.

BOILER AND TURBINE TESTING.

The paper opened with a consideration of the purposes of testing of machinery, which the authors classified as research-testing, prototype-testing, proof-testing and component-testing. They paid a tribute to the pioneer work and the thoroughness of Sir Charles Parsons in that field, and mentioned that, when the battleships of the Queen Elizabeth class were re-engined, the machinery space was reduced by a third, the machinery weight was halved, and the endurance at 10 knots was trebled; "especially in the case of boilers," they added, "were these advances the reward of testing." The paper then reviewed the testing facilities available at the Admiralty Fuel Experimental Station at Haslar; at the establishment of Pametrada, Wallsend-on-Tyne; the Admiralty-Vickers Gearing Research Association; the Distilling Experimental Station, Portland; the Naval Wing of the National Gas Turbine Establishment; and the Admiralty Engineering Laboratory. The most important part of the paper, however, was the description of the tests carried out on a set of machinery for a destroyer of the Daring class, undertaken by Pametrada, and the additional boiler trials at the Admiralty boiler test-house in the Clydebank shipyard of Messrs. John Brown and Company. In the Pametrada tests, the turbines, gearing, boiler and auxiliaries were assembled as they would be in the ship, and extensive trials were run under conditions corresponding to manœuvring in naval service. A certain amount of trouble was experienced, notably with distortion of the turbines, and particulars of this, and of the adjustments made, were given in the paper. There was also some overheating of bearings, and wear on the flexible couplings between the turbines and the pinions. The paper concluded with a section on gas-turbine testing by the Admiralty, the testing of gears, and the testing of auxiliary machinery. The cost of comprehensive and fully-instrumented testing was admitted to be high—about 100,000*l.* in the case of the Daring machinery tested by Pametrada; but, in the authors' opinion, it was fully justified by the improvements in performance that had been achieved, and the elimination of defects that it made possible.

The discussion was opened by Mr. J. H. King, who headed the delegation from the Society of Naval Architects and Marine Engineers, New York. He was particularly pleased, he said, to note that the authors used the term "factors of ignorance," and wished that more people would look at the so-called "factor of safety" in that light. In regard to historical aspects, he felt that the introduction of welding was a development of outstanding importance, in that it made possible the development of boilers of high-pressures. The United States Navy furnished the incentive to the development of welding by private industry, and, in 1930, gave final approval to a specification and method of welding boiler drums. The first such drums were subsequently installed in the cruisers Minneapolis, New Orleans and Astoria. Since then, all boiler drums in the United States Navy and Mercantile marine had been welded. Most development work in America had been by private industry; the Navy furnished the incentive by setting forth general requirements, but the actual development of new and advanced designs, and their construction, was done by industry, subject to final approval by the Navy Department. With regard to testing facilities in Britain, attention might be drawn to a paper in the *Transactions* of the Society of Naval Architects and Marine Engineers, Vol. 55, by Captain Edgar Kranzfelder, U.S.N., entitled "The Naval Boiler and Turbine Laboratory," as it contained a description of the U.S. Navy laboratory at Philadelphia.

The authors had mentioned the tests of the Babcock and Wilcox boiler design, which was "very similar to a boiler of which full data are available to the Admiralty." Mr. King supposed that this referred to tests conducted at the U.S. Naval Boiler and Turbine Laboratory. Boilers of that type, and at similar pressures and temperatures, were installed in a large number of United States combatant ships, and had thoroughly proved their reliability and high efficiency under war conditions. A double air-casing was provided on this test boiler and, in fact, was always used in the United States Navy; it eliminated many problems of the closed stokehold and had other military advantages. Recent tests showed that the leakage was about 3 per cent. In regard to the wetness of steam, the United States Navy specified a maximum of one quarter of 1 per cent., and had no difficulty in obtaining this steam condition. They were not much troubled with oil-fuel contamination by water; the principal difficulty had to do with the constituents of the oil, such as vanadium, sulphur and other minerals. This has been a serious problem, but considerable progress has been made with it; and there appeared to be great promise in the experimental work in hand, concerning certain additions to the fuel before burning.

Dr. S. Livingston Smith, C.B.E., Director of the British Shipbuilding Research Association, found especial interest in the section of the paper dealing with the astern and manœuvring trials of the Daring-class propelling machinery. So far as he was aware, this was the first time that such data had been published. It should convince the most sceptical of the great value of full-scale testing ashore of prototype machinery, which was the only way to obtain accurate information. Refractories presented a problem which existed in a fairly acute form in many merchant ships, and, in consequence, the British Shipbuilding Research Association were engaged in a fact-finding investigation involving the examination of boiler brickwork in a large number of merchant ships. From this investigation, they hoped to define the problem more exactly as it affected the merchant marine, with the ultimate object of improving brickwork life. The Admiralty appear to have devoted their main effort to tightening up their specification for firebricks. So far as naval boilers were concerned, this might be justified, but in the mercantile marine the questions of boiler operation (or mal-operation) and brickwork design were as important as, if not more important than, the actual material used.

The Admiralty had concluded that no advantage was to be gained by increasing the alumina content of firebricks beyond 43 per cent., though at one time they were considering the use of bricks having an alumina content of about 60 per cent. It was fortunate that they had come to that conclusion, as the material required for bricks having an alumina content greater than about 43 per cent. had to be imported. It had long been appreciated that specifications of alumina content meant little as regards refractoriness; so that it was not surprising that the latest Admiralty specifications omitted this item and replaced it by the more logical pyrometric-cone equivalent, together with more rigid specifications covering porosity and contained fluxes. He was glad the authors had drawn attention to the point that, in land generating stations, the machinery was constantly operating under practically laboratory conditions, each power station being a separate full-scale experiment. Too often marine practice was accused of lagging behind land practice; but it must never be forgotten that marine conditions called for absolute reliability. In the case of single power units, there was no standby set to switch in. The marine engineer could not shed his load and call in another station; and with naval machinery, endurance was the major requirement.

Dr. T. W. F. Brown, thanking the authors for their references to Pametrada, wished to make it clear that that organisation not only did research and development, but that a very large part of its work was the preparation of designs. Naturally, the results of the full-scale tests were incorporated in the designs produced. The instrument section, which had been mentioned, was rather a Cinderella department; but, compared with cost of a complete installation of half an engine room and half a boiler room, and the vast quantities of fuel burned, the cost of the instrument section was extraordinarily small, and it enabled investigations to be carried out while routine tests were running. In fact, it was the instrument section which allowed some of the very severe manœuvring trials to be carried out, because one of the instruments produced was an axial clearance gauge which measured differential expansion between the rotors and casing at the end of the turbine cylinder remote from the thrust block; many of the manœuvres were, in fact, controlled by the taking up of clearances. It also enabled anything that appeared to be going wrong to be put right before severe trouble ensued. The total running time of the three sets which were tested amounted to about 1,000 hours; had the machinery been installed in a vessel, that would have represented more than the circuit of the globe. It was in the light of such figures that the costs should be examined, because no one could have carried out ship trials of that duration; and, even if they had been carried out, the accuracy of the results would have been far short of that achieved in shore testing. In specific fuel consumption or water rates, the accuracy was of the order of $\pm\frac{1}{4}$ per cent. The very best that could have been achieved at sea was ± 2 per cent. Pametrada worked under the Admiralty in those trials, and he thought that the combined efforts of the Admiralty and the associations, and the other research facilities which the Admiralty used, had been worth while.

Commander (E) L. Baker, R.N. (retd.), remarking that the research facilities available were paid for by the taxpayer and the shipowners, drew attention to the benefits which accrued to those who paid for those enterprises. The taxpayer was clearly assured of the most efficient Navy that could be produced, which was not so before the recent war. Secondly, the shipowner benefited because the knowledge gained was circulated either through the people working on the various projects or by the presentation of data in technical papers. The need for lighter and more compact machinery was just as pressing in the mercantile marine as in the Royal Navy. Comparing steam and Diesel machinery, the Diesel engine saved about 25 per cent. in fuel, but it weighed about 30 per cent. more and occupied about 15 per cent.more engine-room length. At 7,500 shaft horse-power, those three factors were approximately in balance when considering the ship as a means of carrying cargo economically. The third benefit was that the Admiralty had aided the shipowner by releasing, for civilian manufacture, designs of equipment originally produced for Service needs. Radar was an obvious instance of that kind; and, so far as marine engineers were concerned, the release of Admiralty-designed oil-fuel burning equipment was most important. As one of the well-satisfied users he was extremely grateful for that wise and helpful decision; by fitting their ships with that type of equipment, his firm were saving 25,000*l*. per annum in fuel costs. The history of wear on flexible couplings was of interest, as he had two isolated cases among his ships in which wear was occurring. Both were of conventional design, one American and one British. The American design was known to be out of alignment and it was hoped that, by re-aligning, the trouble would be cured; in the British design, the trouble appeared to be associated with a secondary pinion which was causing wear on the main wheel because of lack of tip relief. It was hoped, when opportunity served, to dress the wheel and solve that problem.

Mr. M. L. Ireland thought that the authors' remarks on ship trials were somewhat discouraging; and Dr. Brown, in the discussion, has quoted an accuracy range of ± 2 per cent., which he agreed was the best that could be expected on ship trials. Fuel-oil meters, if calibrated before and after trials gave results accurate to within a fraction of 1 per cent., and the same could be said for condensate meters; that left the torsionmeter errors as the largest part. The astern tests discussed in the paper were similar to some work done in the United States. He noted that the astern runs were done from a rather low ahead power. It has been the impression in the United States, confirmed by certain tests, that the whole level of the temperatures was influenced by the ahead condition within the turbines. When starting from 100 per cent. ahead power, with the resulting temperature and pressures throughout the high-pressure turbine particularly, and then suddenly reversing and running a steady astern trial, the whole level of temperatures was higher than when starting from a low ahead power. With regard to the bearing difficulties reported in the paper, he asked whether measurements were made of the running position of the journals. He had had occasion recently to do that and had obtained some surprising results for high-speed lightly-loaded journals. They had a tendency to climb right up to the top level of the brass, well beyond the centre.

Captain Peile, replying to the discussion, said that it was a tribute to the closeness of the co-operation between the United States and Britain that results of American designs had been made available, for which British designers were most grateful. Mr. King's point about leakage from casings was particularly relevant; one of the main reasons for the decline in performance in old ships was the leakages developed in the engines after prolonged service. Dr. Livingston Smith was right in saying that the alumina content of the firebrick was the greatest bugbear. There were some very good clays abroad, but it was necessary to work with indigenous clays, and that made the problem difficult. Dr. Brown rather underestimated the expense of instrumentation; but it was worth it, because without that instrumentation they would get nowhere. In reply to Mr. Ireland, owing to the limitations in the astern trials with the Daring-class machinery, they had to start from only 10 per cent. ahead power; but long-period astern runs were unusual, and he did not think it likely that a ship would have to do a long astern run directly from full power ahead. Ship trials were valuable, but mainly from the point of view of the operator rather than the designer; they gave the operator a yard-stick. He did not think that they could rely—certainly, in naval installations, which were extremely congested—on getting sufficient instrumentation to provide a check on the real design data.

The Conference then adjourned until Thursday, June 28.

(To be continued.)

RAILWAY WAGONS FOR SPECIAL PURPOSES.—British Railways have arranged to build, at their Derby works, 32 covered hopper wagons, each having a capacity of 25 tons, for the conveyance of catalysts and sodium tripolysulphate in bulk. The transport of these substances has introduced a new type of traffic to the railway service. The catalyst is employed in the extraction of petroleum products, and sodium tripolysulphate for the manufacture of soap.

ELECTRICITY SUPPLY STATISTICS.—During June, 1951, 4,165 million kWh. of electricity were generated in the power stations under the control of the British Electricity Authority, the North of Scotland Hydro-Electric Board, and the Lochaber Power Company. This represents an increase of 10·9 per cent. over the figures for the corresponding period of 1950. Of the total, 4,077 million kWh were generated in steam stations. During the month the generating capacity was increased by 88·5 MW, bringing the total up to 14,733 MW. The overall increase during the past twelve months was 1,003 MW.

COAL PREPARATION PLANT IN BIHAR.—The General Electric Company of India, Limited, state that they have put into service recently, at the West Bokaro colliery in Bihar, what is claimed to be the first coal-cleaning plant to be erected in India. It operates on the Chance sand-flotation process, and is regarded as of particular importance to Indian industry because the Indian reserves of good-class coking coal are becoming exhausted, and what remains is unsuitable for use in the Tata blast-furnaces at Jamshedpur unless it can be cleaned. The coal is difficult to wash efficiently, but the new plant is expected to deal satisfactorily with it, and to separate it at two specific gravities, providing a coking coal of low ash-content and a boiler fuel of medium ash-content. A second plant has been ordered by the Tata Iron and Steel Company for their Jamadoba colliery.

THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

(Continued from page 74.)

THE introduction of the automatic one-man pick-up hay baler completely mechanised the collection of hay from the field and stocks of pre-formed bales are now a familiar sight in the country-side. Until comparatively recent times, it was only possible to make rectangular-shaped bales, but the development of the Roto-Baler, which was being shown at Cambridge by the manufacturers, Allis-Chalmers Manufacturing Company, Totton, Southampton, has made it possible to form rolled bales for which several advantages are claimed. The hay, for example, is rolled gently into a compact bale without cutting or bruising, and is, therefore, stored in good condition. Furthermore, the rolled bale, unlike rectangular bales, is not dependent alone on ties or twine to hold it together, as each layer of material seals and holds in position the preceding layer during the formation of the bale, and it is only necessary to keep the last layer in place by a helical wrapping of twine, which is not even knotted. It is also claimed that a rolled bale is easier to handle when being used for feeding purposes, as it can be placed in the feedrack and unrolled progressively as and when required.

A photograph of the Roto-Baler in operation is reproduced in Fig. 21, on page 118, from which it will be seen that it is towed behind, and to one side of, a standard tractor in the usual manner. Bales are formed in much the same way as a carpet is rolled up, the different processes of picking up the windrowed hay or straw, feeding it into the machine, bale forming, wrapping with twine and ejection of the finished bale, being entirely automatic, the operator's only function being to drive the tractor; no auxiliary power is necessary as the baling mechanism is driven from the tractor rear power take-off. In operation, the grass is lifted gently by a spiked picker on to a conveyor, which carries it to the press roll, where it is flattened into a wide compact "mat." From the press roll, the material passes into the forming or baling chamber, which comprises two sets of endless flexible belts travelling in opposite directions, the action of which is to roll the layer of material under pressure into the form shown in Fig. 22, page 118; this illustration shows part of the machine with a bale in course of formation. When the roll reaches the desired diameter, the flow of material is stopped automatically, and the bale is wrapped helically with ordinary binder twine before being discharged from the baling chamber.

The action of the baler will be best understood by reference to the drawings reproduced in Figs. 23, 24, 25 and 26, page 118, which show the baling chamber in diagrammatic form. As previously mentioned, the baling chamber *a* is formed by two sets of flexible belting; these are lettered *b* and *c* in the diagrams, the belt *b* being driven by the roller *d* and belt *c* by the roller *e* in the directions indicated, the idlers *f* and *g*, which are known as the upper and lower tension rollers, being free to move against springs as the size of bale increases. In Fig. 23, the mechanism is shown empty, but in Fig. 24 the crop is being fed by the feed roller and stone ejector *h* through the spring-loaded pressure roller *j* to the baling chamber *a*, the upper and lower belts travelling in opposite directions to roll the crop into the form indicated. In Fig. 25, the upper and lower tension rollers have moved from their original positions, thereby permitting the bale chamber to increase in size, and when the bale has reached the required diameter, as shown in Fig. 26, the feed is automatically cut off and the bale wrapped with twine, the trip rollers *k* and *l* subsequently moving apart to release the completed bale. All moving parts then return automatically to the positions shown in Fig. 23, ready to form the next bale.

The length of bale formed by the Roto-Baler is, of course, constant, the actual dimension being 36 in. The diameter, however, can be varied between the limits of 14 in. and 22 in., while the bale density can be adjusted from 40 lb. to 100 lb. Standard binder twine is used to wrap the bales

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, CAMBRIDGE.

FIG. 21.

