RECONSTRUCTION OF THE HOWDON-ON-TYNE GASWORKS.

THE reconstructed gasworks at Howdon-on-Tyne, which were formally declared open by Viscount Allendale, Lord Lieutenant of Northumberland, at a brief ceremony in September of this year, have done much to ease the supply problems of the Northern Gas Board since they were connected to the gas grid. The new works feed into a common distribution grid which serves both sides of the river Tyne and extends from the sea to the boundary of the Hexham division, northwards to the boundary of the Blyth division and southwards to the boundary with the Sunderland division, an area of approximately 400 square miles. This grid was already fed by gasworks at Newcastle, Gateshead, North Shields, South Shields and Jarrow, by two coke ovens in the Gateshead area and one at Jarrow. There is little doubt, therefore, that the effect of the new works at Howdon will be felt all over Tyneside and those areas which have suffered in past winters from reduced pressures should experience no such difficulties in future. The location of the works in relation to the Jarrow tunnel is of considerable significance since the tunnel has made it possible to install a cross-river connection, thus turning the grid into a square whereas previously it was in the form of a letter U, with two heavily-loaded extremities. These extremities are in areas in which considerable industrial and residential developments have taken place and in which the existing gasworks could only cope with a relatively small proportion of the total requirements. The inception of the new plant, therefore, will not only meet the needs of these districts but will leave a good margin for general distribution throughout the grid.

The new works replaces plant built between 1905 and 1908, which occupied an area of approximately 12½ acres and had a nominal capacity of 2¾ million cub. ft. per day. The works consisted of three benches of horizontal D-shaped retorts 22 in. by 16 in. by 20 ft. long, each bench containing six beds of eight retorts. In general, the site occupied by the new carbonising units is situated on the area previously occupied by the outside coal store. To provide an alternative storage area and space for a future gas-holder, purifier extensions and extensions to the railway sidings, additional land was purchased and the total site area is now approximately 21½ acres. The original sidings consisted of four short roads and these have been relaid completely and extended to eight longer roads with an additional shunting leg.

The new works consists of a carbonising plant with a capacity of 8,000,000 cub. ft. per day, a producer-gas plant for firing the chambers, a coke-handling plant, a carburetted-water-gas plant, primary and secondary condensers, wet and dry purification plants, a benzole recovery unit, a waste-heat boiler installation complete with turbo-alternator, a sulphate of ammonia plant, coal handling gear and bunkers and the usual exhausting plant, meter installations, etc. All these various units were installed and put into service without interfering in any way with the production of gas —a remarkable achievement. The principal contractors were Gas Chambers and Coke Ovens, Limited, Chandos House, Buckingham-gate, Westminster, London, S.W.1, who were responsible for the carbonising plant, coal and coke handling plants, producer plant, boilers and primary condensers. The foundation work was carried out by the Demolition and Construction Company, Limited, 3, St. James's-square, London, S.W.1, under a direct contract with the Northern Gas Board. These foundations were designed on behalf of the Gas Board by Messrs. L. G. Mouchel and Partners, Limited, 9, Ellison-place, Newcastle-on-Tyne. The Demolition and Construction Company were also responsible for the reinforced-concrete work carried out in connection with the coal-blending bunkers, the pad-coke and coal bunkers in the carbonising house, the coke wharves and associated conveyor tunnel, the coal-breaker pit and the coke-storage bunkers, the last-named building being the largest reinforced-concrete structure on the site. All this work, however, formed a contract with Gas Chambers and Coke Ovens, Limited, the main contractors, and the various structures were designed on behalf of the main contractors by Messrs. Stroyer & Adcock, 122, Wilton-road, London, S.W.1.

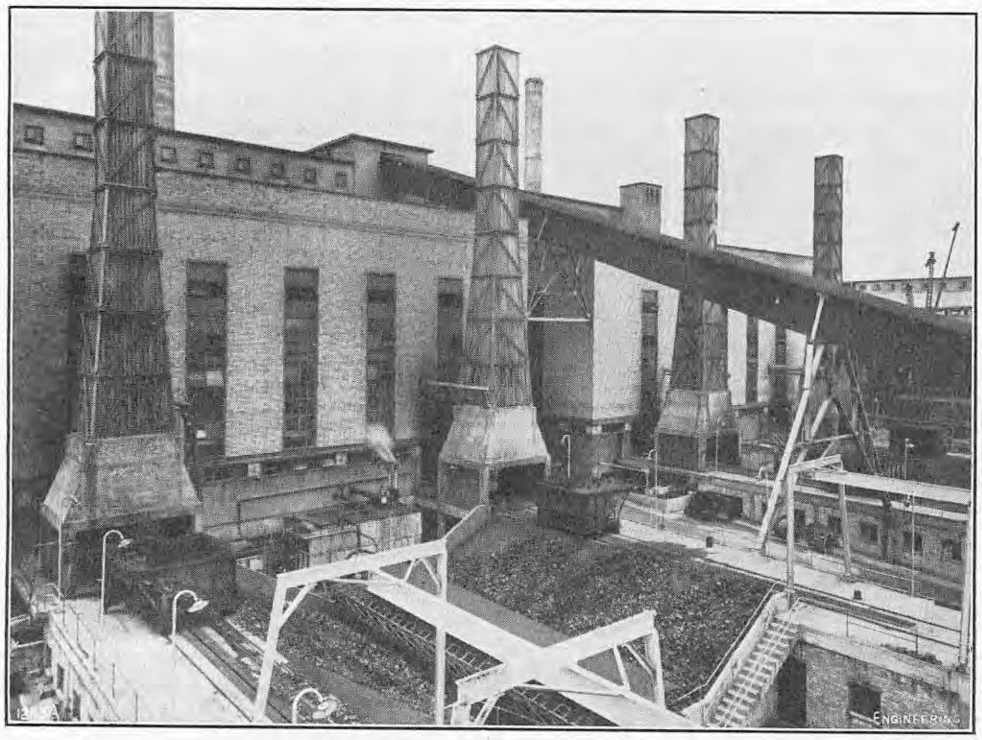

FIG. 1. CARBONISING PLANT AND COKE WHARVES.

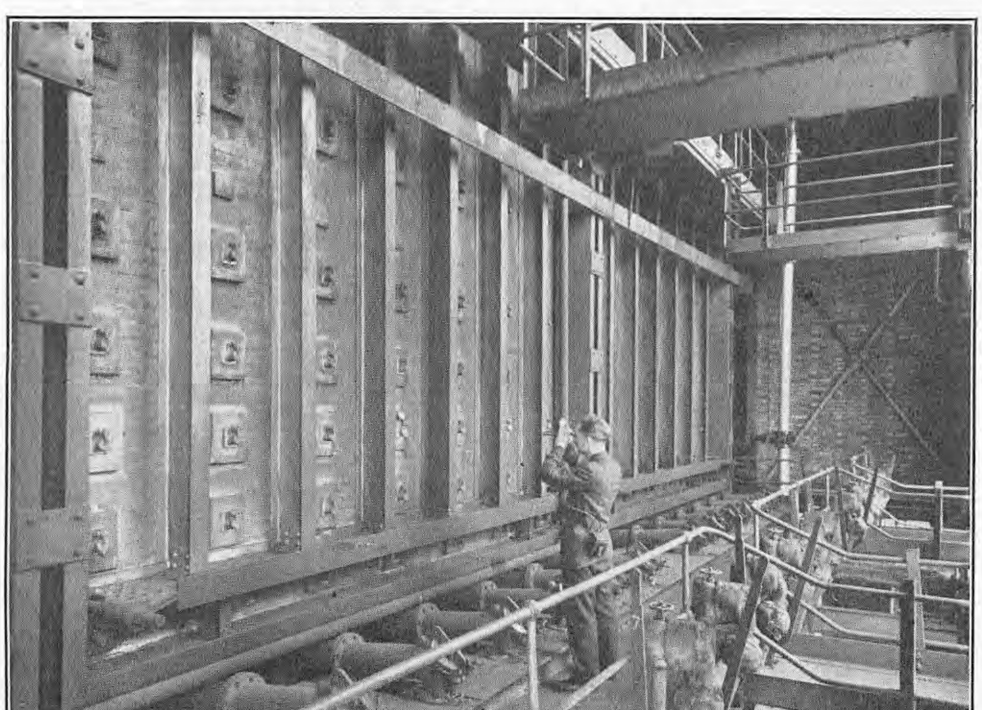

FIG. 2. CHAMBER SIDE OF BENCH.