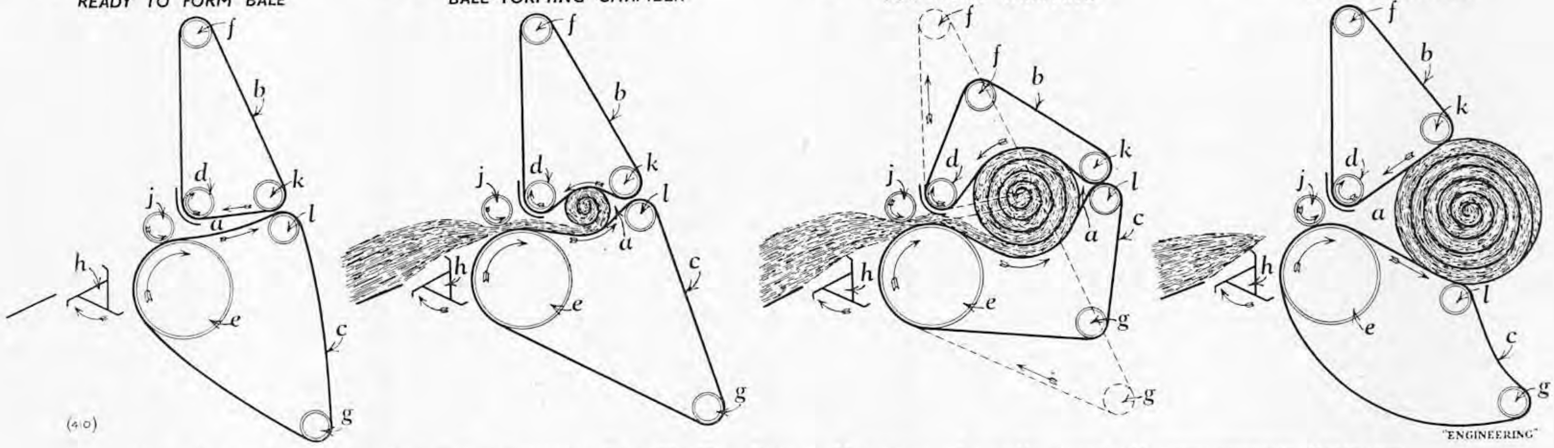
FIG. 22.

Fig. 23: BALER EMPTY READY TO FORM BALE

Fig. 24. CROP ENTERING BALE-FORMING CHAMBER

Fig. 25. BALE READY FOR TWINE WRAPPING

Fig. 26. COMPLETED BALE LEAVING MACHINE



FIGS. 21 TO 26. "ROTO-BALER" AUTOMATIC PICK-UP HAY-BALING MACHINE; ALLIS-CHALMERS MANUFACTURING COMPANY.

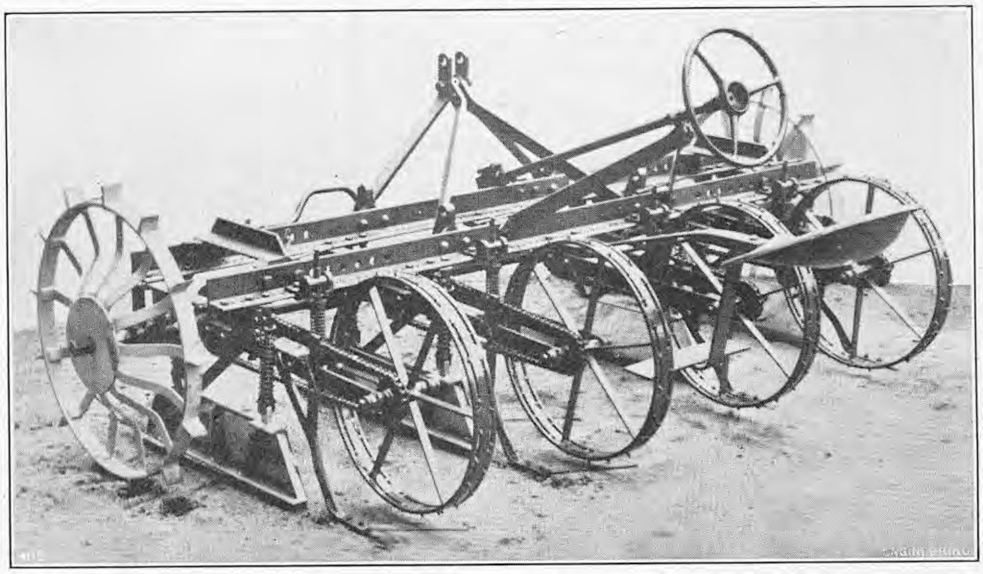


FIG. 27. MULTI-ROW BEET TOPPER; KENNETH HUDSON AND SON.

and the amount used varies from 27 ft. to 45 ft. per bale, depending on the size. It can be operated by any standard tractor capable of hauling a two-furrow plough so long as it has a rear power take-off, and the capacity is stated by the manufacturers as being from 4 tons to 8 tons per hour, according to conditions of working. In working order, the machine has a width of 9 ft. 10 in., but this can be reduced to 8 ft. 10 in. for transport purposes. The overall length is 13 ft. 6 in., the maximum height 6 ft. 11 in., and the weight approximately 2,300 lb.

Some of the exhibits on the stand of Messrs. David Brown Tractors, Limited, Meltham, Huddersfield, were described in the second part of our report on the Show which appeared on page 53, *ante*. This company were also showing a wide range of agricultural equipment designed for use behind their standard tractors and the exhibits included the two furrow one-way mounted plough illustrated in Fig. 28, opposite. This is equipped with semi-digger bodies set for 12-in. furrows and its use eliminates ridging, saves time on the headlands and, for hill farming, enables all furrows to be turned up the hill, thereby helping to conserve water and prevent erosion. As will be seen from the illustration, it is fitted with disc coulters and skims, while the width-control lever, although integral with the implement, is still adjustable from the tractor seat. Depth control is obtained by adjusting the position of the land wheel in the normal manner, the amount of adjustment available being sufficient to give any depth up to 11 in.

Other implements shown on the stand of Messrs. David Brown Tractors included a tractor-mounted beet hoe and a two-row cabbage planter. The beet hoe, which is illustrated in Fig. 29, opposite, is made to follow four-, five- or six-row drills and can be adjusted to various row widths. Each hoe constitutes a separate assembly, which can be adjusted individually for depth of operation, thereby ensuring even working despite ground undulations. It is fully steerable, making it possible to work close up against the rows, and when turning at the headlands it is possible to lift the complete implement clear of the ground by means of the tractor hydraulic linkage; each hoe assembly, however, can be lifted separately when working in shortening rows. Standard equipment supplied with the implement includes "A" blades, "L" blades and discs. Although shown on the stand of Messrs. David Brown, the hoe was manufactured by Messrs. Belton Brothers and Drury, Scunthorpe.

The David Brown two-row cabbage planter is illustrated in Fig. 30, opposite. It consists basically of an adjustable frame for row widths of from 24 in. to 30 in., and is designed to carry two seats and associated foot rests for the operators. Opening bodies make a small trench for "setting-in" the plants, and, after the plants have been placed in position, the trench is refilled by scraper plates, and the soil pressed firmly against the roots by presser wheels set at an angle. The unit has been designed primarily for attachment to the CR/3 cultivator but, by appropriate tine settings, it can be fitted to any David Brown cultivator.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

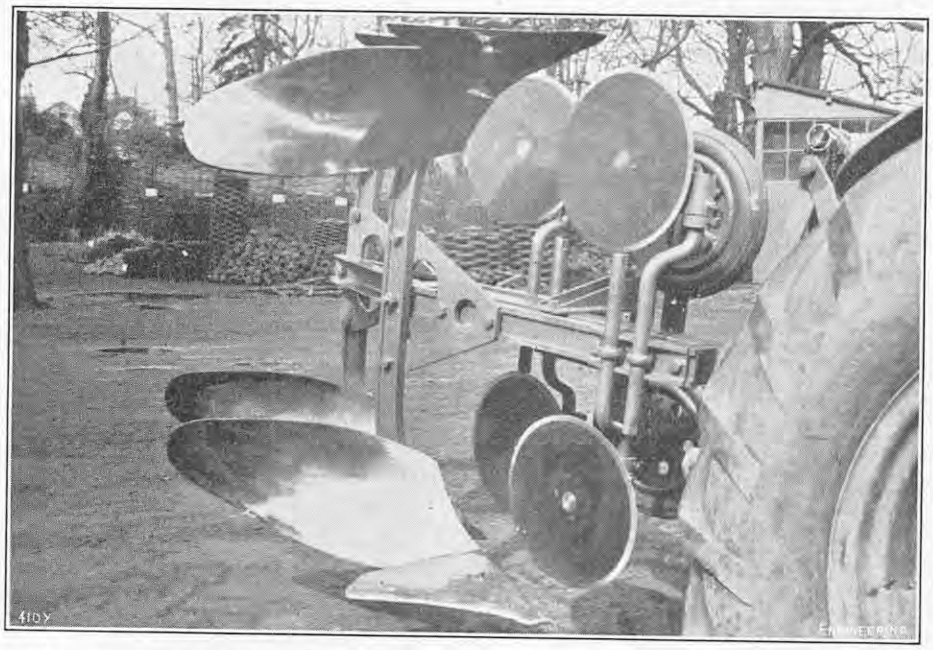


FIG. 28. TWO-FURROW ONE-WAY PLOUGH; DAVID BROWN TRACTORS, LIMITED.

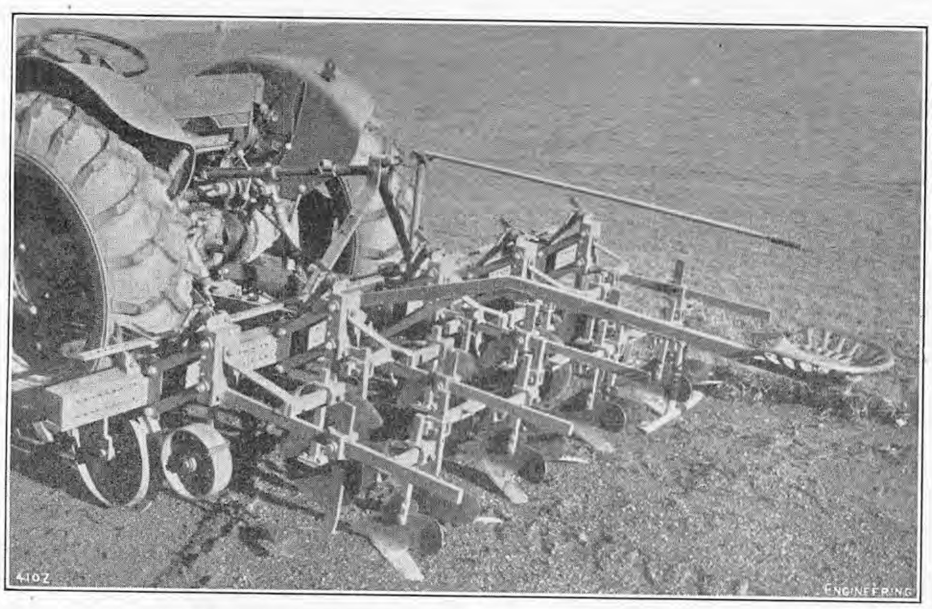


FIG. 29. BEET HOE; BELTON BROTHERS AND DRURY.

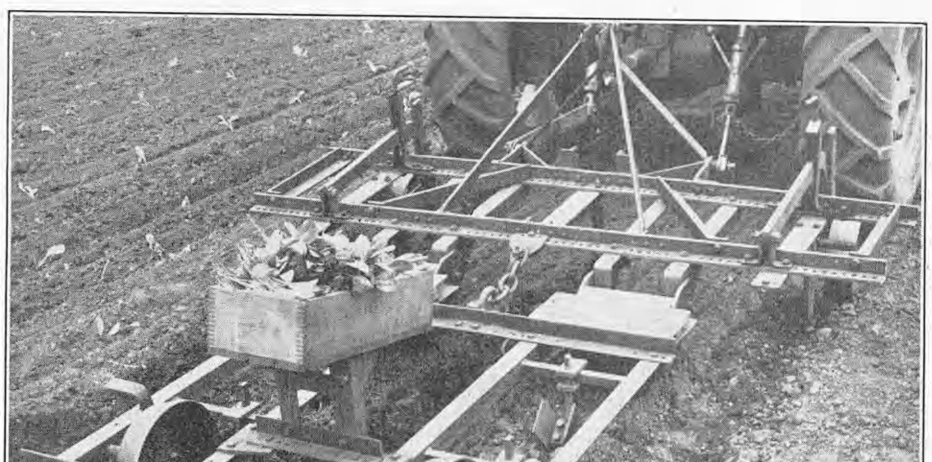


FIG. 30. TWO-ROW CABBAGE PLANTER; DAVID BROWN TRACTORS, LIMITED.

Another interesting exhibit on the stand of Messrs. David Brown Tractors was the David Brown-McConnell hedge cutter. This unit comprises a 4 ft. 6 in. cutterbar mounted on a special framework bolted to a standard David Brown tractor and driven by a Petter A1 petrol engine. The cutter-bar fingers are set at a pitch of 3 in. and the cutters are capable of cutting 2 in. thick twigs with comparative ease. The working angle of the cutter bar can be altered at will and it is possible to cut the top and sides of a hedge with equal facility.

The Ford Motor Company, Limited, Dagenham Essex, have probably done more than any other concern towards the development of power farming, and it was only to be expected that the exhibits on their stand would be centred on their well-proved Fordson Major tractor. The Ford Company have for many years adopted the policy of encouraging implement manufacturers to develop special equipments for use with their tractors. As a consequence, several of the implements exhibited fell into this category, a good example being furnished by the new multi-row beet topper illustrated in Fig. 27, opposite. This machine, which is manufactured by Messrs. Kenneth Hudson and Son, Elland, Yorkshire, has been designed for use in conjunction with the Fordson root harvester and has been fully approved by the Ford Motor Company, Limited. It is based on the Fordson toolbar and can be fitted with a steering gear and operator's seat for use when extreme accuracy is required. Each topping unit is sprung independently and the knives can be adjusted to any position to ensure precision topping, the design being such that all row widths between the limits of 18 in. and 28 in. can be worked.

The feeler wheels are independently sprung and are free to rise and fall so as to give consistent topping regardless of the size of beet, the spring tensions being adjustable either separately or together. The feeler wheels are driven at approximately twice the forward speed of the implement, so that they grip the beet top and hold it firmly for severing by the knife situated immediately behind. The drive is taken from the land wheels through a square drive shaft supported by four bearings and then by individual chains to the feeler wheels. Each knife holder is adjustable in both the vertical and longitudinal directions, the vertical adjustment presetting the topping height while the longitudinal adjustment enables the best position to be obtained in relation to the topping wheel. Specially-toughened carbon steel is used for the knives and the design is such that they can be removed easily for sharpening.

Guides are provided for raising the leaves, thereby making clear paths for the knives. They are independently sprung and completely enclosed, and are shrouded to prevent clogging by dead leaves and trash. The base of each guide is designed so that dead leaves and trash are cut clear from the sides of the beet to prevent the heel of the associated knife holder from riding on accumulated rubbish; independent springing allows each assembly to follow ground irregularities. The driving wheels are provided with spade-type lugs to ensure positive action and can be easily adjusted along the square drive shaft to allow for different row widths.

By no means all implements for use with Ford tractors are manufactured by outside concerns, as the Ford Motor Company also produce a wide range of implements in addition to the tractors. The range includes the root harvester already referred to, ridgers, spring-loaded tine cultivators and a steerage hoe, to mention but a few; examples of all these were being shown at Cambridge. Also on show was a new tractor-mounted two- or three-furrow disc plough designed for working in arduous conditions and specially suitable for use overseas. This implement, it may be mentioned, is being shown in the Country Pavilion at the South Bank Exhibition. It is of exceptionally strong construction, and, being attached to the hydraulic-lift assembly, is easy to transport and manipulate in confined spaces. Several models are available, namely, a three-furrow unit convertible to two-furrow for 10 in. or 12 in. wide ploughing, a two-furrow unit for 10 in. or 12 in. ploughing and a two-furrow unit with extra clearance between the discs, also for 10 in. or 12 in. wide ploughing. All models, however, can easily be converted either from 10 in. to 12 in. wide ploughing or from 12 in. to 10 in. wide ploughing.