CARBONISING PLANT.

The carbonising plant, an exterior view of which is shown in Fig. 1, on this page, consists of two independent units; these are arranged side by side as shown in Fig. 7, on Plate LXII, which gives a part-sectioned drawing of the complete plant. A front view of one of the units is given in Fig. 2. Each unit has two batteries, or benches, of 18 intermittent vertical chambers arranged in three settings of six chambers each. There are, therefore, 72 chambers in all, which, after making due allowance for scurfing, are capable of carbonising 540 tons of coal each 24 hours and producing a total of 8,000,000 cub. ft. of gas. Each chamber has a height of 23 ft. 7½ in. and the capacity with a coal density of 52·5 lb. per cub. ft. is 4·14 tons. Each setting of chambers is built as an independent unit which is free to expand vertically, and allowance has also been made for the accommodation of horizontal expansion. In addition, allowance has been made in the building of the chambers for accommodating the differential expansion between the firebrick lower courses and the silica of the chambers. The heating of each individual chamber is accomplished by means of the maker's system of multiple burners; in this case, five burners are superimposed one above the other. Burner blocks are provided with independent control of the gas and air, further regulation being provided by means of valves to each flue which are adjusted from the producer-gas valve platform at the recuperator side of the settings. The recuperators are used for pre-heating the air for combustion and are built monolithically with the settings from standard tongued and grooved bricks.

The chambers are each provided with three heat-resisting cast-iron charging-hole frames and lids having spherical seatings. Some of these can be seen in Fig. 3, on Plate LXI, which shows one of the charging floors. Cast-iron sight-hole boxes are installed at each side of the bench and the supply of secondary air to the settings is regulated by means of cast-iron air boxes, complete with slides and graduated scales. The bottom doors and frames are manufactured from a special heat-resisting metal and each door is provided with a machined knife edge which makes a gastight metal-to-metal joint with a machined facing on the underside of its corresponding frame. To protect the upper sides of the doors, each is fitted with a series of heat-resisting cast-iron domes which, in addition to reducing the amount of pad coke required, also protect the door from exposure to excessive heating. The domes are hollow and thus form passages for the gas to pass through on its way to the bottom off-takes, thus relieving the bottom of the chamber from excessive gas pressure. Each door is opened by gravity and closed hydraulically, hydraulic power being provided by two electrically-driven three-throw hydraulic pumps and associated accumulators, each pump and accumulator being capable of supplying the complete plant. A hand-operated winch is supplied for each bench, however, for use in the event of a complete hydraulic failure. These winches are of the worm-reduction type and can be operated quite easily by one man. The hydraulic pumps and accumulators are situated in the boiler house and are controlled automatically.

An off-take pipe is arranged at the top of each chamber through which the gas passes into a common collecting main extending the full length of the bench. From the collecting main the tar and liquor pass to the decanting tank and the gas rises through two risers into the foul main to the primary condensers, and from the primary condensers to the exhauster house. An Askania governor, with suitable by-pass and associated valves, is installed in each foul main, these units being located clear of the bench and well away from the heat, but accessible from the charging-floor level. Liquor sprays are arranged adjacent to the governors and a blow-off pipe is provided where the foul main leaves the bench, the blow-off pipe being fitted with a remotely-operated shut-off valve. Gas evolved at the bottom of each chamber passes through a bottom off-take into a common collecting main, which also serves as a tar main, a rising connection from this main conveying the gas into the top collecting main. The rising connection is provided with a shut-off valve and each bottom off-take is fitted with a cleaning cover, screw-down locking gear and an isolating valve.

Wet Purification Plant.

The wet purification plant, supplied by W. C. Holmes and Company, Limited, Turnbridge, Huddersfield, consists of primary condensers, exhausters, secondary condensers, ammonia and naphthalene washers. The secondary condensers are illustrated in Fig. 4, on Plate LXI, and the ammonia and naphthalene washers in Fig. 5. There are five primary condensers and these are arranged for working in pairs on two streams of gas in parallel, with the fifth condenser acting as a standby and available for use in either stream. Each condenser is capable of cooling 2,000,000 cub. ft. of gas per day, the temperature of the gas on entering being 180 deg. F. saturated and on leaving, within 6 deg. F. of the inlet temperature of the cooling water. To prevent naphthalene blockages in the condensers, the two coldest bays in each are fitted with sprays for irrigating the gas side of the tubes. After leaving the primary condensers, the gas passes to two of three Boston-type Holmes-Connersville exhausters, the third unit acting as a standby. The exhausters work in parallel and each is driven by a Belliss and Morcom two-crank vertical compound steam engine, the capacity of each unit being 4,000,000 cub. ft. per day and the pressure rise 54 in. of water when running at 403 r.p.m. The exhausters deliver the gas, still in two streams, to the secondary condensers; these are constructed on similar lines to the primary condensers, there being three in all, one of which acts as a standby. The secondary condensers are followed by electrostatic detarrers of the tubular type; these were supplied by Simon-Carves, Limited, Cheadle Heath, Stockport, Cheshire, and, like the other units in the plant, each is capable of dealing with 4,000,000 cub. ft. of gas per day. High-tension direct-current is supplied to each unit through an independent shock-proof high-tension static rectifier of Simon-Carves-Ferranti design.

On leaving the electrostatic detarrers, the gas passes in two streams into Holmes Multifilm static washers arranged in parallel. Each washer is in the form of two units, one with four chambers and the other with six chambers, the two end chambers in each six-chambered unit serving as a napthalene washer and the remaining eight chambers as an ammonia washer. Water and weak-ammonia liquor connections are arranged in such a way that either softened water or weak liquor with an ammonia content of 0·47 per cent. can be used and if required, water can be used in one unit and liquor in the other. The naphthalene washers are fed with a small stream of stripped oil from the benzole plant, the used oil, in turn, being pumped back to the rich-oil tank of the benzole plant. Adoption of this scheme enables the naphthalene washers to operate without making special provision for a clean-oil supply.

Dry Purification Plant.

The dry purification plant was supplied by the Oxley Engineering Company, Limited, Clarence-road, Leeds, 10. The complete installation consists of three units each capable of dealing with 4,500,000 cub. ft. of gas per day. A view showing one of the units at deck level is given in Fig. 6, on Plate LXI. Each unit consists of four boxes 40 ft. long by 30 ft. wide by 8 ft. deep which are housed in a steel structure 174 ft. long and 50 ft. wide. The boxes are of mild-steel construction throughout with all joints electrically welded. The bottom plates are laid on rolled-steel joists and there are four discharge openings to each box for emptying purposes. These plates are protected by a layer of reinforced concrete which is extended to the height of the lower tier of grids on the side, end and division plates. The boxes are arranged in line, those adjacent to each other having a common division plate, and the deck plates are arranged to give four openings to each box. These openings measure 16 ft. 6 in. by 11 ft. 3 in. and each is provided with a cover, the covers being handled by 3-ton pulley blocks operating on overhead runways. These covers and overhead runways can be seen in Fig. 6, on Plate LXI. The gas connections are made from 24-in. diameter welded steel pipe and are arranged for backward rotation with double-faced gas valves of Westwood and Wright manufacture. Each box, together with its valve casings, is drained into a sealing pot which, in turn, discharges into a common 4-in. diameter drain extending the length of each unit. All boxes are fitted with a 3-in. connection for the delivery of air supplied by a Root's blower.

The steel-framed building housing each set of purifiers consists of main and subsidiary stanchions and associated joists, arranged to support the purifier boxes 12 ft. above ground level, with a reinforced-concrete revivifying floor for the oxide 31 ft. above ground level. All three units are interconnected at the level of the revivifying floors with covered gangways 8 ft. wide for distribution of the oxide. There are openings in the floors over each purifier box with fittings for a canvas chute to direct the oxide into the boxes. After disintegration and mixing at ground level, the oxide is raised to the revivifying floor by an electrically-operated semi-automatic skip hoist having a capacity of 18 cwt. The bucket is fed from a reinforced-concrete hopper and at the top of its travel discharges into a steel bunker from which the oxide is distributed to the various boxes by means of Lister trucks. The skip hoist is controlled by a push-button, but the operation is automatic from the moment the fuel bucket leaves ground level until it returns empty. The one skip hoist serves all three units and is fitted to No. 2 unit.

On leaving the dry-box purifiers the gas passes through two Holmes-Connersville meters arranged in parallel. These two meters are illustrated in Fig. 8, on Plate LXII. They are made almost entirely from cast iron and are of the two-lobe double-impeller type, a form of meter that has proved most popular for measuring gas in bulk. The design is such that the errors due to clearances are negligible but, on the other hand, the clearances are sufficient to reduce friction to a minimum, thus ensuring that low differential pressures will operate the meter. At normal loading the capacity of each meter is 250,000 cub. ft. of gas per hour and the meters are fitted with a pressure, volume, temperature and time-recording instrument. The chart is revolved by the meter itself, thereby making it possible to obtain a true average pressure and temperature by means of a polar planimeter.

Coal and Pad-Coke Bunkers.

A separate bunker for the coal and pad coke is provided for each bench. These are of reinforced-concrete construction and are arranged at the opposite end of the carbonising house to the quenching chambers. They were erected by the Demolition and Construction Company, Limited, and each has a capacity of 270 tons of coal and 40 tons of pad coke. They are built in pairs, one pair for each unit, and the space between them is filled in at each side with reinforced-concrete panels down to the underside of the hoppers. A flat reinforced-concrete roof extends over the bunkers, and the sides above the top of the bunkers are glazed, access to the space thus formed above the bunkers being gained by a set of staircases and landings arranged within the covered space between the bunkers. The sloping sides and bottom of each coal compartment, and the complete interior of each pad-coke compartment, are lined with 1½-in. thick tiles set in mortar, special dovetail tiles being fitted to all vertical faces. The coal sections of the bunkers are provided with twelve outlets and the pad-coke sections with six outlets, each outlet being fitted with a quadrant gate arranged so that three units work together. A reinforced-concrete floor is provided below the bunkers and this is arranged so that it forms a continuation of the platform over the top of the settings, thus giving access to the bunker doors. Below this floor is a further reinforced-concrete platform which forms the floor of the boiler house and also the ceiling for the offices and mess-rooms, which are arranged at the floor level of the carbonising house.

Coal-Handling Plant.

Apart from the conveyors which finally deliver the coal into the bunkers in the carbonising house, separate coal-handling plants are provided for each

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RECONSTRUCTION OF HOWDON-ON-TYNE GASWORKS.

(*For Description, see Page* 809.)

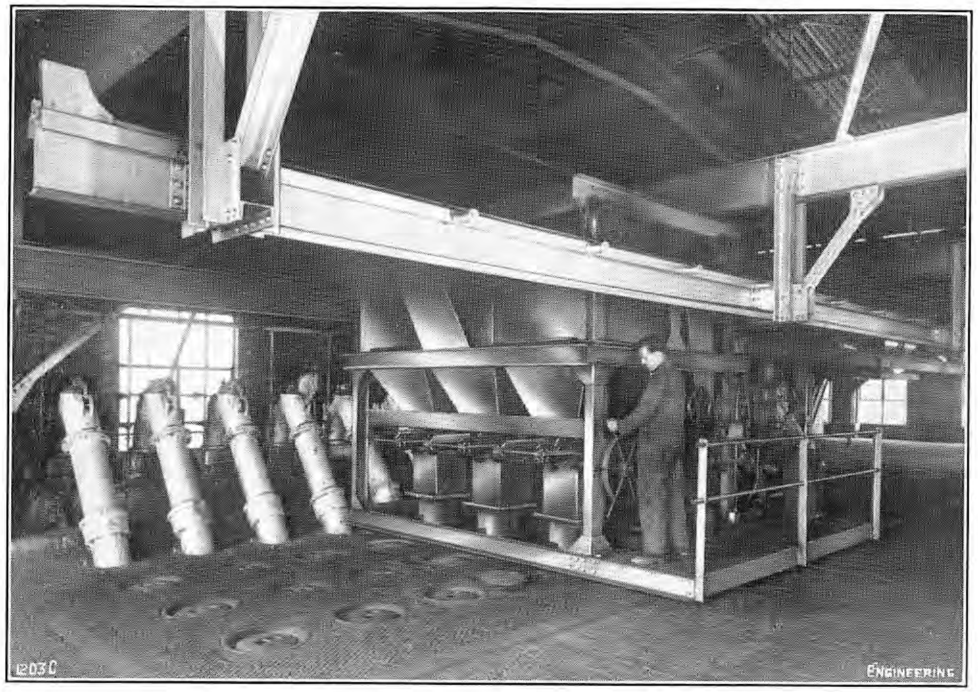

FIG. 3. CHARGING FLOOR AND COAL AND PAD-COKE CHARGING CAR.

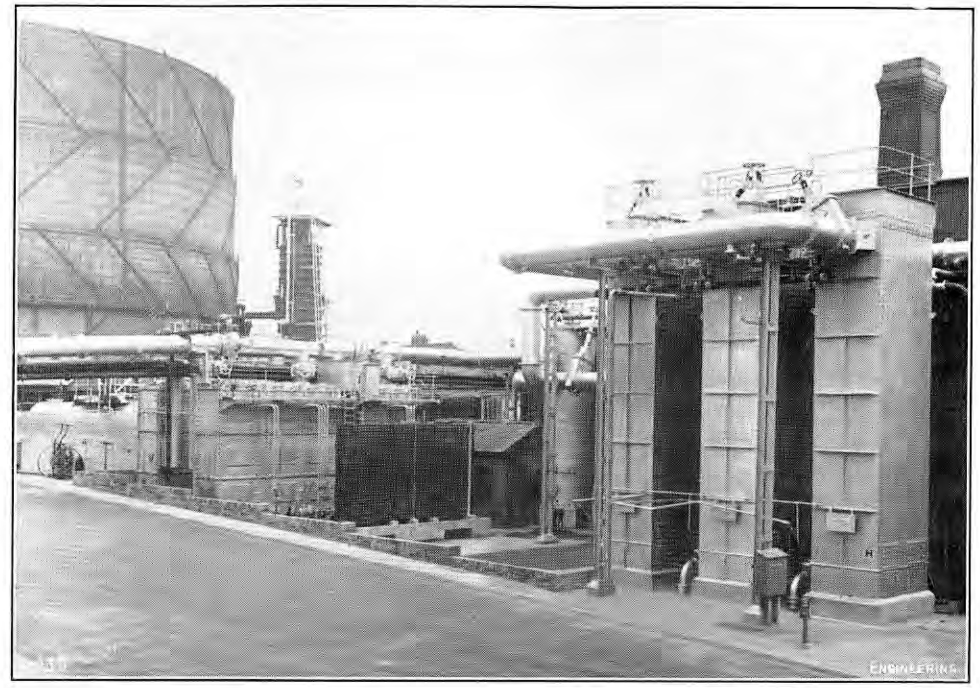

FIG. 4. SECONDARY CONDENSERS, DETARRERS AND AMMONIA AND NAPHTHALENE WASHERS.