The structure in each case is built up from heavy cast-steel triangular segments designed to give maximum strength. Depth of ploughing is adjusted by loosening two set screws fitted to the depth-wheel "stalk" and moving the wheel to the desired position before tightening, while the front furrow width is adjusted by loosening two bolts and sliding the cross shaft in a lateral direction. Levelling is accomplished by means of the levelling box on the three-point linkage and the pitch is adjusted by altering the length of the top connecting link. The discs, which are 26 in. in diameter, are made from hardened steel and are supported from heavy cast-steel legs by taper-roller bearings sealed against the entry of grit and dirt. The weight varies according to the type of plough, but the three-furrow 10-in. or 12-in. model weighs approximately 948 lb. and the weight of the two-furrow standard-clearance model is 796 lb.

(To be continued.)

BOOKS RECEIVED.

Symposium on the Identification and Classification of Soils. Presented at the Fifty-Third Annual Meeting, American Society for Testing Materials, Atlantic City, New Jersey, June 29, 1950. The American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price 1·65 dols.]

Christianity and Human Relations in Industry. By SIR GEORGE SCHUSTER. The Epworth Press, Epworth House, 25-35, City-road, London, E.C.1. [Price 6s. 6d.]

Die Umlaufrädergetriebe. By DR.-ING. HELMAR STRAUCH. Carl Hanser-Verlag, Leonhard Eck-strasse 7, Munich 27, Germany. [Price 7·80 D.M.]

Department of Scientific and Industrial Research. Memoirs of the Geological Survey of Great Britain. The Mesozoic Ironstones of England. The Northampton Sand Ironstone: Stratigraphy, Structure and Reserves. By DR. S. E. HOLLINGWORTH and DR. J. H. TAYLOR. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 17s. 6d. net.]

Air Registration Board. Fourteenth Annual Report. Year ended March 31, 1951. Offices of the Board, Brettenham House, Strand, London, W.C.2.

Engineering Materials Manual. Edited by T. C. DUMOND. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 36s. net.]

Elementary Electrical Engineering. By DR. ALBERT E. CLAYTON and HERBERT J. SHELLEY. Third edition. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 14s.]

Report of the Second Conference of Industrial Research Directors and Managers. The Planning and Financial Control of Industrial Research. Organised by the F.B.I. Industrial Research Committee and held at Ashorne Hill, Leamington Spa, Warwickshire, 10 to 12 November, 1950. Federation of British Industries, 21, Tothill-street, London, S.W.1. [Price 3s.]

Your British Railways. 1951. The Railway Executive (British Railways), 222, Marylebone-road, London, N.W.1. [Price 2s. net.]

Department of Scientific and Industrial Research. Technical Information and Documents Unit. Report No. RMS-2. *A Bibliographical Survey of the Development and Use of Substitute Materials for Non-Ferrous Metals and Alloy Steels in Germany.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]

1950 *Supplement to Book of ASTM Standards, Including Tentatives.* Part I. *Ferrous Metals.* Part 2. *Non-Ferrous Metals.* Part 3. *Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, Soils.* Part 4. *Paint, Naval Stores, Wood, Adhesives, Paper, Shipping Containers.* Part 5. *Textiles, Soap, Fuels, Petroleum, Aromatic Hydrocarbons, Antifreezes, Water.* Part 6. *Electrical Insulation, Plastics, Rubber.* The American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price, each part, 3·50 dols.]

ASBESTOS CONSUMPTION IN THE UNITED STATES.—Returns for 1950, recently published by the United States Bureau of Mines, show that the domestic production of asbestos in that year contributed only 41,358 short tons towards the total apparent consumption of 728,786 short tons. Imports, mainly from Canada, were 705,253 short tons, which is stated to be a record amount.

LABOUR NOTES.

THE concern of the trade unions at the constantly increasing cost of living was clearly reflected in the list of motions to be presented for discussion at the fiftieth annual conference of the Labour Party, which will open at Scarborough on October 1. It is noteworthy that in the list of motions to be dealt with there are no fewer than 134 on wages, prices and profits. The agenda, which was issued last Monday, also contains 37 motions on the Government's rearmament programme and 27 on various aspects of the national health insurance scheme. The Amalgamated Engineering Union has put forward a motion expressing strong approval of the Government's proposals for imposing economic controls, in view of the "alarming increase" in the cost of raw materials. The same Union demands that immediate action shall be taken to deal with distribution costs, profit margins and purchase tax, and pleads for a more realistic cost-of-living index. The Union contends that the index should be based on the present-day expenditure of working-class households.

A motion proposed by the National Union of Tailors and Garment Workers calls for the reintroduction of such controls as may be necessary to avoid any further worsening of the purchasing power of wages. Five other unions, representing vehicle builders, draughtsmen, boiler makers, builders, and plumbers, have sponsored motions on various aspects of the wages, prices and profits problem. Their demands include an extension of price controls, strict limitations on profits, a capital levy, a new form of cost-of-living index, and a wider range of utility goods. Altogether, motions dealing with the nationalised industries number 21 and many of these clamour for an increase of employees' representation on the various Boards and Executives. No fewer than 14 motions call upon the Government to introduce a capital levy or some other form of tax on capital. A number of motions suggest that State pensions should be increased, possibly to 40s. a week for single persons.

Economic problems were discussed at a private meeting of the trade-union group of Members of Parliament at the House of Commons on Monday last. About a hundred members were present at the meeting, which was addressed by the Prime Minister and Mr. Hugh Gaitskell, the Chancellor of the Exchequer. The main object appears to have been to afford the trade-union members some opportunity for expressing their views on the economic situation prior to yesterday's debate. It is understood that the discussions centred mainly round the increasing cost of living and the methods which the Government might employ to reverse the spiral, or, at all events, to halt its upward trend. As is usual on occasions when rising prices are under consideration, suggestions seem to have been made for the imposition of further controls, dividend limitations, and increased subsidies on food. In a general way, the trade unions and their officials appear to be mainly concerned at the present time with how to halt the rising cost of living, while, on the other hand, the Government is anxious to improve production in all branches of industry, curtail the demands of the unions for increased wages, and obtain greater freedom of movement for the transfer of man-power from industry to industry, and from place to place, according to where the need is most urgent.

The demands of the Post Office Engineering Union for wage increases in respect of some 50,000 of its members in the engineering, supplies and motor-transport sections of the postal services were considered at a meeting of the Civil Service Arbitration Tribunal in London on Monday last. The Union asked for increases varying from 16s. a week for labourers to 30s. a week for technicians with more than one year's service. Larger increases were also claimed for technical officers in the higher grades. It was stated on behalf of the Post Office that the increases demanded, if granted in full, would cost 5,250,000*l*. in a full year. The wage bill of the men concerned amounted to 19,500,000*l*. annually at the current wage rates, so that the sums claimed represented a projected increase in wages of 21 per cent.

The deputy general secretary of the P.O.E.U., Mr. C. H. Kilby, claimed on behalf of the men that the real value of wages had fallen very considerably since 1946, when wages for the grades concerned were last settled. He suggested to the Tribunal that the wages in the Post Office were substantially lower than those obtaining in many parallel industries, although the employees in the postal services were frequently called upon to exercise a much higher degree of skill and versatility than was required from those engaged elsewhere. The Union rejected some time ago an offer of smaller increases than those claimed and decided to refer the question to the Tribunal. The hearing was concluded and the findings of the Tribunal will be made known at a later date.

Suggestions made recently by the Ministry of Fuel and Power that miners should resume Saturday work in August, in view of the decline in the production of coal, were referred by the National Union of Mineworkers to its area organisations for discussion. The British coalfield conference, summoned a few months ago to consider this question, decided that the working of voluntary shifts on Saturdays should cease during June, July and August, and not be recommenced until Saturday, September 1, in order that the miners might have a chance to recuperate after their months of Saturday working earlier this year. The national executive of the Union met in London yesterday to consider the voting in the areas on this subject.

It is known that the South Wales and Scottish areas of the N.U.M. are opposed to the resumption of Saturday working earlier than the date decided upon by the coalfield conference. At a delegate conference of South Wales miners at Porthcawl on Monday last, it is understood that the plan to resume working on the four Saturdays in August was rejected by a substantial majority. The area President, Mr. Alfred Davies, stated after the meeting that the delegates were of the opinion that the interests of the industry and the men would be served best if there was no interference with the three months' relaxation from overtime. If, however, it should be disclosed at the meeting of the national executive that there was a majority in favour of an earlier resumption of Saturday shifts, he had no doubt that South Wales miners would fall into line.

A very similar attitude was adopted by the executive committee of the Scottish area of the N.U.M. at a meeting in Edinburgh on Monday. The President of the Scottish area, Mr. Abe Moffat, stated subsequently that the Scottish executive committee had decided to reject the proposals to resume Saturday shifts prior to September, as they considered that there should be no modification of the decision taken at the special coalfield conference last April, except at a further coalfield conference, at which the local branches could express their opinions. A delegate conference for the area would be held in Edinburgh on August 13 and the question of an earlier resumption of Saturday working would be added to the agenda. By Wednesday, it became known that the various areas of the Union were fairly equally divided on the question. In addition to the South Wales and Scottish areas, Cumberland, Northumberland, Durham, Nottingham and Somerset were stated to be opposed to the scheme, and the Midlands, North Wales, Yorkshire, Derbyshire, Leicestershire, Lancashire and Cheshire areas in favour of it.

A go-slow movement among technicians and supervisors in the employment of British European Airways at Renfrew, Northolt and Jersey, which commenced on July 19 as a result of claims for increased wages, came to an end on Wednesday, when normal working was resumed. The dispute arose when demands by the men's union, the Association of Supervisory Staffs, Executives and Technicians, for an increase of 10 per cent. for airways staff in the provinces, and of 15 per cent. for employees in London, were refused. Counter offers of lesser amounts by the British European Airways and the British Overseas Airways Corporation were rejected by the Association. The claims were presented to both organisations but only men employed by the B.E.A. took part in the go-slow movement. A large number of the continental services of the B.E.A. soon became disorganised as a result of the men's work-to-rule methods and it was estimated, when the settlement was announced, that the dispute had caused the loss to the B.E.A. of some 70,000*l*. of revenue, between 30 and 50 flights having had to be cancelled each day

Mr. Alfred Robens, the Minister of Labour, intervened in the dispute early this week. He took part in discussions with representatives of the two Corporations and the A.S.S.E.T. on Tuesday regarding the men's wage claims, and the two sides undertook to resume direct negotiations immediately. After a joint meeting of some hours' duration, it was announced that agreement had been reached between the two Corporations and the Association regarding the working arrangements and remuneration of the airways' staffs. The actual terms of the agreement were not disclosed and a further joint meeting between the parties was held yesterday to settle outstanding points and to sign the final agreement. Nearly 500 men at the three airports concerned took part in the work-to-rule movement. Owing to the large number of aircraft awaiting overhaul when the settlement was reached, it was estimated by the B.E.A. that several days must elapse before the Corporation would be able to resume the full working of all its Continental services.

RESISTANCE EXPERIMENTS ON THE "LUCY ASHTON."

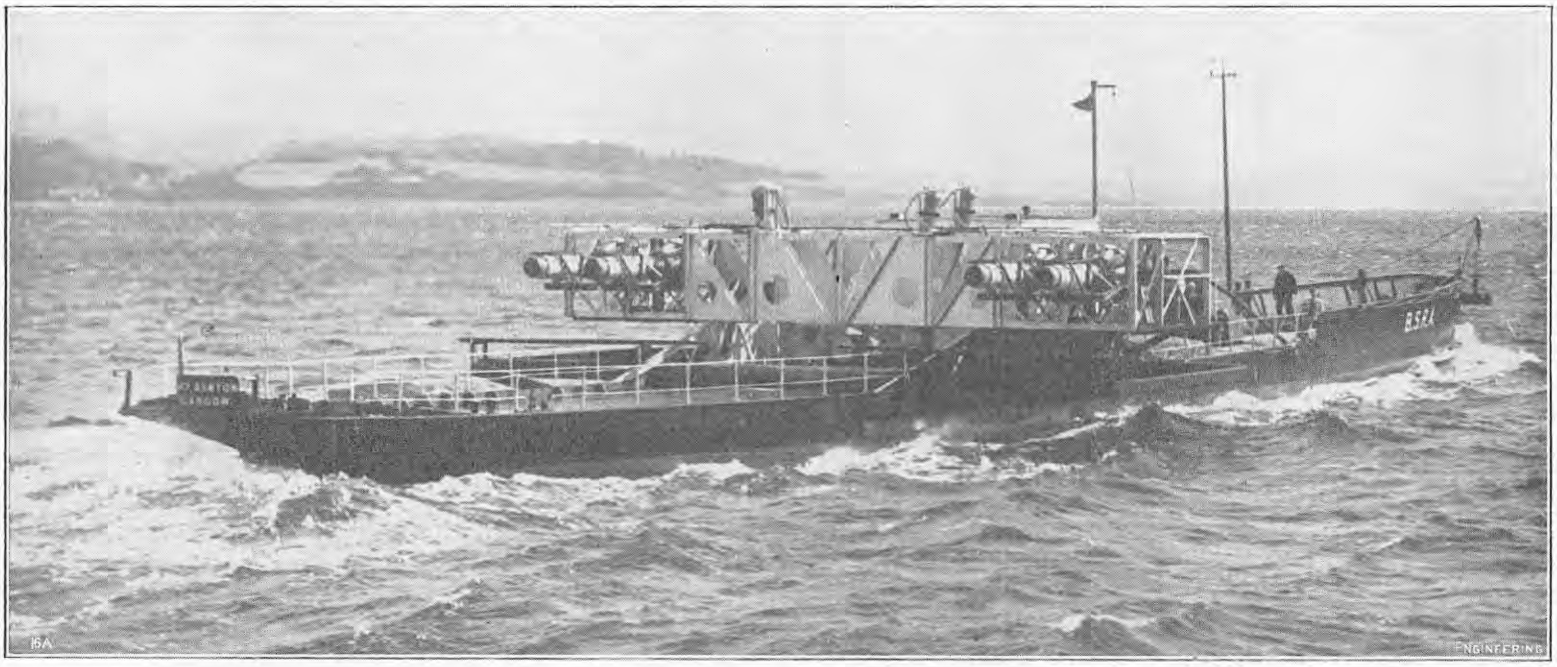


FIG. 1. VESSEL AS MODIFIED FOR EXPERIMENTS.

RESISTANCE EXPERIMENTS ON THE "LUCY ASHTON."*

By SIR MAURICE E. DENNY, Bt., K.B.E.

FOR many years I have hoped that I might see the day when full-scale resistance tests should be carried out on the hull of a ship. It is, therefore, with peculiar pleasure that, on behalf of the Council and as chairman of the Research Board of the British Shipbuilding Research Association, I have the honour to present this paper to the Institution of Naval Architects for reading and discussion at the International Conference of Naval Architects and Marine Engineers, 1951.

The purpose of this first paper is to give a general review of the scope of the full-scale resistance experiments carried out on the former Clyde paddle steamer Lucy Ashton by the British Shipbuilding Research Association and to state the underlying aims and objects of the work. The paper deals primarily with the full-scale research carried out on the ship. A second paper will deal completely with the correlation of the full-scale resistance with that of models tested in experiment tanks.

A surface vessel in steady motion through the water experiences resistance due to the friction of the water on the surface of the hull (usually known as "skin friction") which varies in a regular manner with speed, is influenced relatively little by proportions and fineness and depends primarily on the area, length and roughness of the wetted surface; to the generation of surface waves, which manifests itself in the form of normal pressures on the hull, is usually known as "wave-making resistance," and generally varies in an undulatory manner with speed, due to interference of the bow and stern wave systems; and to energy losses due to the formation of eddies. In a well-designed hull this component of the resistance is generally small compared with the skin friction and wave-making components. Froude recognised that the skin-frictional and wave-making resistances followed different physical laws and, in his law of comparison, enunciated that the "residuary resistance" (i.e., the total resistance less the skin-frictional component) for geometrically similar ships and models would vary as the cube of the linear dimensions at "corresponding speeds." The corresponding speeds were defined as those which are proportional to the square roots of the ship's linear dimensions; or, to put this into the simplest language, in comparing geometrically similar ships, or ships with models, the residuary resistance per ton of displacement would be the same at the same value of the speed-length ratio $\frac{V}{\sqrt{L}}$, V and L being the speed and length of the ship or model, respectively. Froude based this on formulæ and coefficients derived from his experiments on the surface friction of plane surfaces towed in an experiment tank. These experiments form the basis of the skin-friction corrections published by his son, R. E. Froude, in the form of the well-known "O" values.