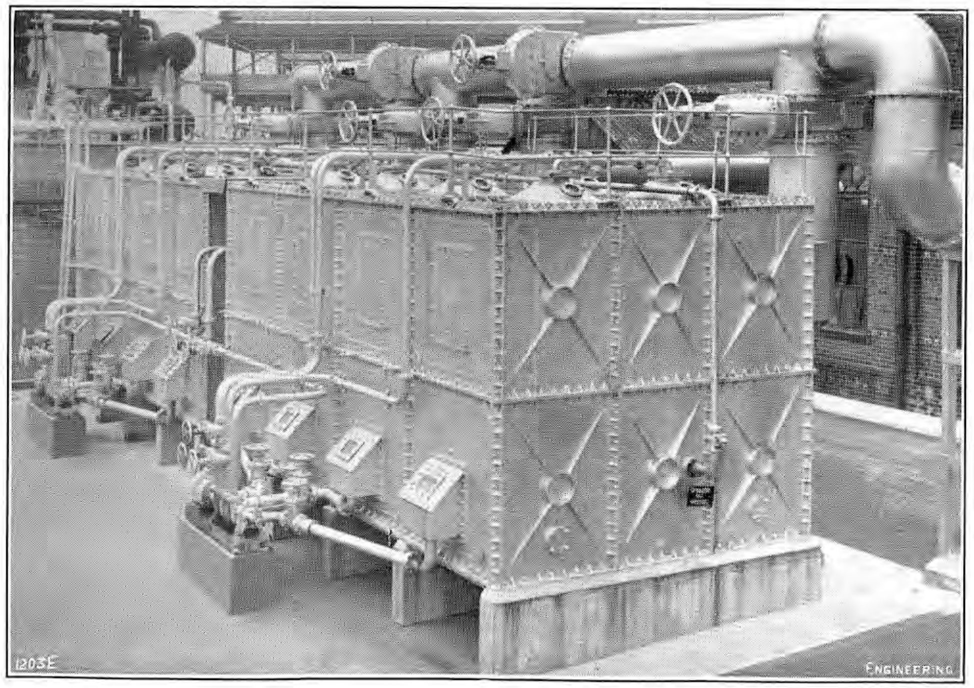

FIG. 5. AMMONIA AND NAPHTHALENE WASHERS.

FIG. 6. TOP OF PURIFICATION BOXES.

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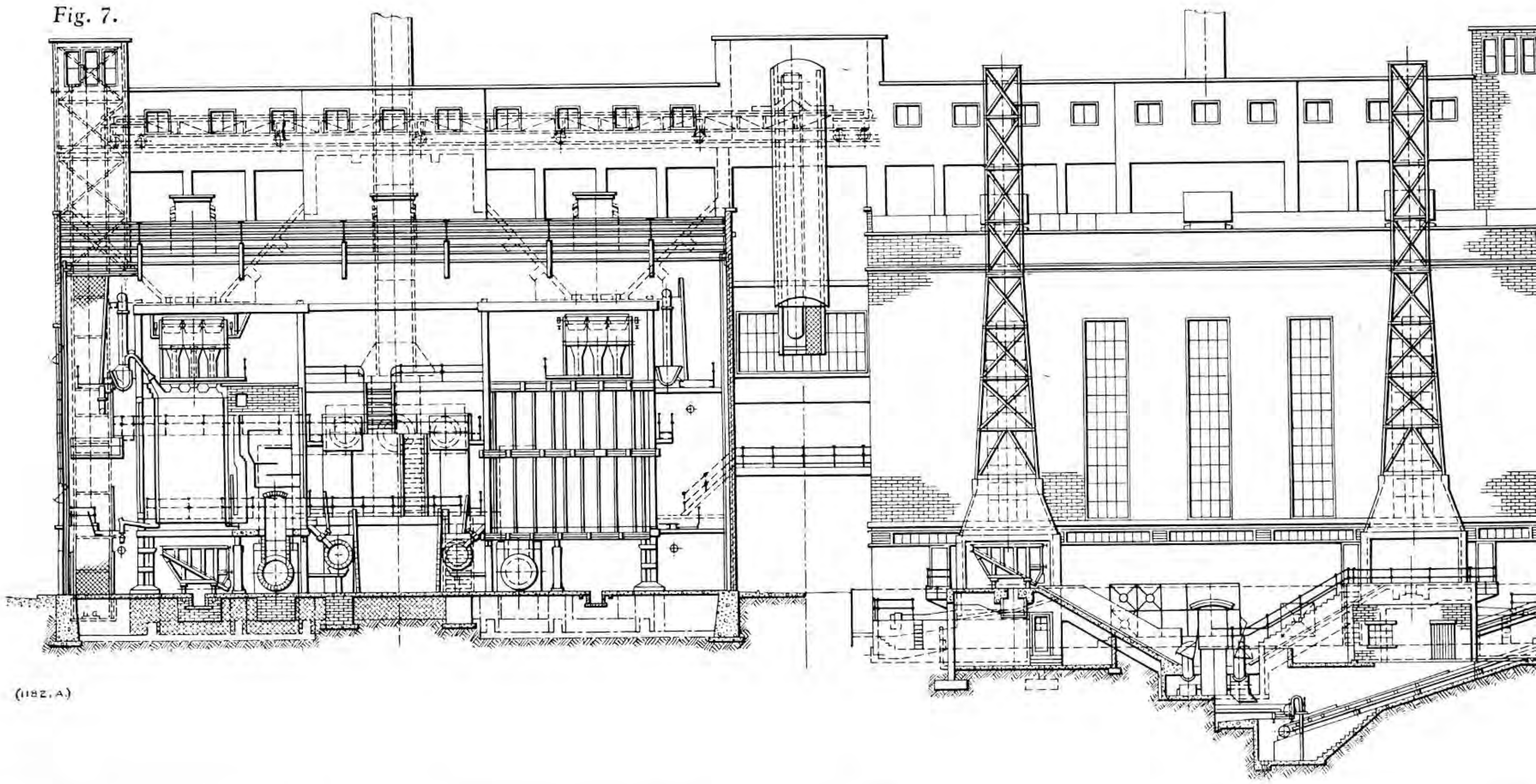
Fig. 7.



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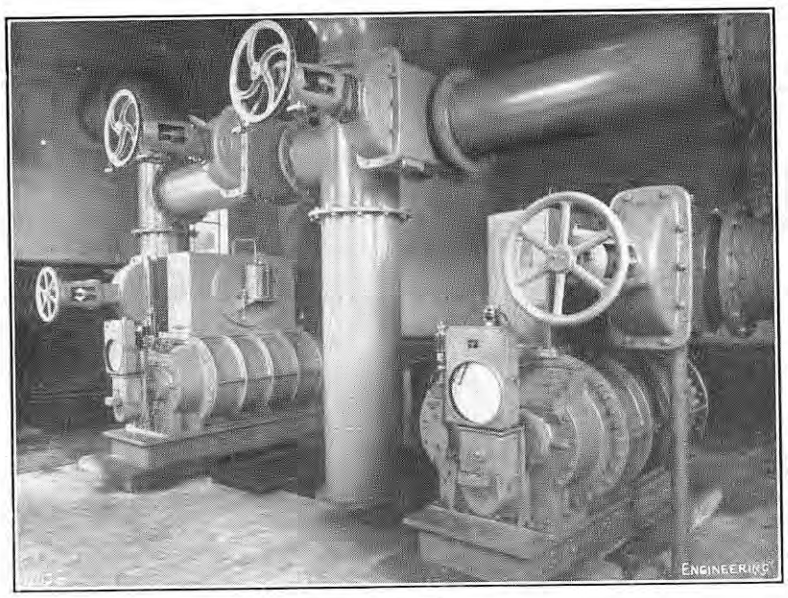

Fig. 8. Gas Meters.

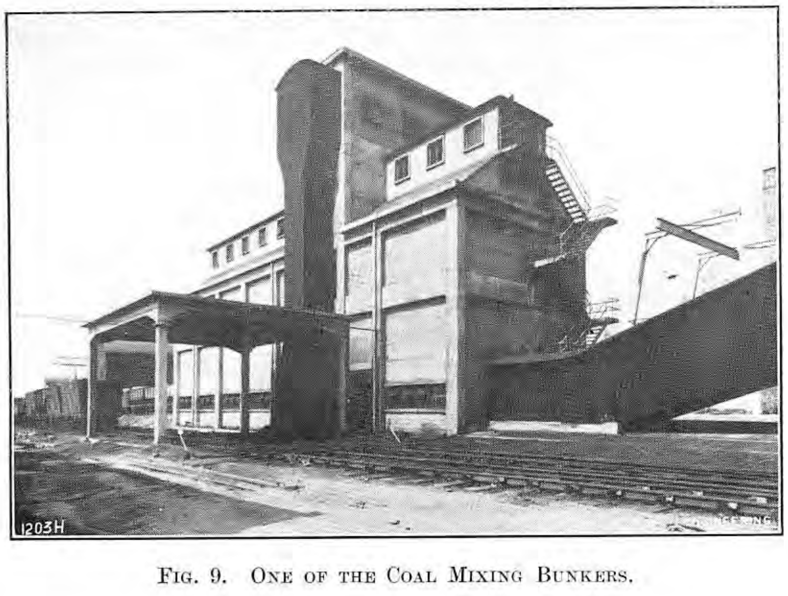

Fig. 9. One of the Coal Mixing Bunkers.