To verify his law of comparison, Froude, with Admiralty assistance and co-operation, arranged and carried out full-scale resistance tests on H.M.S. Greyhound in 1874, which was towed from an outrigger fitted to a larger vessel, H.M.S. Active. These important experiments were the first of their kind to be made on a full-size ship and the details of the investigation and the results are given in Froude's paper to the Institution of Naval Architects in 1874. The results of these trials were not entirely conclusive so far as proving the law of comparison was concerned, in that the measured ship resistance was appreciably higher than that predicted from the resistance of the model. Froude ascribed this discrepancy, however, to an increase in the skin-frictional resistance set up by the deteriorated and roughened condition of the copper sheathing of the Greyhound. He found that by augmenting his estimated smooth skin friction for the ship by some 30 per cent. to allow for the roughened surface, good agreement was obtained between the actual ship resistance and that predicted from the model, and he was satisfied that his law of comparison had, to all intents and purposes, been vindicated.

Very few other experiments of this nature have been attempted. The store of knowledge relating to model experimental technique, the conclusions drawn and the important practical deductions therefrom have rested securely upon the foundations laid by William Froude.

Recent years have witnessed new developments in the practice of model testing. The fitting of trip wires or other turbulence-stimulating devices has become fairly general, and the desirability of introducing new methods of making the skin friction correction between models and ship is being considered. It has also become increasingly clear that the quality and condition of the surface in contact with the fluid is of paramount importance. For these reasons, it was considered that the time had come when measurements of actual ship resistance might again be usefully attempted.

When it became known that the hull of the Lucy Ashton was to be sold for breaking up, arrangements were made to purchase the hull with the object of carrying out resistance measurements. Examination of the hull showed that its proportions and fineness, etc., were suitable for the purpose in mind. It was estimated that, at a speed of 15 knots, the resistance would be of the order of $5\frac{1}{2}$ tons, which was of manageable proportions, though it was recognised that 15 knots was an uneconomic speed for the ship in service. Further, the Reynolds number at 15 knots was reasonably high, of the order of $3{\cdot}75 \times 10^8$, which would enable a most valuable comparison to be made with predictions from model tests under a fairly high degree of extrapolation.

Accurate values of ship resistance over a wide speed range enable extremely valuable comparisons to be drawn between these resistances and the corresponding values of resistance deduced from model tests. Such comparisons would clarify the relative merits of the various methods for calculating the skin-friction correction between model and ship. There are also attractive possibilities in ship resistance tests of assessing the effect of fairing seams and butts, different ship surfaces, paint deterioration, of determining the resistance of appendages, and of obtaining virtual inertia factors from acceleration and retardation tests, etc. A programme of full-scale research was prepared as follows:—

Resistance tests over a range of speeds from 5 to 15 knots in the following conditions:—

1. Clean naked hull, having a red-oxide paint surface and sharp seams.

*2. As (1), but with a bituminous aluminium paint surface.

3. Clean hull, with red-oxide paint surface and dummy twin-screw bossings.

4. Clean hull, with red-oxide paint surface and dummy twin-screw "A" brackets and shafts.

5. Clean naked hull having a red-oxide surface and seams faired off with a plastic composition.

*6. As (5), but with a bituminous aluminium paint surface.

7. Naked hull with bituminous aluminium paint surface allowed to foul for about one month.

8. Acceleration and retardation tests, to be carried out as opportunity offered.

At the time of writing, the full-scale programme has been largely carried out. In conjunction with this, comparable tests are being carried out on a series of geometrically similar models in an experiment tank. There will be six model sizes in all, ranging in length from 9 ft. to 30 ft.

The Lucy Ashton was originally a Clyde paddle steamer and plied her trade as a passenger ferry almost without a break since she was first put into service in 1888. She was built in that year by T. B. Seath and Company, of Rutherglen, near Glasgow, and was engined in the first place by Messrs. Hutson and Corbett. Later she was re-engined by A. and J. Inglis, Limited, in 1902. At the time of her retirement from service in 1949 she was the oldest railway steamer plying on the Clyde.

For reasons which will be explained later, propulsion by means of aircraft jet engines was chosen. Considerable alterations were made to the hull. The outer surface of the shell plating (which had flush butts, with internal straps), was carefully cleaned and found to be very rough, and pitted in various localities. The shell surface was therefore made as smooth as possible by means of fairing material and the plate edges were

* Paper (comprising Part I—Full-Scale Measurements of a report by the British Shipbuilding Research Association), presented to the International Conference of Naval Architects and Marine Engineers, at a meeting in London, June 26, 1951. Abridged. [Fig. 1, above, is not identical with the author's corresponding illustration, which was not available.—ED. E.]

* The application of the bituminous aluminium paint in conditions 2 and 6 was made solely for technical reasons, the object being to obtain the smoothest possible hull surface for comparison with the results obtained with smooth models tested in an experiment tank.

RESISTANCE EXPERIMENTS ON THE "LUCY ASHTON."

Fig. 2

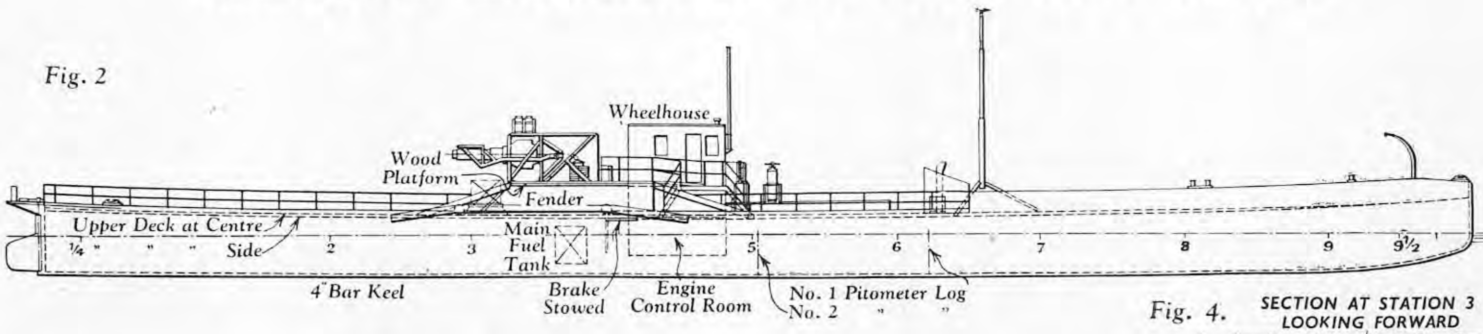
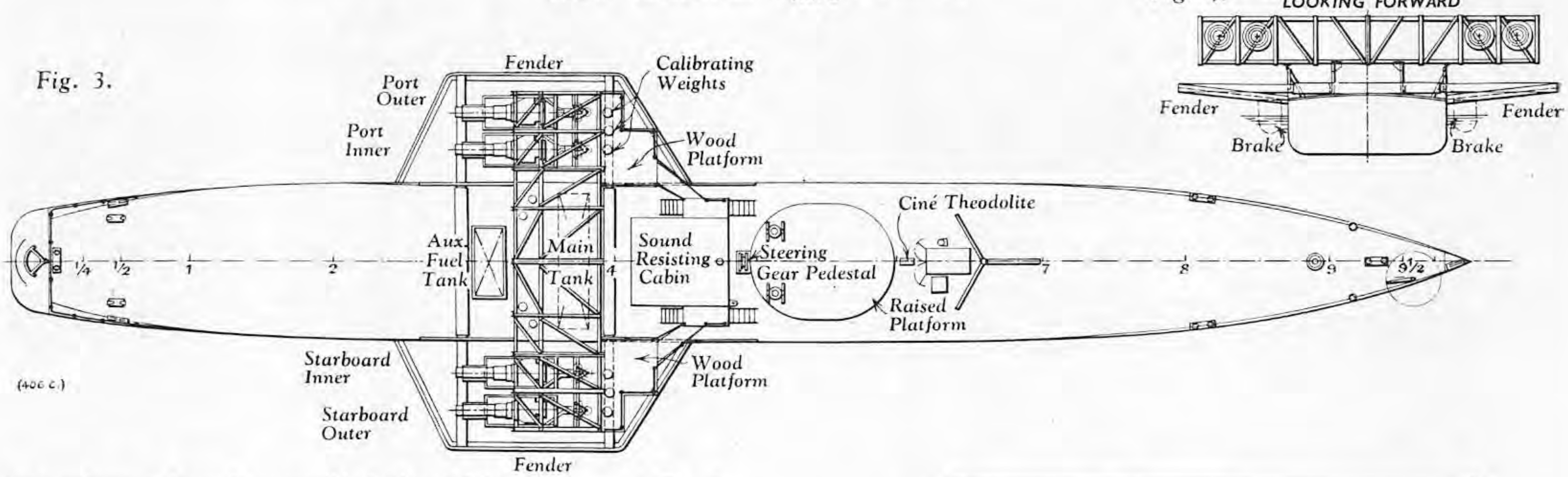


Fig. 4.

Fig. 3.



sharpened so as to be, as far as possible, in the condition prevailing in a new vessel. Due to the combined effects of age and the application of fairing material, the plating was practically smooth so far as rivet points were concerned, since few, if any, of these protruded from the finished surface.

Machinery, paddle-wheels, sponsons and deckhouses were removed. The internal hull was stripped, sand ballast was loaded, a gantry for carrying the jet engines was fitted, and the necessary fuel tank was built and fitted at a position approximately at the same fore and aft position as the centre of flotation. Additional fore and aft stiffening was fitted to the weather deck to ensure against possible excessive distortion. A photograph of the ship as modified for the experiments is reproduced in Fig. 1, on page 121.

To protect the observers and crew from the high-frequency noise emitted by the four Rolls-Royce Derwent V jet engines, a sound-resisting cabin was constructed in what had been the engine-room hatch, as shown in Figs. 2 and 3. This house was arranged in two storeys, the upper compartment being the wheelhouse and the lower the engine-room. The sound insulation consisted of three thicknesses of ½-in. "Celotex" boarding with a 3-in. air-gap between the thicknesses, making an overall thickness of insulation of 7½ in. This proved most effective and it was estimated that the noise reduction was of the order of 60 decibels. To protect observers and crew who had to go on deck, special ear muffs were worn, known as "No-Sonic" ear protectors, which were supplied by the Mallock Armstrong Company, of London. Since no drawing of the lines existed, the offsets were carefully measured while the vessel was on a slip. The steel hull, constructed in 1888, was in relatively good condition.

It is not possible to reverse the direction of the jet-engine thrusts, so the vessel had no astern power. To overcome this defect to some extent, and to assist in stopping the ship in an emergency, two large steel hinged flaps were fitted, one to port and one to starboard underneath the engine gantry, as shown in Fig. 4. These are normally stowed in a horizontal position clear of the water, but can be dropped to the vertical position to act as water brakes in an emergency. They are released by means of a lever in the wheelhouse and are very effective in taking way off the ship. Trials have shown that, by using the brakes, the ship can be pulled up from a speed of 11 knots to 2 knots in about 4½ lengths.

The principal dimensions and particulars of the vessel are as follows:—

Length between perpendiculars ...	190 ft. 6 in.
Breadth moulded	21 ft. 0 in.
Depth moulded	7 ft. 2 in.

Most of the experiments were made at a mean draught of 5 ft. 4 in. (measured over the 4-in. deep bar keel) corresponding to a displacement in salt water of 390 tons at level trim. The coefficients of form in this condition were as follows:—

Block coefficient	0·685
Prismatic coefficient	0·705
Midship area coefficient	0·972

The wetted surface area in this condition, including rudder and bar keel, was 4,488 sq. ft.

The modifications to the hull described in this Section were carried out on behalf of the British

Fig. 5.

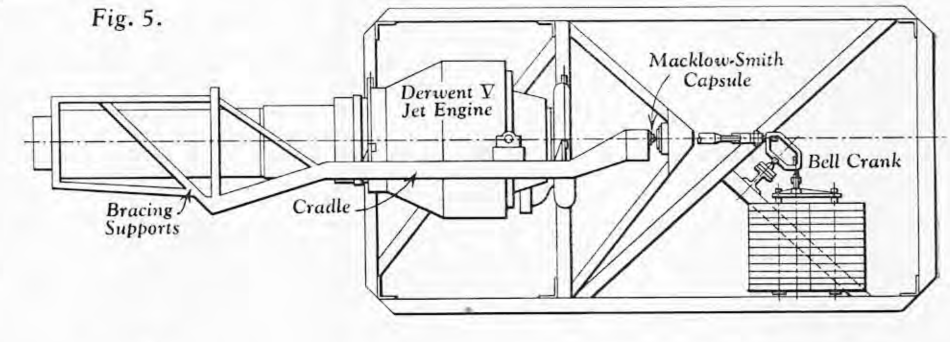


Fig. 6.

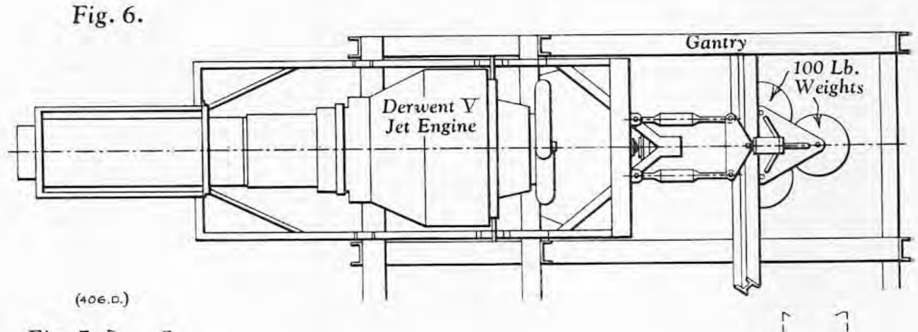
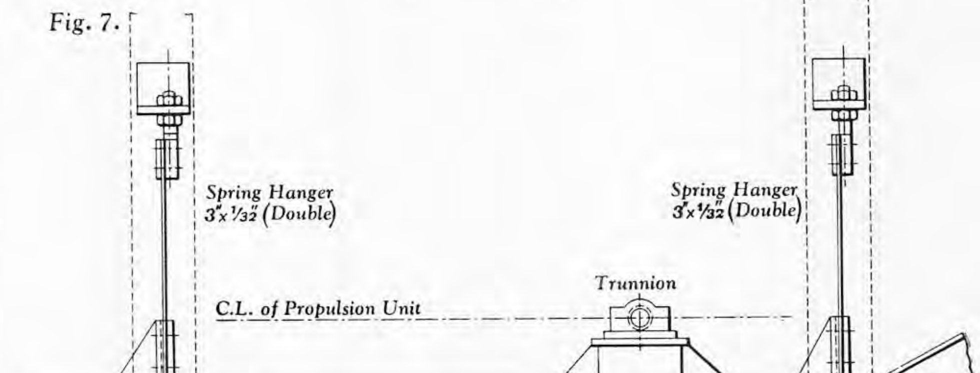


Fig. 7.



Shipbuilding Research Association by William Denny and Brothers, Limited, Dumbarton.

The Greyhound was towed from an outrigger fitted to the Active. William Froude was well aware of the manœuvring difficulty referred to above, so much so that he had to abandon the idea of making runs over a measured mile, the tests being finally made over a straight course in open water. This necessitated the use of towed logs to measure the speed through the water, which gave rise to difficulties.

Another possibility was to tow the ship in line with a towing ship on a very long tow, as was done in the case of the Japanese destroyer Yudachi. The length of tow was made sufficiently long to ensure that, as far as possible, the towed ship was not affected by the wake of the towing ship; but this method is subject to the same doubts and manœuvring difficulties as the outrigger method, and there is also the difficulty of surging and consequent unsteadiness of the towing force.