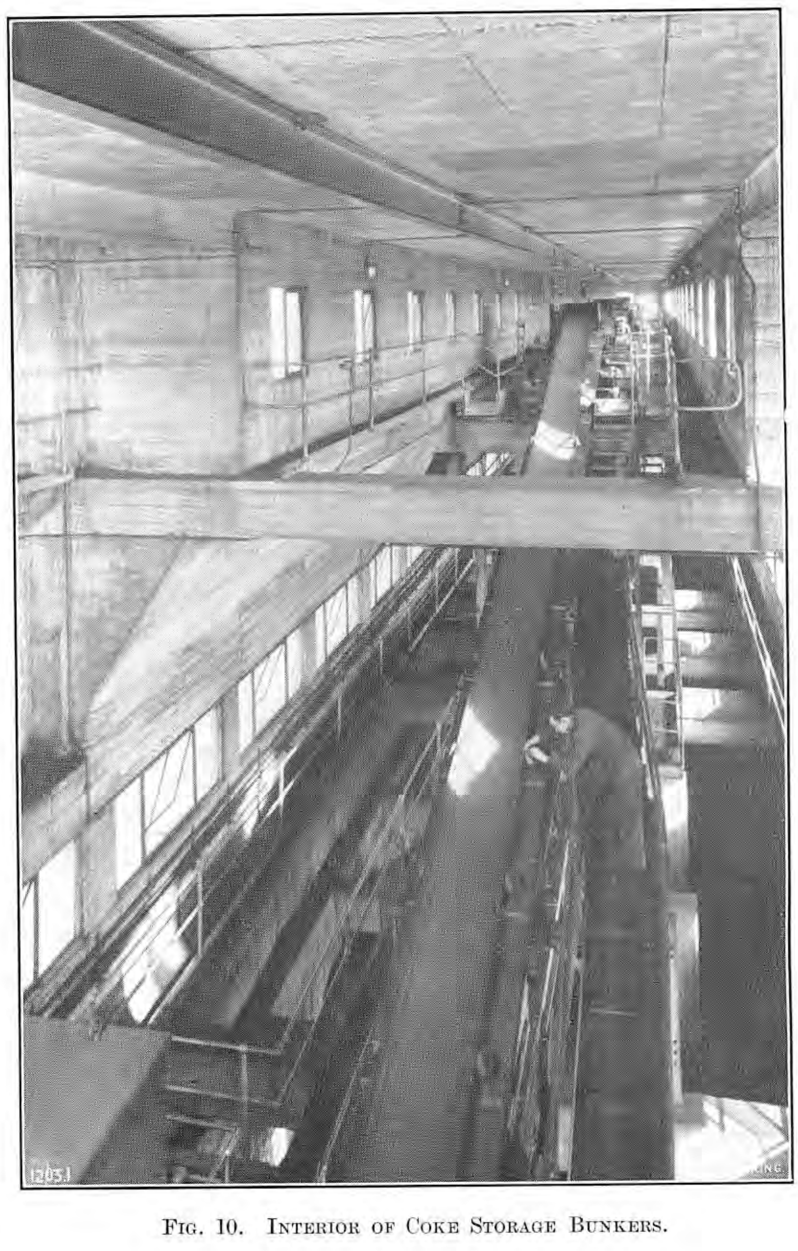

Fig. 10. Interior of Coke Storage Bunkers.

WDON-ON-TYNE GASWORKS.

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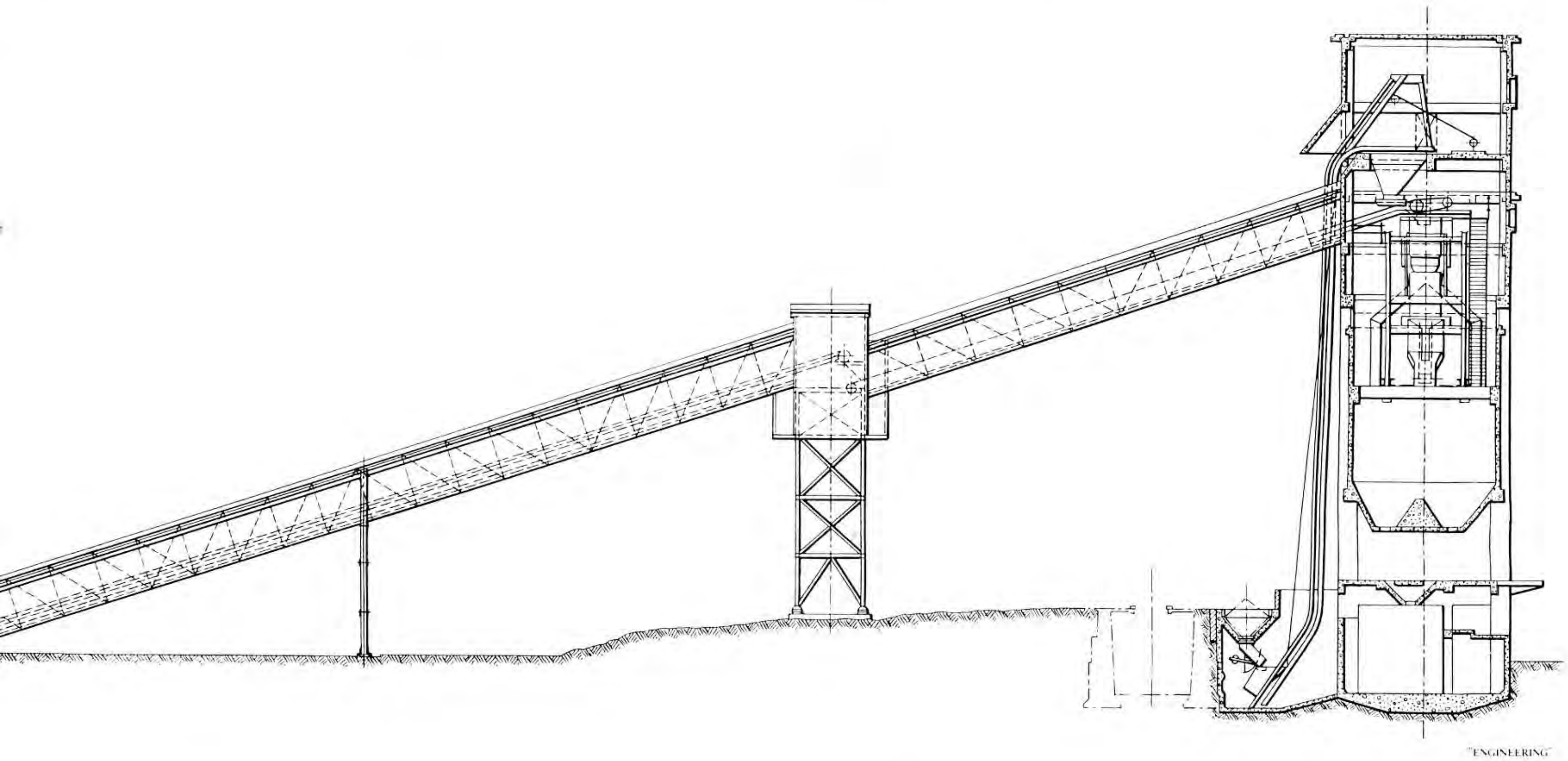

FIG. 11. COKE STORAGE BUNKERS.