Propulsion by means of airscrews is possible, but the highly periodic thrust developed by an airscrew is difficult to record accurately. Interference effects between airscrews and hull, due to induced and slip-stream velocities, appear to be unavoidable and it would be difficult accurately to allow for them. On the other hand, an aircraft jet engine gives a steady thrust which is easily and rapidly altered by comparatively simple controls. With jet engines mounted beyond the vessel's beam at such a distance as to preclude impingement of gases discharged from the jet pipe on any part of the hull or impingement on the water in its immediate vicinity, the thrusts recorded on these jet engines give an accurate assessment of the hull resistance. These are important advantages and the main disadvantages are solely the high fuel consumption and the noise emission.

It was decided, therefore, to propel the ship by means of four Rolls Royce Derwent V jet engines, obtained with the co-operation of the Ministry of Supply. Messrs. Rolls-Royce Limited, contributed much useful technical information and provided expert assistance on board throughout the trials.

These Derwent V jet engines were each rated to deliver a thrust of 3,600 lb. at 14,500 r.p.m., which gave an available total propulsive force of just over 6 tons. The fuel consumed by these engines is special-quality aviation kerosene, and the consumption is approximately 1 lb. per hour per pound of thrust at full load. The fuel tank fitted in the ship had a capacity of about 9 tons, which was estimated to be sufficient to carry out a day's running on the mile. Experience showed, however, that a greater reserve of fuel was required to meet contingencies and, to avoid delays due to frequent refuelling, an auxiliary tank was subsequently fitted to take an additional 3 tons of fuel.

The engines were mounted, two port and two starboard, on an athwartship lattice girder and were designated "Port Inner," "Port Outer," "Starboard Inner" and "Starboard Outer," according to their position as shown in Figs. 3 and 4. The engines overhang the ship's side, and their spread was determined by the requirement that the exhaust gases in the jet streams should not foul the hull or impinge on the water in its immediate vicinity. Consideration was also given to the possibility of interference or "resistance augment" effects in way of the air intakes to the jet engine compressors. These air intakes are situated near the forward side of the open lattice girder, well clear of the hull. In the Derwent V engines, the intakes consist of circumferential annuli on each side of the compressor, resulting in a balanced radial ingress of air to the engine, with no fore and aft component force on any part of the surrounding structure due to airflow into the compressors.

The mountings of all four engines were identical and are shown in detail in Figs. 5, 6 and 7, opposite. Each engine rested in a welded rectangular steel cradle, the weight being taken by the two trunnions near the centre of gravity of the engine and the after end supported by the bracing shown in way of the jet pipe. Each cradle was then slung from the upper members of the athwartship girder by four sets of vertical flexible steel strips, as shown in Fig. 7. This method of suspension formed, in effect, a parallel motion which gave the engines a limited degree of freedom of motion in one direction only, i.e., fore and aft. The transverse rigidity of these strips and their longitudinal disposition on the engine cradles effectively restrained the engine in all other directions. The engine thrust is therefore first transmitted to the cradle through the trunnions and from the cradle through the centre of its heavy forward cross-member to the thrust-measuring device, which is rigidly attached to the structure of the ship.

The engines and cradles were aligned so that the axis of thrust was parallel to the water plane of the ship. Care was also taken to ensure that all connections to the engines, such as control cables, fuel pipes, etc., were sufficiently flexible not to affect the delivered thrust.

(*To be continued.*)

HYDRO-ELECTRIC POWER IN THE NORTH OF SCOTLAND.*

THE North of Scotland Hydro-Electric Board's annual report for 1950 shows that, in the previous year, they extended their supplies to 105 villages and housing areas, connected 22,140 new consumers, and generated 877,979,479 units of electricity. They installed, during 1950, hydro-electric generating plant with a total capacity of 197,950 kW and Diesel generating sets with a capacity of 5,980 kW, a total of 203,930 kW, and, at the end of the year, had in operation 13 hydro-electric, six steam, and 28 Diesel stations; nine hydro-electric schemes were under construction. Work is to start soon on the construction of additional plant at Gaur and Lawers (Perthshire), Glascarnoch-Luichart-Torr Achilty (Ross-shire), Moriston and Garry (Inverness-shire). These schemes will have an approximate capacity of 198,000 kW and an average estimated annual output of 736,000,000 units of electricity. Capital expenditure during 1950 was 12,213,551*l*. The profit of 5,204*l*. for the year has been added to the balance of 22,470*l*. brought forward from 1949 and the aggregate surplus of 27,674*l*. is being carried forward.

The Board had under survey last year hydro-electric schemes estimated to have an approximate capacity of 278,500 kW and an estimated average annual output of 1,068,000,000 units. These included the Shin, Orrin, Kilmelfort and Breadalbane schemes, and also proposals to use the water of the Rivers Farrar and Beauly, the Tay Basin, and extensions to the Affric scheme. By the end of 1950, the development programme for the Highlands had reached the stage shown in Table I, herewith.

TABLE I.

——	Total Capacity, kW.	Estimated Annual Output, kWh.
In operation	199,700	376,000,000
Under construction	299,300	465,000,000
Promoted and just starting.. ..	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

The Board promoted seven constructional schemes in 1950, namely, the Mucomir hydro-electric scheme, near Fort William, which will have an installed capacity of 1,500 kW and an estimated annual output of 9,000,000 units; Diesel generating stations at Kirkwall in Orkney, Lerwick in Shetland, and Stornoway on the Island of Lewis; a Diesel generating station and an extension to an existing small hydro-electric station at Tobermory, on the island of Mull; and the erection of 132,000-volt transmission lines from the Fasnakyle generating station of the Affric scheme to Fort Augustus, and from Boat of Garten to Aberdeen.

The total number of consumers receiving a supply from the Board by the end of the year was 244,314, a figure which represents a population of approximately 855,000; but, in the Board's area, there are about 120,000 potential consumers, or a population of about 400,000, still without a supply of electricity. During the year, 12,082 consumers were changed over from direct-current to alternating-current supply. The total length of distribution lines at the end of the year was 5,808 miles, about 310 miles of which were erected during 1950. The 132,000-volt Highland grid system, in operation or under construction at the end of 1950, consisted of 1,120 miles of lines and ten switching stations. The Board have promoted ten schemes for main transmission.

A record output was obtained from the hydro-electric schemes during 1950. The total installed capacity in the Board's generating stations at the end of the year,

TABLE II.

——	Kilowatts Installed.	Units Generated.
Water power	284,750	521,524,062
Steam	130,875	284,374,805
Diesel (for public supply)	29,285	52,447,650
Diesel (for temporary constructional supply)	8,060	19,632,962
Total	452,970	877,979,479
Corresponding total for 1949 ..	250,970	710,194,025

and the number of units generated at these stations during the year, are shown in Table II, herewith.

At Caroline Port generating station, Dundee, the rebuilding of an old boiler house for the 12,500/15,000-kW closed-cycle gas turbine and the preparation of foundations were completed and the first large component, the air preheater, was installed by the end of the year. The oil tanks were erected, and half of the fuel pipes from a wharf to the tanks and on to the station were laid. The turbines, compressors, rotors and casings were under construction, most of the blading being already completed.

Local stone is being used as far as possible in the building of generating stations, sub-stations and staff houses; a policy which has contributed to a revival of the Scottish stone-quarry industry in the North and the craft of the stonemason. The first stone building completed for the Board was the Lochalsh generating station, opened in 1948. Stone buildings completed during 1950 were the control houses at the sub-stations at Fasnakyle and Beauly. Tarradale sandstone is being used to face the Grudie Bridge station, and Burghead stone will be used to face the Fasnakyle station. The new Diesel generating station at Kirkwall, one of the largest Diesel stations in Britain, has been built of local stone, and so has the small hydro-electric station at Gairloch. Local stone is also to be used for a number of other stations, under construction or about to be begun.

Research work undertaken in 1950 included an investigation into new methods of tunnel driving; experiments with an electrical fish screen and an electric enumerator to count fish passing up the fish passes at dams; research work in connection with a peat-fired gas turbine; and the drying of hay by electricity. The foundations and steel tower of the 100-kW experimental windmill were erected on Costa Hill, Orkney, and the machinery, after being tested in the manufacturer's works, was shipped to Orkney in preparation for installation.

* Report of the North of Scotland Hydro-Electric Board, 1950. Abridged.

ROLLS-ROYCE "DART" PROPELLER-TURBINE ENGINE.

A 500-HOUR endurance test has recently been completed successfully by a production 1,400-h.p. Rolls-Royce Dart propeller-turbine engine, of the type installed in the Vickers-Armstrong Viscount air liner. The flame tubes, the burners and the air casing of the engine under test had already completed 240 hours running; no parts of the engine were replaced during the test, except the exhaust unit, which was undergoing development. The test was carried out in one of the hangars at the main works of Messrs. Rolls-Royce Limited, Derby, to a test schedule simulating, so far as is possible on the ground, the conditions likely to be encountered by a Viscount aircraft flying on the European routes. Since the power developed at any given engine speed is higher at sea level than at altitude, the test conditions, in that respect, were more severe than would be encountered in normal operation.

Part of the test, in which taxying (six minutes at 6,000 r.p.m.), and take-off conditions (one minute at 14,500 r.p.m.), were simulated, was carried out in an artificial sandstorm, 0·03 gramme of sand per cubic foot of air being injected, corresponding to over 1 lb. per minute of sand at take-off revolutions per minute. Over the whole period of the test, nearly 2 cwt. of sand passed through the engine. Under climbing conditions (42 minutes at 13,300 r.p.m.), the oil temperature was maintained at the maximum permissible value 90 deg. C. During each cruising period of 2 hours 11 minutes at 13,300 r.p.m., the de-icing system was in operation for 30 minutes. Water, at a rate of 50 gallons per hour while taxying, and 150 gallons per hour during take-off, was sprayed on to the engine during part of each flight to reproduce a heavy rainstorm. During one flight in every 100 hours, the engine was operated at take-off revolutions per minute for five minutes, and the climbing and cruising revolutions were increased.

It may be noted that 5,000 hours of test flying have now been carried out on Rolls-Royce Dart engines without any case of failure in flight. On the test-bed at Derby, Dart engines have now completed 9,500 hours running.

GAUGE AND TOOLMAKERS' EMERGENCY COMMITTEE.—The Gauge and Toolmakers' Association has appointed an emergency committee to assist the Ministry of Supply in connection with the re-armament programme. Midland members of the committee include Mr. S. J. Harley, managing director of the Coventry Gauge & Tool Co., Ltd.; Mr. H. S. Holden, chairman of the Association, and managing director of the Brooke Tool Manufacturing Co., Ltd.; and Mr. F. H. J. Mills, managing director of B.I.P. Tools, Ltd. The Association is setting up regional panels to advise users of jigs and tools. Mr. Holden is chairman of the panel which covers Birmingham, Coventry and the Midlands.

IMPROVEMENTS IN COMMER COMMERCIAL VEHICLES.

As a result of the success obtained with their six-cylinder horizontal under-floor petrol engine, Commer Cars, Limited, Luton, decided to fit a similar engine in their new range of Superpoise commercial vehicles. It is illustrated in Fig. 1, herewith. The new unit follows the general design of the under-floor engine, but has the cylinders arranged vertically. It is a six-cylinder overhead-valve engine, with a bore and stroke of $3\frac{1}{2}$ in. and $4\frac{3}{8}$ in., respectively, and develops approximately 85 brake horse-power and a maximum torque of 200 lb.-ft. This represents a 7 per cent. increase in horse-power and a 14 per cent. increase in torque over the original engine fitted to the Superpoise range of vehicles. These improvements have been obtained partly by the introduction of overhead valves and partly by attention to details such as the adoption of machined combustion chambers combined with well-proportioned manifolding and careful attention to carburation. Other points which have received special consideration are the cooling and lubrication systems, a distribution pipe installed in the cylinder head ensuring that the coolant is directed to the hotter areas, such as exhaust ports and sparking-plug bosses, while liberal lubrication is obtained by employing an exceptionally large gear-type pump capable of delivering $6\frac{1}{2}$ gallons a minute when the engine is running at 3,000 r.p.m. The seven-bearing crankshaft has four integral balance weights. To allow for the increased output, the radiator capacity has been enlarged and the design altered to give improved air-flow.

Several refinements have been introduced in the chassis. Detail improvements have been made, for example, in the braking system; the 2-3 ton and 3-4 ton models retain the Girling hydraulically-operated system with two leading shoes, and, though the drum diameters remain at 14 in., the shoe widths have been increased from $1\frac{3}{4}$ in. to $2\frac{1}{2}$ in. at the front and from $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in. at the rear, thereby increasing the lining area from 232 sq. in. to 328 sq. in., a gain of some 41 per cent. On the 5-ton models, the diameter of the two leading-shoe front brakes have been increased from 14 in. to 16 in., the width remaining constant at $2\frac{1}{2}$ in., while the rear brakes, which have been altered to give equal retardation in both directions of travel, have had the diameter changed from 16 in. to $15\frac{1}{4}$ in., but the width increased from 3 in. to $4\frac{1}{4}$ in. This gives an overall increase in lining area from 309 sq. in. to 408 sq. in., a gain of 32 per cent. On the 3 to 4-ton and 5-ton models, the Girling hydraulic equipment is supplemented by $5\frac{1}{4}$-in. Clayton-Dewandre servo units, and the tractor models have brake-fluid reaction valves.

Chassis strengths have been improved considerably and all frames are now made from 38-46 ton carbon-manganese steel. On the 2 to 3-ton and 3 to 4-ton models, the side members are made from $\frac{7}{32}$-in. thick material and have a depth of 8 in. with a flange width of $2\frac{9}{16}$ in. at the top and 3 in. at the bottom. On the 5-ton models, the frame has been increased in depth to $8\frac{9}{16}$ in. In the suspension, all road-spring leaves are now "shot-peened" on the tension side to increase their resistance to fatigue, and the spring holding-down bolts have exceptionally fine threads and are fitted with extra-deep nuts. Other refinements include stronger front-spring brackets and the provision of hydraulic shock-absorbers; the last-named items, however, are optional extras.

To cater for the increased engine output, larger universal joints and stronger propeller shafts have been incorporated in the transmission. The rear axle follows conventional design, but the pinion is straddle-mounted and the half shafts, now made of high-tensile steel, are of increased diameter. Only the more important improvements have been mentioned above. The general design of the new range of vehicles follows that of their immediate predecessors and, as will be seen from Fig. 2, herewith, they are similar in appearance. If required, the 3 and 4-ton models, the 5-ton models and the tractor version, can be supplied with a Perkins P6V Diesel engine. This is a six-cylinder unit developing 79 brake horse-power at its governed speed of 2,400 r.p.m. and producing a maximum torque of 198 lb.-ft. at 1,500 r.p.m.

SUPPLIES OF ZINC.—The Lord Privy Seal (the Rt. Hon. R. R. Stokes, M.P.), who is responsible for the Ministry of Materials, has issued a statement urging United Kingdom zinc smelters to increase their output to the utmost to meet the growing demand for the metal. The use of alternative materials should be encouraged in every way, he emphasises, and research into ways of saving zinc in galvanising and other processes should be accelerated, as the demands of the defence programme, and progressive industrial development at home and overseas, are such that the present shortage is likely to continue, though the Ministry will increase imports as rapidly as possible. The economies to be expected will not be sufficient to meet the growing demand.

IMPROVED COMMER COMMERCIAL VEHICLES.