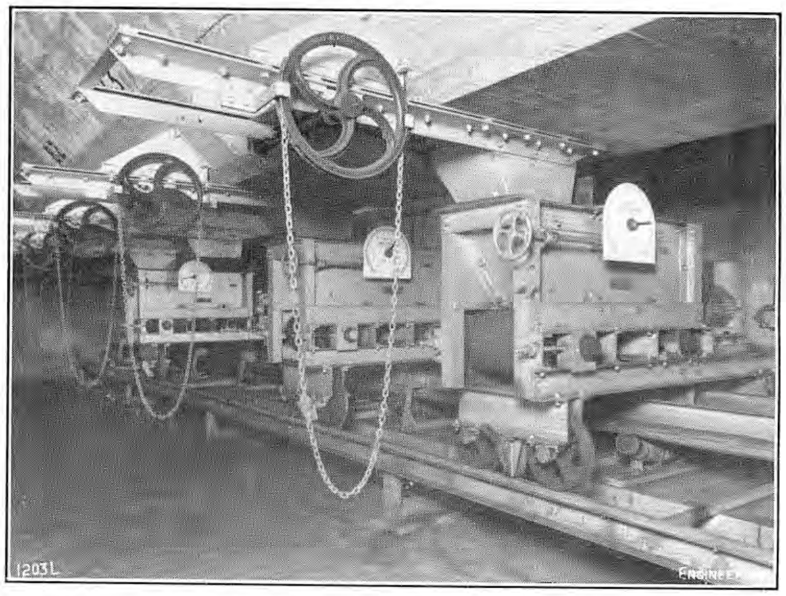

FIG. 12. "CUBIMETERS" IN COAL MIXING BUNKERS.

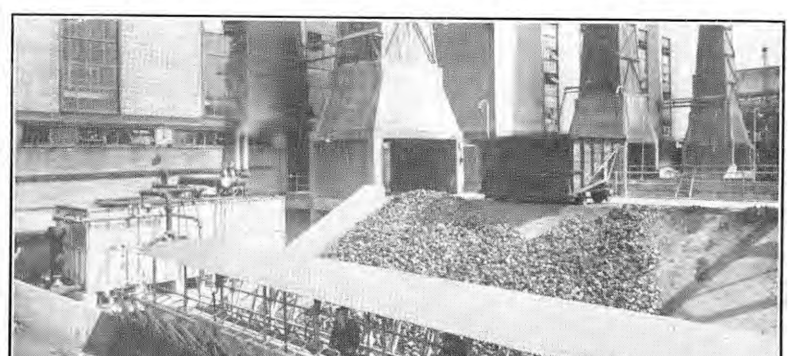

FIG. 13. WHARVES FOR QUENCHED COKE.

RECONSTRUCTION OF HOWDON-ON-TYNE GASWORKS.

(*For Description, see Page* 809.)

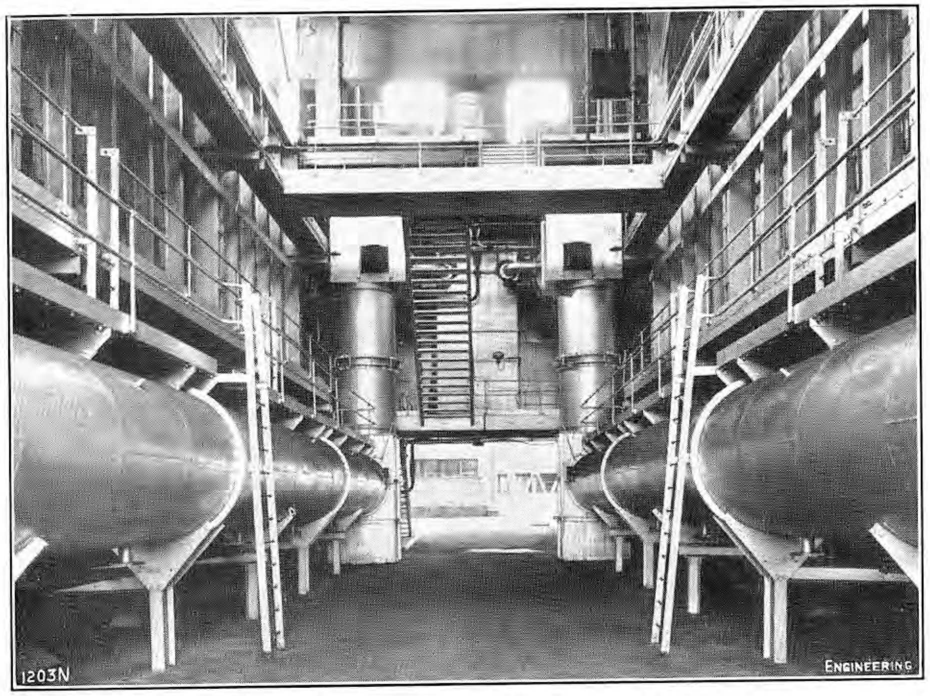

Fig. 14. Producer-Gas Mains Behind Benches.

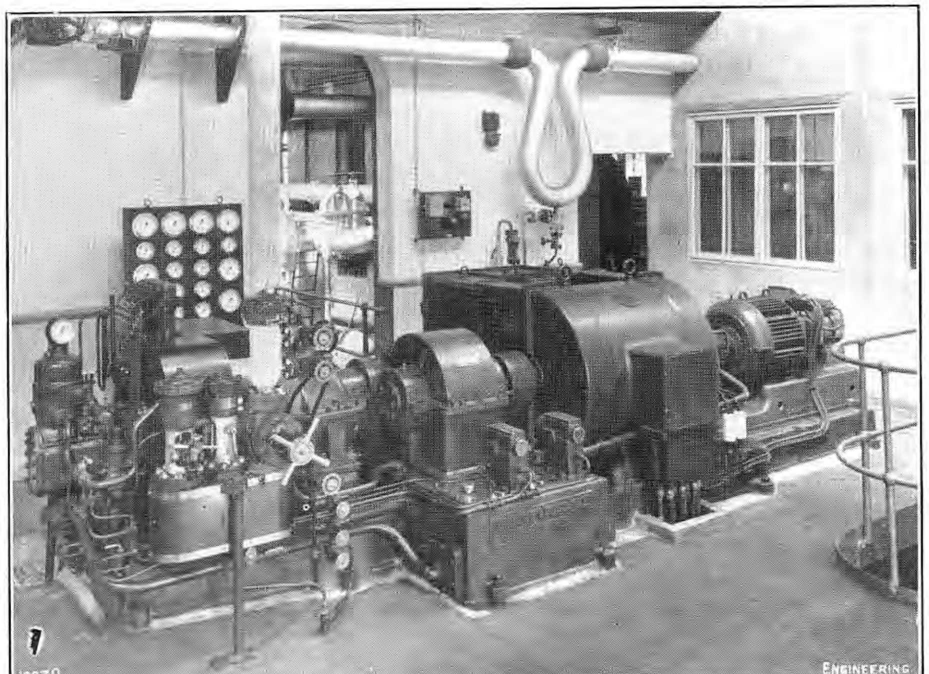

Fig. 15. 530-KW Turbo-Alternator.