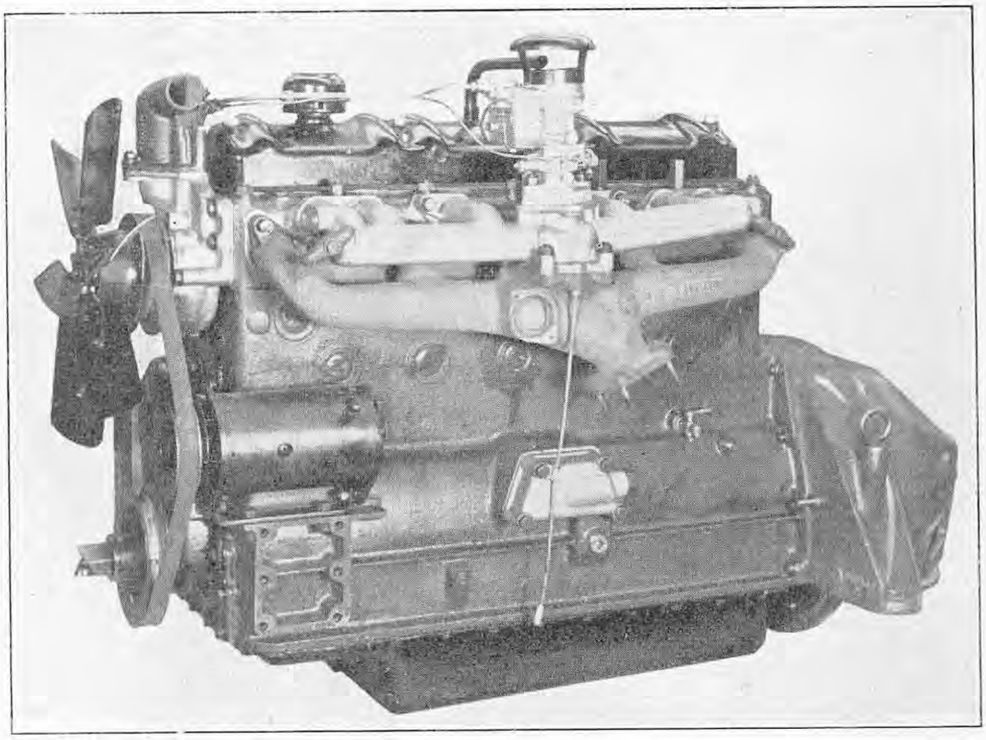


FIG. 1. 85 B.H.P. SIX-CYLINDER OVERHEAD-VALVE ENGINE.

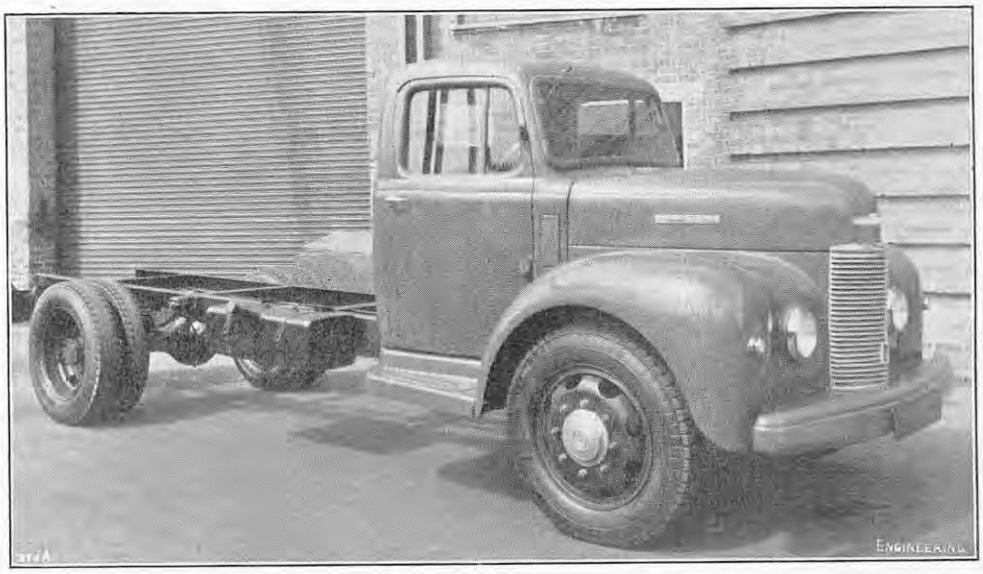


FIG. 2. 2-3 TON "SUPERPOISE" CHASSIS AND CAB.

ANNUALS AND REFERENCE BOOKS.

Directory of International Scientific Organizations.—Some of the activities of the United Nations Educational Scientific and Cultural Organisation (Unesco) may not have attracted approval commensurate with the labour and expense involved, but there is little doubt that this directory will be widely welcomed. Its preparation was suggested by "prominent members of the Canadian, Australian and New Zealand Government services," and approved by the General Conference of Unesco in 1948. The Department of Natural Sciences and the Department of Exchange of Information collected the material by circulating a questionnaire which appears to have been fairly well received. The information gathered includes the address, nature and aims of each society or organisation; particulars of governing bodies and officers; the sources of revenue; membership; publications issued; relations with other international organisations; and a "short history" (though the lengths vary considerably) of its origin and development. More than 150 international organisations are listed, and are grouped under the three main headings of "Basic Sciences," "Applied Sciences" and "Miscellaneous." The second of these classifications is further divided into "Agriculture," "Engineering" and "Medical." The Directory is published by Unesco in Paris, but is available in this country from H.M. Stationery Office, York House, Kingsway, London, W.C.2, at the modest price of 6*s*. net. Apparently, no decision has been reached to make it a periodical, but a "possible re-issue" is hinted at in the preface.

Water Engineer's Handbook, 1951.—In general arrangement, the 1951 edition of this useful reference book—the 19th annual issue—follows the lines already familiar to users of it, the principal feature, naturally, being the directory of water undertakings in the British Isles. More than 1,600 are given, with the names of their chief officers, their sources of supply and areas of distribution, and particulars of the nature of the water, the water rate and rateable value, number of consumers' meters, etc. Statistics are also given regarding the populations served, the consumption (daily average total and gallons per head), storage capacities, and length of mains. Other sections cover the River Boards and Catchment Boards, with their officers, addresses, and rateable values; the panels of qualified civil engineers officiating under the Reservoirs (Safety Provisions) Act, 1930; the Government Departments and professional institutions concerned with water supply, purity and pollution, hydro-electric power, geology, research, etc.; and British Standards applicable to water engineering. The book concludes with 60 pages of "Technical Information," and indexes. What is, in effect, another index, is the list of chief water engineers, managers and consulting engineers, indicating the water authorities with which they are connected. The *Handbook* is published by the Colliery Guardian Co., Ltd., 30 and 31, Furnival-street, London, E.C.4, at 15*s*. (15*s*. 7*d*., including postage).

HEAT TREATMENT OF PIPELINE WELDS.

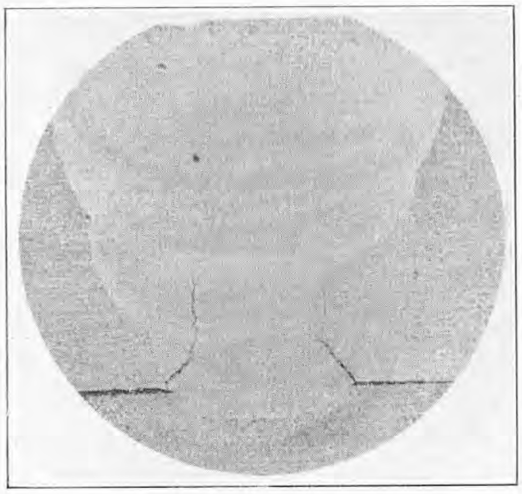


FIG. 1. BASAL CRACKS IN WELD ON BACKING RING. × 3·5.

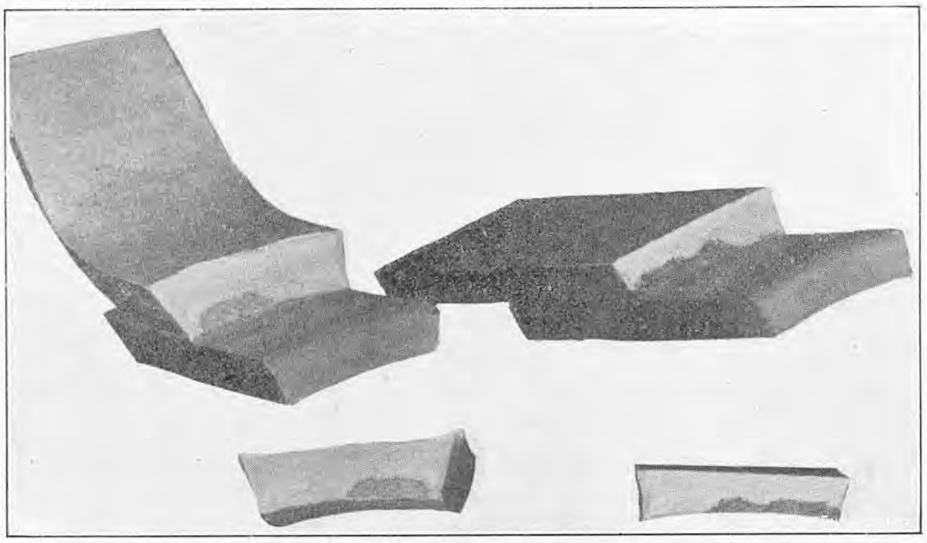
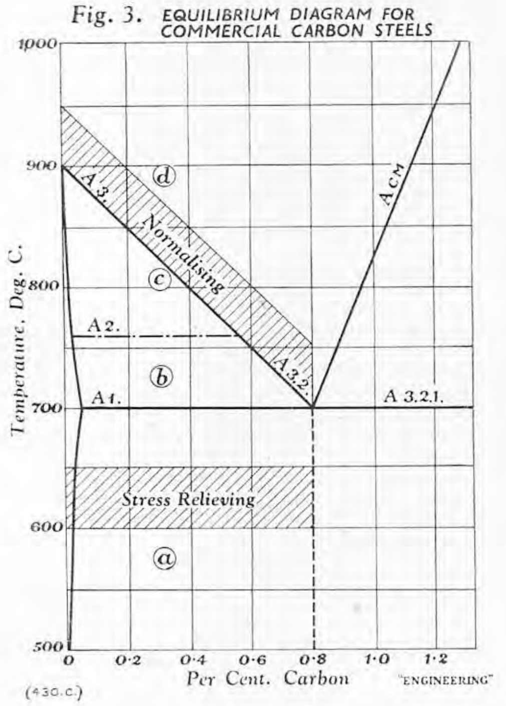


FIG. 2. WELD BROKEN TO SHOW CRACKS.

Fig. 3. EQUILIBRIUM DIAGRAM FOR COMMERCIAL CARBON STEELS



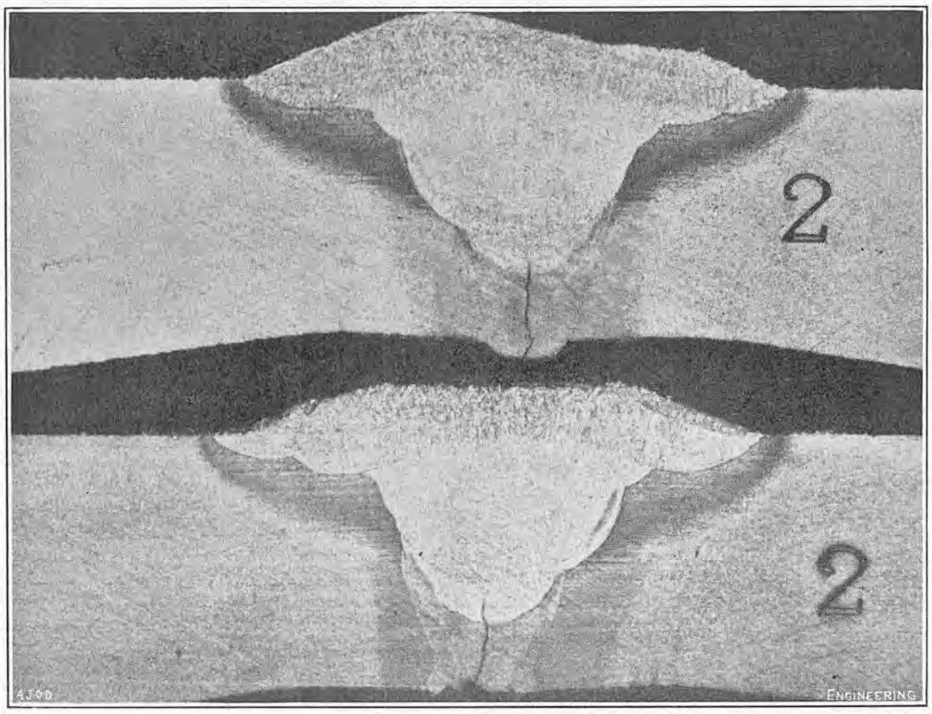


FIG. 4. CRACKS IN WELDS ON CHROME-MOLYBDENUM PIPE.

THE HEAT TREATMENT OF WELDS IN PIPELINES.*

By A. H. GOODGER, M.Sc.Tech., A.R.I.C.

IT is unfortunately true that the reasons for the heat treatment of welds are not always clearly understood by those interested in the construction of pipelines. For the conditions normally covered by heating services, namely, pressures up to 250 lb. per square inch and temperatures not exceeding 425 deg. F., heat treatment is not considered essential where the pipe-wall thickness does not exceed $\frac{7}{16}$ in. The reasons for the desirability of heat treatment for greater thicknesses or more exacting conditions will be clearer when the different services and different types of steel are considered as a whole. Heat treatment of welded joints in pipe-lines is used at two distinct stages, referred to as preheating and postheating.

The reasons for heat treatment may be summarised as follows. Preheating is used in oxy-acetylene welding to aid the welder to obtain good root fusion in a thick-walled pipe; with arc welding, it prevents basal cracking as a result of hardening and rigidity, and it prevents zones of high hardness. Postheating (usually normalising) is used with oxy-acetylene welds to refine the structure and so to improve mechanical properties, and for the removal of internal stress. It is applied to metallic-arc welds usually for stress-relieving, to remove internal stress, and it also has the effect of tempering heat-affected zones which have high hardness.

The main object of preheating is to obtain a sound weld; a secondary effect to obtain high-affected zones with low hardness, which are less notch-sensitive. With oxy-acetylene welds, preheating materially eases the task of welding the first run on a thick-walled pipe. There is a limiting wall thickness of between $\frac{7}{16}$ in. and $\frac{1}{2}$ in., below which it is a comparatively easy matter for a good welder to heat the root of the weld groove so that simultaneous fusion and addition of filler metal can be obtained. Above this thickness, it is difficult to obtain consistently sound welds without either preheating with a second torch during welding or by first preheating the pipe ends uniformly in the vicinity of the weld. For all thicknesses below $\frac{7}{16}$ in., preheating should be unnecessary with oxy-acetylene welding. This is true of the carbon steels and most of the low-alloy steels. Even if no preheat is used, there is a large input of heat before melting of the edges occurs, and the parent metal near the weld will be heated considerably. There is, therefore, no possibility of partial quenching of either the weld metal or the parent metal, as the temperature gradient is not steep.

Striking an arc on cold base-metal immediately raises the base metal near the arc to melting point. Heat dissipation can occur so rapidly as to amount, on a moderately thick wall, to a mild quench, and the thicker the base metal the more vigorous the quench effect. Here the temperature gradient is very steep. If the base metal were carbon-free, the quench would have little hardening effect, but, with increasing carbon content and with low-alloy steels, the hardening effect at the heat-affected zone increases. Pipe ends are rigid, and when a first run of arc-weld metal is cooling in a pipe joint there is considerable restraint to its shrinkage. Preheating somewhat offsets the effects of rigidity by reducing the heat gradient away from the weld, causing higher temperature of the base metal near the weld and hence greater plasticity. This allows shrinkage of the first run to occur, thus reducing the tendency to crack. Any feature of weld design which leads to increased rigidity or resistance to shrinkage of the first bead increases the tendency to crack.

The cracks which form at the base of a single-sided weld may occur at a moderately high temperature as a result of rigidity resisting the shrinkage stress when the weld metal is weak. They may also occur at a relatively low temperature, due to volume changes of the structural constituents arising from the quench effect. Typical basal cracks are shown in Fig. 1, herewith. They usually take the form of small arcs of cracked material, which may be distributed round the wall of a pipe; they seldom occur as continuous cracks. A typical fracture through a weld containing basal cracks is given in Fig. 2, herewith.

Heating a carbon steel above the lower critical point A1, in Fig. 3, on this page, will cause carbon atoms to pass into solid solution in the form of austenite. On cooling down to about 100 deg. F., this austenite transforms suddenly to the hardened condition of marten-

* Paper presented at the summer meeting of the Institution of Heating and Ventilating Engineers held in Buxton, on June 19, 1951. Abridged.

HEAT TREATMENT OF PIPELINE WELDS.

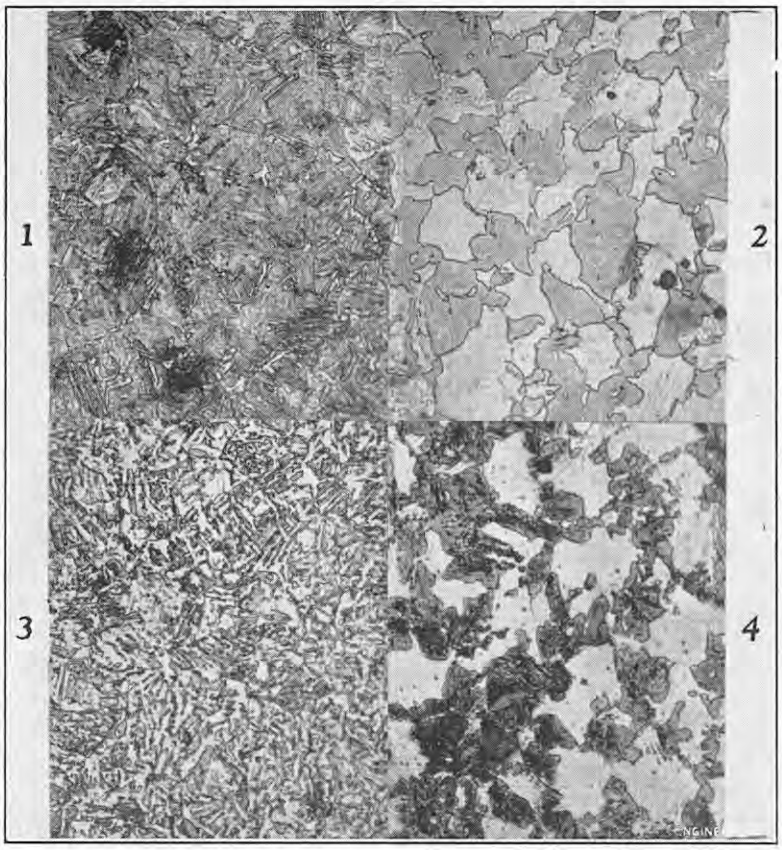


FIG. 5. CHROME-MOLYBDENUM STEEL AFTER OIL QUENCHING.

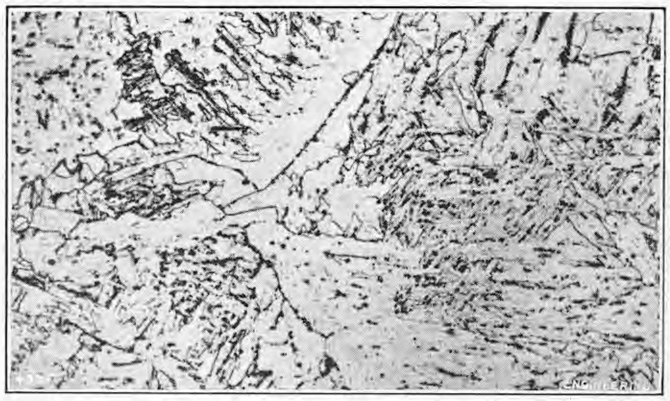


FIG. 6. OXY-ACETYLENE WELD METAL. × 100.

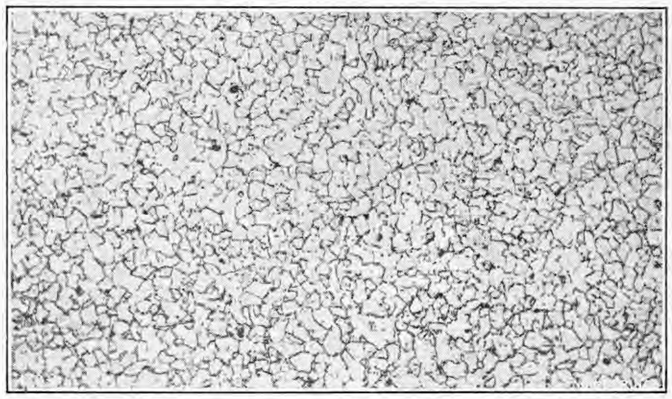


FIG. 7. OVERHEATED METAL, NORMALISED. × 100.

site. This change involves a well-defined dilatation and may result in cracking. As the base metal is colder during the laying of the lower runs, it is there that the tendency to crack is also greatest. It increases with rising carbon content, and the British Standards Institution has laid it down that, for all ordinary purposes, a mild steel of carbon content not exceeding 0·26 per cent. can be welded without preheating, providing the thickness is below 2 in.

The effect of preheating is to reduce the rate of heat dissipation by lowering the temperature gradient and hence the hardening effect. It also slows down the rate of transformation of the austenite formed, so that, instead of taking place in a few seconds, the action may be prolonged to hours. This grain-by-grain transformation in a matrix that is still plastic effectively reduces the danger of cracking.

The suggestion by Hopkin that hydrogen, derived from water in the electrode coating and finally occluded in the weld metal or heat-affected zone, was a major factor in weld cracking. This work has given rise to electrodes which have coatings specially low in hydrogen. The effect of preheating on hydrogen cracking has been shown by Christensen and recently by M. W. Mallet and P. J. Rieppel, who suggested that occluded hydrogen caused brittleness, due to added stress during the austenite-martensite transformation. Preheating prevents the formation of martensite and hence reduces the cracking tendency. The author has found that low-hydrogen electrodes do not always confer freedom from cracking; on a low-chrome molybdenum steel pipe, it was found that welds made with these electrodes always cracked, while those from an ordinary type of molybdenum-steel electrode never cracked. In both cases, similar conditions of size, voltage, current and preheat were used (see Fig. 4, on page 125). No explanation is given of this phenomenon.

The three possible causes of basal cracking—hardening, rigidity, and occluded hydrogen—may operate separately or together. The first cause is probably the most important and can be avoided by preheating. Countering rigidity is assisted by preheating, but it is mostly a matter of joint design. The third is probably the least important cause of cracking on ordinary pipe-line work, but it is good advice to dry all electrodes before use. Where work is to be done outside or in exposed situations, it is good practice to dry the electrodes and store them in air-tight metal boxes until immediately before use.

All authorities in this country are agreed that preheating for mild-steel piping is generally unnecessary for wall thicknesses below ¾ in. There is no harm in using preheat for lower thicknesses if it is found helpful, or for cases of particular rigidity. It is usually considered to be bad practice to attempt to weld when the piping in the vicinity of the weld is below a temperature of 40 deg. F., owing to the possibility of brittle fracture. For piping in higher-carbon steels, and for low-alloy steels, the preheat conditions which are accepted good practice agree fairly well in most codes.

The case of austenitic steel is unusual: The characteristics of this steel are low carbon, high coefficient of expansion, low conductivity, and increased susceptibility to micro-cracking, the nearer the material becomes to purely austenitic. The cause of micro-cracking is obscure, some researchers considering it to be a result of inclusion of intergranular silicate films. For pipe welding it is usual, where the mechanical and creep properties of the weld and pipe are to be nearly alike, to use electrodes depositing a weld metal containing a controlled amount of ferrite, from 2 per cent. to 5 per cent. More ferrite than this is objectionable for service at high temperatures, owing to liability to formation of sigma, the brittle phase which forms from the ferrite considerably increasing the notch sensitivity.

The main cause of cracking of austenitic steel piping during welding is the rapid local expansion, which is aided by the low conductivity; cracking occurs, due to the resulting high stresses, at places where the strength and ductility are naturally very low at the high temperature. It is common American practice to cool austenitic piping on either side of a weld by use of a cooling coil or even by wet rags. In addition, the heat input at the electrode is kept to a minimum consistent with the deposition of sound metal.

The main reason for heat-treating welds in pipes is to prevent them cracking or clinking as a result of brittle fracture from suddenly applied loads or shocks at any time after welding is complete. Pipe welds do occasionally fail in this way, and two cases of sudden failure in power-station piping have recently come to the author's attention. A large section of opinion believes that brittle fracture only occurs when a steel has a high notch-sensitivity at the temperature of fracture, that there is a suitable notch present in the weld or parent metal, and that a shock or suddenly applied load is given. A common opinion is that the high notch-sensitivity is associated with low temperatures, with the steel below its transition temperature. This body of opinion considers that internal stress arising from welding is not the main cause or even a contributory cause; but it is difficult to see how the immense amount of energy required in some of the practical cases of brittle failure could have arisen in a stress-free article, dropping in temperature from 60 deg. to 40 deg. F.

Brittle fractures seldom, if ever, occur in stress-relieved articles, and it is fairly certain that, whatever the causes of commencement of a brittle fracture, the propagation and continuance of it is largely the result of the stored elastic strain energy. Internal stress in a brittle material like glass readily causes fracture under shock, vibration, or even spontaneously. Very few persons considering brittle fracture do more than investigate the impact resistance or notch sensitivity of an unwelded steel, but the notch sensitivity of heat-affected zones can be much greater.

TABLE I.

Heat treatment.	Direction of Test.	Temperature of Test, deg. F.	Energy to Fracture, Ft.-lb.	Brinell Hardness.
Tube as normalised	Longitudinal	70	81–75–81	
	,,	50	78–76–76	
	,,	30	77–59–90	
	,,	10	69–66–82	
	,,	−10	62–88–60	
Specimen 1. Quenched from 900 deg. C.	Longitudinal	50	18–15–16	364
	,,	10	17–13–11	
	,,	−10	10–13–11	
	Transverse	−10	11	
Specimen 2. Quenched from 750 deg. C.	Longitudinal	50	3–3–3	269
	,,	10	2–2–2	
	,,	−10	2–2–2	
	Transverse	−10	1	
Specimen 3. Quenched from 900 deg. C. at 120 deg. C., representing preheat	Longitudinal	50	38–41–36	248
	,,	10	26–34–25	
	,,	−10	22–22–22	
	Transverse	−10	24	
Specimen 4. Quenched from 750 deg. C. at 120 deg. C., representing preheat	Longitudinal	50	6–6–5	241
	,,	10	4–5–4	
	,,	−10	3–3–3	
	Transverse	−10	3	

The author carried out some tests on the 1 per cent. chrome ½ per cent. molybdenum pipe referred to earlier. The wall was ⅝-in. thick. It seemed probable that the steel quenched just above the lower critical temperature, 700 deg. C.—at, say, *b* (Fig. 3)—would have distinctly different impact properties from which it would have if quenched above the upper critical point, at, say, *d*. At the lower temperature, the carbon atoms would pass into solid solution locally in the lattice and, on quenching, would produce a local area of strong martensite. At the higher temperature *d*, the carbon

MOTORSHIP "CIUDAD DE MEDELLIN."

FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN.

atom would diffuse and on quenching would form a weak martensite. Tests at different temperatures confirmed these figures to a remarkable degree. To obtain bars with consistent structures, pieces were quenched in oil with and without preheat. The results compared with the untreated tube material are given in Table I, and the micro-structures in Fig. 5, numbered to correspond with the Table. The specimens were stress-relieved with the results shown in Table II.

TABLE II.

Heat Treatment.	Direction of Test.	Temperature of Test, deg. F.	Energy to Fracture, Ft.-lb.	Brinell Hardness.
Specimen 1. Quenched 900 deg. C. Stress-relieved 650 deg. C.	Longitudinal	50	90	223
Specimen 2. Quenched 750 deg. C. Stress-relieved 650 deg. C.	Longitudinal	50	85	179
Specimen 3. Quenched 900 deg. C. at 120 deg. C. Stress-relieved at 650 deg. C.	Longitudinal	50	96	192
Specimen 4. Quenched 750 deg. C. at 120 deg. C. Stress-relieved 650 deg. C.	Longitudinal	50	93	174

These quench tests are more severe than normal welding conditions, but they give a picture of the direction in which the properties of the heat-affected zones tend, and demonstrate the improvement likely to follow stress relief. A study of the hardness figures after the various heat treatments shows that Vickers or Brinell figures may bear little relation to the true state of affairs in a heat-affected zone, and are certainly no guide to notch sensitivity. Micro-hardness figures give a better guide. The remarkable improvement shown by all the specimens on stress-relief is striking.

It is probable that a number of cases where fractures have started in heat-affected zones, in steels which normally would be considered satisfactory, could be explained by the notch brittleness of certain zones as shown above. It is probable that a crack starting from some cause in a grain in such a zone would involve so rapid and sharp a change in stress distribution as to ensure the fracture progressing as long as the elastic strain energy persisted.

Many engineers feel that repeatedly applied stress is additive to internal stress, but there is a mounting mass of experimental evidence to show that the view is not correct, except, perhaps, in very exceptional circumstances. For many years, it has been the practice of some makers to stress-relieve welded parts mechanically by a slow over-pressure test, and years ago some metallurgists felt that applied alternating stresses tended to reduce residual stress. It has been shown recently by Ros, Soete, Weck, Wilson and others that, during fatigue tests, there is a progressive reduction in internal-stress; so that, when a crack starts, the residual stress may be no more than 10 per cent. of the original figure. L. D. Hall and D. R. Parker stated, as a result of tests, that a residual tensile stress of 25,000 lb. per square inch had no more effect on fatigue strength than the low residual stress remaining after the stress-relief. Others have found that a high initial residual stress reduces the fatigue limit by no more than 10 to 15 per cent.

It is difficult, perhaps, to align these views with the very common failures of dynamically loaded shafts which have been welded or repaired by welding, but it is also difficult to see how internal stress is contributory even here. It may well be that differences in structure arising from heat-affected zones with low fatigue resistance, or even the presence of micro-cracks or notches, may be the explanation. The conclusion is, therefore, that postheating on pipe-line welds is for the purpose of reducing the risk of sudden failure by shock or rapidly applied load of any sort, rather than for avoiding failure from repeated loading, racking or fatigue. In pipe-lines working at high temperatures, when creep is a factor in design, any residual stress will gradually die away as a result of creep in service.

Oxy-acetylene welding of most steels results in a great increase in grain size, usually referred to as overheating. As the temperature rises above the upper critical point as shown by line A_3 in Fig. 3, the grain size progressively increases until the melting point, and this change is not reversible on cooling (see Fig. 6, opposite). Normalising is the name given to the process of correcting a structure with such a large grain size. When the overheated steel is heated through the upper critical point, a re-arrangement of atoms occurs, together with a complete re-crystallisation; so that, if the temperature is kept from rising too high above this line, the grain size will be quite small (see Fig. 7, opposite). The allowable temperature range is quite wide, even as much as 100 deg. C., without the new grain size from normalising being unduly large. Nearer the exact critical temperature, the time required for normalising increases.

The increase in grain size due to overheating has little effect on the tensile strength or ductility of a metal as measured in the normal way, but it does have a deleterious effect on results obtained in bend tests, especially as the thickness increases. It is on the resistance to impact or notch-sensitivity tests that the effects are most marked.

(To be continued.)

AGRICULTURAL MACHINERY AT THE SCIENCE MUSEUM.—One of the sections of exhibits at the Science Museum, South Kensington, S.W.7, removed to the country for safety on the outbreak of war in 1939 was the series showing the historical development of agricultural implements and machinery. Only recently has it been possible to arrange for the display of this collection, which was re-opened by Mr. George Tomlinson, M.P., Minister of Education, on July 25—the 120th anniversary of the first public demonstration of the McCormick harvester. The portion now on view deals with arable farming, and has been supplemented by nearly 100 models, contributed by a score of firms, showing modern developments. The Keeper of the section is Mr. W. T. O'Dea, B.Sc., M.I.E.E.

SINGLE-SCREW CARGO VESSEL FOR COLOMBIA.

THE FAIRFIELD Shipbuilding and Engineering Company, Limited, Govan, Glasgow, recently completed the Ciudad de Medellin, a single-screw cargo vessel, for Flota Mercante Grancolombiana S.A., of Colombia. She is the first of two sister ships, for the carriage of general cargo. The vessel measures 395 ft. between perpendiculars and 421 ft. overall, with a breadth of 55 ft. and a depth, to main deck, of 24 ft. 6 in. The gross tonnage is 5,500, and speed, 14½ knots. The illustration shows the vessel on trials.

The hull was built under special survey to Lloyd's highest class and has a continuous shelter deck, together with a main deck and a lower deck extending forward from the machinery spaces. Seven watertight bulkheads divide the vessel into eight compartments, there being three cargo holds forward and two holds abaft the engine room. The double bottom is subdivided for the carriage of oil fuel and water ballast, and the 'tween deck cargo space extends from the after tonnage well to the fore-peak bulkhead. The propelling machinery consists of a direct-reversing single-acting two-stroke Fairfield-Doxford Diesel engine. This has four cylinders with a diameter of 670 mm. and a combined stroke of 2,320 mm., delivering 4,600 brake horse-power at 118 r.p.m. Current for the engine-room auxiliaries and ship's services generally is provided by three 340-kW Diesel-driven generating sets.