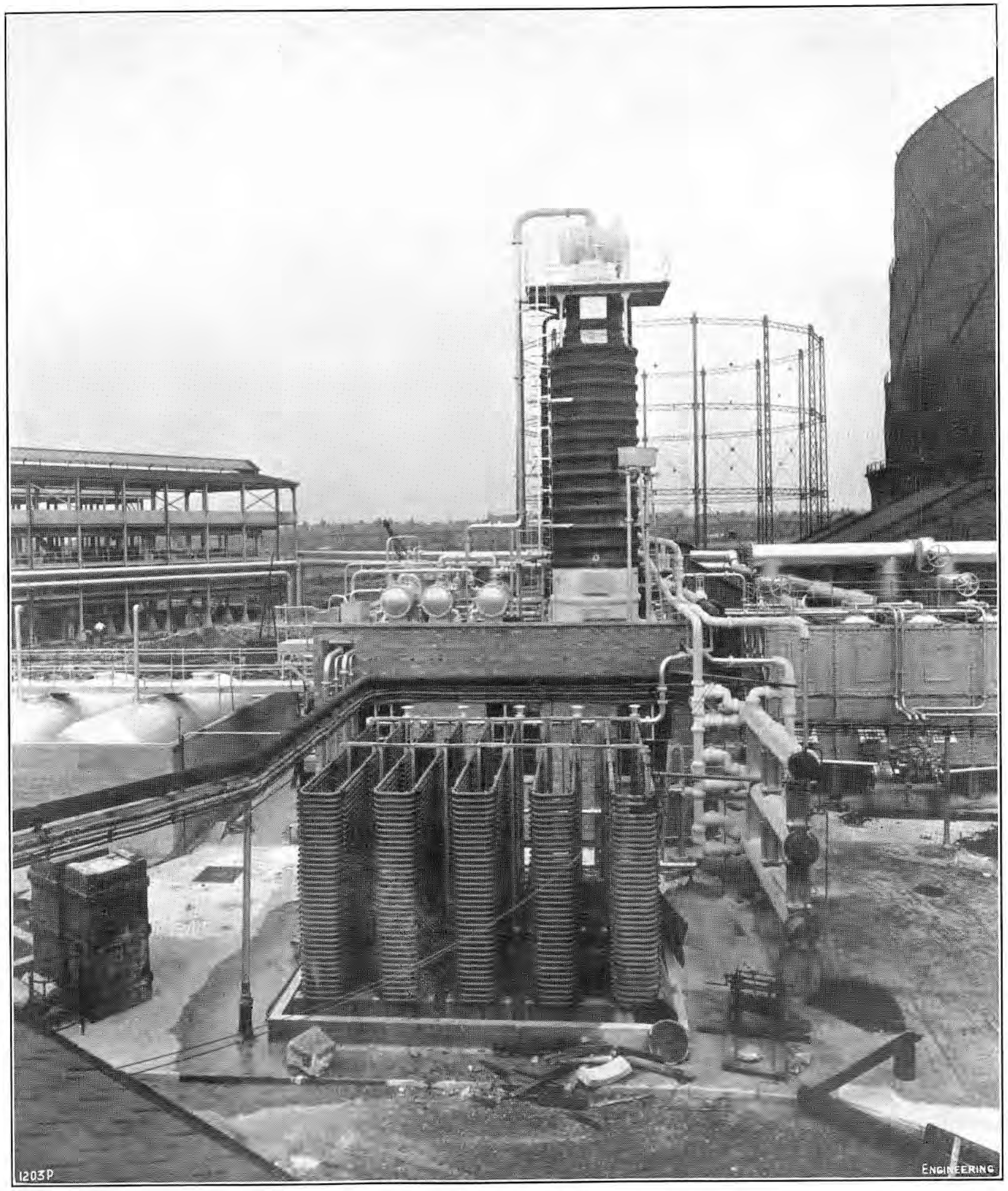

Fig. 16. Benzole Plant.

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RECONSTRUCTION OF HOWDON-ON-TYNE GASWORKS.

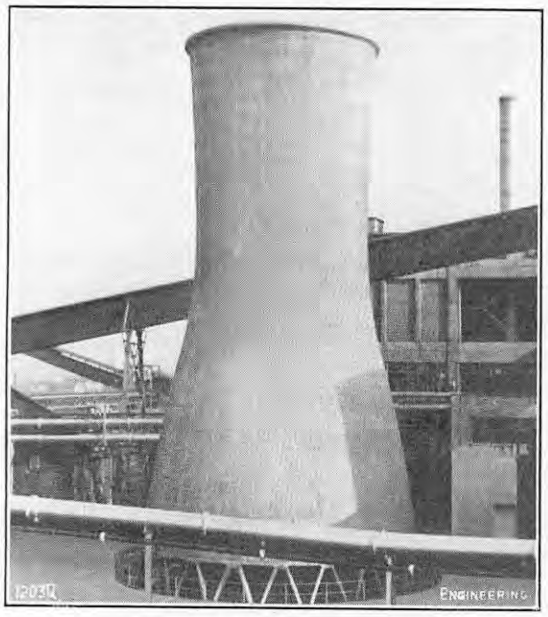


FIG. 17. FORCED-DRAUGHT COOLING TOWER.

FIG. 18. CARBURETTED-WATER-GAS PLANT.

carbonising unit. In each case the coal is delivered from 20-ton bottom-discharge railway wagons into an underground hopper. From this hopper the coal is fed by a reciprocating feeder into a crusher, a by-pass being arranged so that coal below 1 in. is diverted past the crusher; provision is also made for by-passing the crusher completely when required. The broken coal is discharged from the crusher into a lip-bucket conveyor that elevates and delivers it to a reversible shuttle-type belt conveyor which, in turn, directs the coal into the mixing bunker. One of the mixing bunkers, which are of reinforced-concrete construction and were erected by the Demolition and Construction Company, Limited, is illustrated in Fig. 9, on Plate LXII. These bunkers each have a capacity of 790 tons, are self-emptying and are divided into three sections, the bottom of each section being provided with outlets and shut-off gates.

The coal is discharged from the outlets through Cubimeter machines, which measure the quantities of each class of coal, on to a collecting belt conveyor situated below the bunker. One set of Cubimeters and the associated collecting conveyor are illustrated in Fig. 12, on Plate LXII. Each collecting conveyor is arranged so that it discharges at the end of the mixing bunker nearer the centre line of the carbonising plant, the discharge being directed on to an inclined belt conveyor. This conveyor, in turn, elevates the coal to a transfer tower and delivers it to a further inclined belt conveyor. This latter conveyor is arranged at right angles to that just referred to and conveys and elevates the coal to both sets of bunkers in the carbonising house, final discharge of the coal into the bunkers being effected through a reversible shuttle-type conveyor. This is provided with a bifurcated chute which directs the coal into the various sections of the bunker.

The coal and pad coke are fed into the vertical carbonising chambers by means of charging cars. These were constructed by Messrs. M. B. Wild and Company, Limited, Argyle-street, Nechells, Birmingham, to the order of Gas Chambers and Coke Ovens, Limited. There is a separate car for each battery or bench and one of the cars is shown in action in Fig. 3, on Plate LXI. They are arranged to run on overhead rails which pass below the base of the main coal and pad-coke bunker so that they can be filled directly by gravity. Each car consists of a structural-steel frame provided with two sets of three hoppers for receiving coal and pad coke, respectively. There are three outlets and the design is such that, once the car is manœuvred into position over the chambers, both the pad coke and coal can be discharged without having to move the car. The outlets are provided with hand-operated drop sleeves which register with the charging holes on the chambers, thus preventing the smoke normally generated during the charging operation from escaping into the carbonising house. The capacity of the coal and pad-coke hoppers is sufficient for one charge but each coal hopper is provided with an adjustable plate so that the operator can pre-determine the exact amount of coal to be fed into the chambers. The car is provided with roller-bearing cast-steel wheels and a travelling motor, together with reduction gearing and a controller. A solenoid-operated brake is fitted and this is interlocked with the drop sleeves previously referred to so as to prevent the car travelling with the drop sleeves lowered. Electric current for operating the car is fed through a spring-loaded reeling cable, and hand-operated travelling gear is provided for use in the event of a mains failure. Each car is fitted with a vibrating mechanism and, to enable each coal charge to the chambers to be weighed, a weighbridge is provided in each set of overhead runways.

COKE-HANDLING AND SCREENING PLANT.

After the carbonising process is completed, the coke is discharged from the base of the chambers into hot-coke cars, there being a separate car for each battery. These operate on rails laid below each bench so that they can be located under each chamber as required. The cars were manufactured by M. B. Wild and Company, Limited, and the haulage gear by Naylor Brothers, Limited, Golborne, Lancashire, to the order of Gas Chambers and Coke Ovens, Limited. After receiving the hot coke, each car is hauled into a quenching chamber, of which there are four in all, situated outside the carbonising house. After quenching, the car is hauled from the quenching chamber to its associated coke wharf, where the coke is discharged. From the coke wharf, the quenched coke is discharged through finger gates on to a belt conveyor, the coke wharves and conveyors being arranged in pairs, that is, one pair for each complete carbonising unit, with a finger-gate operating platform between each pair of conveyors. This arrangement will be clear from Fig. 13, on Plate LXII, which shows one pair of coke wharves with the finger-gate platform situated centrally between them. The conveyors situated between the coke wharves are discharged on to a further conveyor arranged at right angles to the wharves, which, in turn, delivers the coke to an inclined belt conveyor, the discharge end of which is situated at the top of a transfer tower arranged further inclined conveyor with belt weigher, which conveys it to a screening plant, or on to a level conveyor set at right angles to the run of the inclined conveyors, and designed to discharge the coke to the stockpile. This latter conveyor, which is known as the stocking conveyor, is fitted with a travelling tripper and bifurcated chute for discharging the coke, but a cast-iron helical chute is provided for forming the initial stockpile. The coke is reclaimed from the stockyard by a travelling grab crane which delivers it either directly to trucks or to an automatic skip hoist which elevates the coke to the screening plant. Coke is, therefore, delivered to the screens either directly from the carbonising plant or from stock by the skip hoist.