The captain's accommodation and owner's suite, each consisting of a day room, a bedroom and toilet, occupy a deckhouse on the boat deck. The deck and engineer officers are accommodated in separate cabins in a deckhouse on the bridge deck and at the forward end of the shelter-deck house. Some of the crew have their quarters in the after portion of the shelter-deck house and the remainder on the shelter deck and main deck aft. The amenities provided for the officers include a well-furnished smoking room which, like the dining saloon and suites, is panelled with polished hardwoods. Two-berth and three-berth cabins are provided for the crew, who also have the use of large messing and recreation rooms.

The vessel will be employed on services involving extreme variations of temperature; for this reason, the whole of the accommodation is insulated and is ventilated by means of mechanical supply fans with mechanical supply and exhaust fans to the galley. Reversible fans are fitted for ventilating the cargo holds, and the accommodation is heated by electrical radiators. Two lifeboats are carried and these are fitted under Lum-type davits and the complete life-saving equipment more than complies with the requirements of the Ministry of Transport. Comprehensive navigational equipment is provided; it includes radar, directional wireless, echo-sounding gear and a gyro-compass installation. Cargo is handled by 16 five-ton electric winches fitted with remote-control gear and arranged to serve 16 five-ton derricks; there is also a 30-ton derrick on the fore-mast and a 15-ton derrick on the mainmast. The stearing gear is of the electro-hydraulic type, and other deck machinery includes an electric windless forward on the forecastle deck and an electric capstan aft on the shelter deck.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

This list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

EXHIBITION OF EXHIBITIONS.—Tuesday, May 1, to Saturday, September 29, at the Royal Society of Arts, John Adam-street, London, W.C.2. See also our issue of April 27, page 497.

EXHIBITION OF SCIENCE.—Friday, May 4, to Sunday, September 30, at the Science Museum, South Kensington, London, S.W.7. Organised by the Festival of Britain authorities. Apply to the information officer, 2, Savoy-court, London, W.C.2. (Telephone: WATerloo 1951.) See also our issue of May 11, page 567.

EXHIBITION ILLUSTRATING HISTORY OF ALUMINIUM.—Thursday, May 10, to Friday, September 28. Organised by the Aluminium Development Association at their headquarters, 33, Grosvenor-street, London, W.1. (Telephone: MAYfair 7501.) See also our issue of May 18, page 599.

MAN-POWER EXHIBITION.—Friday, May 18, to Saturday, September 29, at the Safety, Health and Welfare Museum, Horseferry-road, London, S.W.1. See also our issue of May 25, page 630.

EXHIBITION OF INDUSTRIAL POWER.—Monday, May 28, to Saturday, August 18, at the Kelvin Hall, Glasgow. Organised by the Festival of Britain authorities. Apply to the information officer, 2, Savoy-court, London, W.C.2. (Telephone: WATerloo 1951.) See also our issue of June 1, page 663.

RADIO CONVENTION.—Various dates between Tuesday, July 3, and Thursday, September 6, at London, Southampton and Cambridge. Organised by the British Institution of Radio Engineers, 9, Bedford-square, London, W.C.1. (Telephone: MUSeum 1901.) See also our issue of March 30, page 377.

BRITISH ASSOCIATION.—Wednesday, August 8, to Wednesday, August 15, at Edinburgh. Apply to the joint local secretaries: Dr. G. B. Warburton, 11, Gracemount-road, Edinburgh, 9, and Mr. J. D. Robson, Engineering Department, Edinburgh University, Mayfield-road, Edinburgh, 9. See also page 96, *ante*.

UNITED STATES CONFERENCE ON PRESTRESSED CONCRETE.—Tuesday, August 14, to Thursday, August 16, at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A. Organised by the Institute. See also our issue of June 22, page 756.

"MODEL ENGINEER" EXHIBITION.—Wednesday, August 22, to Saturday, September 1, at the New Royal Horticultural Hall, Greycoat-street, London, S.W.1. Organisers: Messrs. Percival Marshall and Company, Limited, 23, Great Queen-street, London, W.C.2. (Telephone: CHAncery 6681.) See also our issue of June 15, page 721.

18TH NATIONAL RADIO SHOW.—Tuesday, August 28, to Saturday, September 8, at Earl's Court, London, S.W.5. Applications to be made to the Radio Industries Council, 59, Russell-square, London, W.C.1. (Telephone: MUSeum 6901.)

8TH INTERNATIONAL CONGRESS OF REFRIGERATION.—Wednesday, August 29, to Tuesday, September 11, at Church House, Westminster, London, S.W.1. Held under auspices of International Institute of Refrigeration. Apply to the secretary of the Congress, Dalmeny House, Monument-street, London, E.C.3. (Telephone: AVEnue 6851.) See also our issue of June 29, page 791.

SUMMER SCHOOL ON PRODUCTION ENGINEERING.—Wednesday, August 29, to Sunday, September 2, at University College, Durham. Organised by the Institution of Production Engineers, 36, Portman-square, London, W.1. (Telephone: WELbeck 6813.) See also our issue of April 6, page 395.

ENGINEERING, MARINE AND WELDING EXHIBITION.—Thursday, August 30, to Thursday, September 13, at Olympia, London, W.14. Organisers: Messrs. F. W. Bridges and Sons, Limited, Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

EUROPEAN MACHINE-TOOL EXHIBITION.—Saturday, September 1, to Monday, September 10, at Paris. Further particulars obtainable from the General Commissary of the Exhibition, 2 bis, Rue de la Baume, Paris, 8e. See also our issue of January 12, page 34.

LEIPZIG FAIRS.—*Autumn Fair*: Sunday, September 2, to Friday, September 7. Organised by Leipziger Messeamt, Platz des Friedens 8, Leipzig C.1, Germany.

THIRD ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—Monday, September 3, to Friday, September 7, at Brighton. Convened by the Royal Aeronautical Society, and the Institute of the Aeronautical Sciences (of America). Apply to the secretary of the Royal Aeronautical Society, 4, Hamilton-place, London, W.1. (Telephone: GROsvenor 3515.)

SUMMER SCHOOL ON RELAXATION METHODS.—Monday, September 3, to Friday, September 21, at the Imperial College of Science and Technology, South Kensington, London, S.W.7. Apply to Mr. D. N. de G. Allen at the College. (Telephone: KENsington 4861.) See also our issue of April 13, page 447.

SECOND INTERNATIONAL CONGRESS ON ASTRONAUTICS.—Monday, September 3, to Saturday, September 8, at Caxton Hall, London, S.W.1. Organised by British Interplanetary Society, 157, Friary-road, London, S.E.1. See also our issue of June 29, page 781.

SUMMER SCHOOL ON PHYSICS OF SOLIDS.—Thursday, September 6, to Saturday, September 15, at the University, Bristol. Apply to Mr. W. E. Salt, Director of Adult Education, The University, Bristol, 8. (Telephone: Bristol 24161.) See also our issue of April 13, page 429.

ENGINEERING SCHOOL OF GHENT.—Saturday, September 8, to Thursday, September 13, at Ghent, Belgium. Congress and exhibition in commemoration of the 75th anniversary of the A.I.G. (Association des Ingénieurs Sortis des Écoles Spéciales de Gand). Apply to Professor G. Willems, 155, Rue de la Loi, Résidence Palace, Brussels.

BUILDING RESEARCH CONGRESS.—Tuesday, September 11, to Thursday, September 20, in London. Detailed information may be obtained from the organising secretary, Building Research Congress 1951, Building Research Station, Bucknalls-lane, Garston, Watford, Hertfordshire. (Telephone: Garston 2514.)

CONFERENCE ON HEAT TRANSMISSION.—Tuesday, Wednesday and Thursday, September 11, 12 and 13, in London. Organised by technical societies in Britain, the United States, and on the Continent. Apply to the secretary, Institution of Mechanical Engineers, Storey's-gate, London, S.W.1. (Telephone: WHItehall 7476.) See also page 96, *ante*.

SUMMER SCHOOL IN AUTOMATIC COMPUTING.—Tuesday, September 11, to Friday, September 21, at the University mathematical laboratory, Cambridge. Apply to Mr. G. F. Hickson, Board of Extra-Mural Studies, Stuart House, Cambridge. (Telephone: Cambridge 56275.) See also our issue of June 1, page 673.

FARNBOROUGH FLYING DISPLAY AND EXHIBITION.—Wednesday, September 12, to Sunday, September 16. Organisers: Society of British Aircraft Constructors, Limited, 32, Savile-row, London, W.1. (Telephone: REGent 5215.) See also our issue of January 12, page 35.

CONGRESS OF INTERNATIONAL SCIENTIFIC FILM ASSOCIATION.—Saturday, September 15, to Saturday, September 22, at the Municipal Museum, The Hague, Holland. Information obtainable from the secretary, the Scientific Film Association, 4, Great Russell-street, London, W.C.1. (Telephone: MUSeum 2403.) See also our issue of May 18, page 612.

PRESTRESSED-CONCRETE STRUCTURES.—Monday and Tuesday, September 24 and 25, at the Institution of Structural Engineers, 11, Upper Belgrave-street, London, S.W.1. Apply to the secretary, the organisers, the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1. (Telephone: SLOane 5255.) See also our issue of May 11, page 574.

9TH INTERNATIONAL ROAD CONGRESS.—Monday, September 24, to Monday, October 8, at Lisbon. Sponsored by the Permanent International Association of Road Congresses, 24, Rue de l'Université, Paris. Apply to the joint honorary secretary, British organising committee, International Road Congress, Berkeley Square House, London, S.W.1. (Telephone: MAYfair 9494.)

INTERNATIONAL NAUTICAL EXHIBITION (MARITIME AND INLAND WATERWAYS INDUSTRIES).—Saturday, September 29, to Sunday, October 14, at Paris. Organised by the Chambre Syndicale des Industries Nautiques, 8, Rue Jean-Goujon, Paris, 8e.

ASLIB ANNUAL CONFERENCE.—Friday, October 5, to Monday, October 8, at Ashorne Hill, near Leamington Spa. Apply to the secretary, Aslib, 4, Palace-gate, London, W.8. (WEStern 6321.) See also our issue of March 23, page 350.

33RD NATIONAL METAL CONGRESS AND EXPOSITION.—Thursday, October 11, to Saturday, October 20, at Detroit, Michigan, U.S.A. Apply to Mr. W. H. Eisenman, secretary, American Society for Metals, 7301, Euclid-avenue, Cleveland 3, Ohio, U.S.A. See also our issue of January 19, page 79.

WORLD METALLURGICAL CONGRESS.—Monday, October 15, to Friday, October 19, at Detroit, Michigan, U.S.A., under auspices of the American Society for Metals. Apply to Mr. W. H. Eisenman, secretary, American Society for Metals, 7301, Euclid-avenue, Cleveland, 3, Ohio, U.S.A. See also our issue of January 19, page 79.

ENGINEERING INDUSTRIES ASSOCIATION.—Tuesday and Wednesday, October 16 and 17, at the Horticultural Hall, Greycoat-street, Westminster, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, London, W.1. (Telephone: WELbeck 2241.)

LAUNCHES AND TRIAL TRIPS.

M.S. "WESTERN COAST."—Single-screw cargo vessel, built by the Goole Shipbuilding & Repairing Co., Ltd., Goole, for the Coast Lines, Ltd., London, E.C.3. Main dimensions: 220 ft. between perpendiculars by 35 ft. by 21 ft. to shelter deck; deadweight capacity, about 1,250 tons on a mean draught of 13 ft. 11 in. British Polar seven-cylinder two-stroke Diesel engine, developing 1,140 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Speed, 12 knots. Launch June 19.

M.S. "NORFOLK FERRY."—Twin-screw train-ferry vessel, built and engined by John Brown & Co., Ltd., Clydebank, for the Harwich-Zeebrugge service of British Railways, Eastern Region. Main dimensions: 380 ft. between perpendiculars by 61 ft. 6 in. by 34 ft. 9 in. to upper deck. Two six-cylinder Sulzer Diesel engines together developing 2,680 b.h.p. at 194 r.p.m., and giving a service speed of 13 knots in loaded condition. Delivered, July 12.

S.S. "BRUNSWICK WHARF."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1. First vessel of a series of three. Main dimensions: 257 ft. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a draught of 17 ft. 1 in. Direct-acting triple-expansion engine of reheat design developing 800 i.h.p. at 78 r.p.m., constructed and installed by George Clark (1938), Ltd., Sunderland, and one coal-burning boiler. Speed, 10½ knots. Launch, July 3.

M.S. "NICOLINE MÆRSK."—Single-screw cargo vessel, to carry twelve passengers, built and engined by Burmeister & Wain, Copenhagen, for A. P. Möller, Copenhagen, Denmark. Main dimensions: 445 ft. between perpendiculars by 63 ft. 6 in. by 41 ft. 6 in. to upper deck; deadweight capacity, 9,650 tons on a summer draught of 27 ft. 8⅝ in.; cargo capacity, 638,700 cub. ft. Ten-cylinder single-acting two-stroke Diesel engine, developing 9,200 b.h.p. at 115 r.p.m. and a speed of 17¼ knots. Delivered, July 6.

M.S. "MARGARET ONSTAD."—Single-screw oil tanker, built and engined by the Götaverken A/B., Gothenburg, Sweden, for Skibs A/S Alse, Oslo, Norway. Main dimensions: 593 ft. 6 in. by 74 ft. 6 in. by 42 ft. 3 in.; deadweight capacity, 23,360 tons on a draught of approximately 32 ft. Götaverken nine-cylinder oil engine developing about 10,000 i.h.p. and a speed of 14¾ knots in service. Trial trip, July 6.

S.S. "KENYA."—Twin-screw liner, to carry 150 first-class and 123 tourist-class passengers, built and engined by Barclay, Curle & Co., Ltd., Glasgow, for the United Kingdom/East Africa service of the British India Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 540 ft. overall by 71 ft. by 38 ft. 6 in.; gross tonnage, 14,500; refrigerated-cargo capacity, 25,000 cub. ft. Two sets of steam turbines with single-reduction double-helical gearing and three oil-burning boilers. Service speed, 16 knots. Trial trip, July 12.

M.S. "CERES."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Rederiaktiebolaget Ceres, Stockholm, Sweden. Main dimensions: 496 ft. between perpendiculars by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, about 16,300 tons on a draught of 29 ft. 1 in.; oil-cargo capacity, 15,560 tons. N.E.M.-Doxford five-cylinder single-acting two-stroke oil engine, developing 5,500 b.h.p. at 114 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Launch, July 18.

M.S. "RANA."—Single-screw tug, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for Gaselee and Son, Ltd., London, E.C.3. Main dimensions: 80 ft. between perpendiculars by 21 ft. 6 in. by 10 ft. 9 in.; gross tonnage, 100. Five-cylinder opposed-piston Diesel engine, developing 700 b.h.p. at 220 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by Amos and Smith, Ltd., Hull. Launch, July 19.

S.S. "BELTINGE."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Constants (South Wales), Ltd., London, E.C.2. Main dimensions: 320 ft. between perpendiculars by 46 ft. 4 in. by 24 ft. 3½ in. to shelter deck; deadweight capacity, about 4,650 tons on a draught of 20 ft. 5¼ in. Triple-expansion steam engines of 1,250 i.h.p. at 75 r.p.m. and two oil-fired boilers. Speed, 10½ knots. Launch, July 19.

M.S. "THORSKOG."—Single-screw oil tanker, built by the Greenock Dockyard Co., Ltd., Greenock, for A/S Thor Dahl, Sandefjord, Norway. Main dimensions: 512 ft. between perpendiculars by 69 ft. by 38 ft. 6 in. to upper deck; deadweight capacity, 16,500 tons on a mean draught of 29 ft. 6 in.; gross tonnage, 11,400; oil-cargo space, 802,000 cub. ft. Wallsend-Doxford five-cylinder opposed-piston oil engine, developing 5,500 b.h.p. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Speed, 14 knots. Launch, July 20.