The coke-storage bunkers were constructed by the Demolition and Construction Company, Limited. The bunkers, which are illustrated in Figs. 10 and 11, on Plate LXII, are of reinforced concrete, with a reinforced-concrete house above to contain the screening plant. The screening plant consists of a vibrating scalping screen which removes all coke below $3\frac{1}{2}$ in., coke larger than this passing to an adjustable coke cutter; provision is made for by-passing the cutter when required. Coke below $3\frac{1}{2}$ in. passes on to four single-deck vibrating screens arranged at suitable intervals above the top of the storage bunkers. These screens are connected to each other by short belt conveyors and are designed to divide the coke into five different sizes ranging from breeze, that is, below $\frac{3}{8}$ in., to that between 2 in. and $3\frac{1}{2}$ in. Two shuttle conveyors are provided for distributing two of the intermediate grades into the bunkers.

The bunkers are of the self-emptying type and have a total capacity of 1,040 tons, comprising 120 tons of breeze; 100 tons of $\frac{3}{8}$ in. to $\frac{3}{4}$ in.; 300 tons of $\frac{3}{4}$ in. to $1\frac{1}{4}$ in.; 100 tons of $1\frac{1}{4}$ in. to 2 in.; 300 tons of $1\frac{1}{4}$ in. to 2 in.; and 120 tons of 2 in. to $3\frac{1}{2}$ in. The bottom of the bunkers is stepped to conform as far as practicable with the fall of the ground and are provided with base outlet gates and operating gear. Provision is made for removing the breeze from, and discharging into road or railway wagons, each size of coke, and bagging stages and associated equipment are provided for the three smaller sizes. The breeze is removed by ten travelling-type A.C.E. debreezers, and five Belle Isle bagging and weighing machines are provided for the bagging stations. Below the bunkers there are operating platforms and troughs to receive the breeze from the debreezing screens, the troughs being fitted with outlets for discharging the breeze into railway wagons. Like the main structure, the operating platforms and troughs are constructed from reinforced concrete.

PRODUCER-GAS PLANT.

As already mentioned, the benches are fired by means of producer gas. This is supplied by four mechanical gas producers installed in a separate building adjacent to the carbonising house. Size $1\frac{1}{4}$-in. to 2-in. coke is used in the producers and this is fed from the main storage bunkers by a travelling feeder which deposits it on an inclined conveyor extending along the length of the bunker house. Part of the inclined conveyor can be seen in Fig. 10, on Plate LXII, which shows the interior of the coke-storage bunkers. This conveyor, in turn, deposits the coke on to a further inclined conveyor set at right angles to the longitudinal axis of the bunker house and arranged to carry the coke to storage bunkers situated above the producer plant. The discharge end of the conveyor is provided with a three-way chute, through which the coke is discharged on to a shuttle conveyor that can be positioned to distribute the coke as required in the bunkers. The coke delivered to the gas-producer plant is weighed by an automatic belt weigher incorporated in the first of the inclined conveyors. Pad coke for the chamber bottom doors is also conveyed from the coke storage bunkers on the two inclined belts, but is discharged through the three-way chute just mentioned on to a short inclined conveyor that carries it into the battery-bunker house, a shuttle conveyor installed above the bunkers directing it into the required bunker. The third leg of the three-way chute discharges the coke on to a belt conveyor which carries it to the carburetted-water-gas plant. The capacity of the plant delivering the coke to the producer-gas plant, carburetted-water-gas plant and pad-coke bunkers is 35 tons an hour.

The producer-gas plant, as previously mentioned, comprises a battery of four mechanical gas producers. These were supplied by the Power Gas Corporation, Stockton-on-Tees, and are situated in a building at the north side of the battery bunkers with the coke-storage bunkers above. The bunkers consist of four hoppers which are capable of storing sufficient coke for 48 hours operation. The producers are of the self-vaporising type and each unit is capable of gasifying 38 tons of coke per 24 hours at normal load. Normally, one of the three producers acts as a standby. Each producer embodies a revolving grate, automatic continuous ash discharge, an internal distributing chute to ensure an even bed, air-blown poke-holes and mechanically-operated cyclic coke feed. The coke feed for each unit consists of a chute from the overhead bunkers which has a mechanical screen and feeds into an intermediate measuring hopper. From the hopper the fuel is fed intermittently according to requirements into the charger, the latter having a sliding valve with protected faces at the top and a bell-type valve at the base which controls the actual discharge into the producer. The feed is controlled by an electrode in the distributor, installed inside the producer; mechanical and electrical sequence interlocks are provided between the various sections. The revolving grate in each case is actuated by a hydraulic-type driving gear designed to give a wide range of speeds. Air for operating the producers is supplied by two electrically-driven blowers each of which is capable of dealing with the maximum requirements of any three producers. Four dust catchers are provided, one for each producer; these are of the vortex pattern and are lined internally with firebricks, the connections to the corresponding producers being made by refractory-lined pipes. The producer gas is led to the carbonising houses through welded-steel mains and in the carbonising houses a separate main is provided for each bench; these are arranged at floor level along the recuperator side of the bench, as shown in Fig. 14, on Plate LXIII. All producer-gas mains are lined internally with refractory-insulating and insulating brickwork.

WASTE-HEAT BOILERS.

Six Spencer-Bonecourt horizontal induced-draught waste-heat boilers are installed below the main coal and pad-coke storage bunkers in the carbonising house. They are designed for a pressure of 300 lb. per sq. in. and each is capable of handling the waste gas from one bench of chambers; with the carbonising plant fully at work, therefore, two boilers act as standbys. Each boiler is provided with an electrically-driven induced-draught fan, the drive to which incorporates a Vulcan-Sinclair scoop-controlled coupling for speed variation. Four electrically-operated feedwater pumps and associated tanks are provided, each pump being capable of meeting the requirments of two boilers under full load. The waste gases from the benches are collected in a flue arranged above the carbonising-house floor and under the recuperators of each bench. This terminates at approximately the centre of the boiler house, where it rises above the boiler-house floor and is connected to the boilers.

The waste-gas flues, consisting of steel casings lined with firebrick and insulating brick, are fitted with dampers, etc., for isolating the boilers as required, There are two brick-lined steel chimneys, each of which is large enough to provide adequate natural draught for one complete unit, that is, 36 chambers. The steam services consist of a ring main, 4 in. in diameter, from which connections are made to the various sections of the plant. A steam manifold is arranged along the chamber side of each bench with connections to each door frame, isolating and reducing valves being installed at the end of each manifold. The branch connections are also provided with isolating valves and an orifice plate to regulate the rate at which steaming is carried out.

CARBURETTED-WATER-GAS PLANT.

To meet peak-load requirements, a carburetted-water-gas plant has been installed. This unit, which is illustrated in Fig. 18, on page 811, was supplied and erected by Messrs. Humphreys and Glasgow, Limited, and has a capacity of 4,000,000 cub. ft. of gas per day with a calorific value of 475 B.Th.U. The plant consists of a water-sealed self-clinkering generator, with annular jacket boiler and automatic coke-charging gear, separate carburetter and superheater, raised washer with conical bottom and rotary valve for easy sludge removal, and a waste-heat boiler. The plant is operated hydraulically; the system was developed by Messrs. Humphreys and Glasgow, and incorporates Lockheed components. Separate gas-cooling, cleaning and purifying plant is provided for the water-gas and consists of a vertical-tube multi-pass condenser, a detarrer and a set of oxide purifiers. Coke is brought to the plant by means of a belt conveyor, and a bunker gives sufficient storage capacity for 24-hours operation. Clinker, ash and coke screenings are removed by underground conveyor belts, the breeze being used subsequently in the works water-tube boilers. The complete plant is housed in a steel-framed brick-panelled building of sufficient size to accommodate a future duplicate plant.

WATER SERVICES.

Water for use in connection with the various processes is taken from the mains, and to economise in its use, a combined natural and forced-draught hyperbolic reinforced-concrete cooling tower has been installed. This unit, which was designed and constructed by the Davenport Engineering Company, Limited, Harris-street, Bradford, Yorkshire, is illustrated in Fig. 17, on page 811. It is capable of cooling 179,000 gallons of water an hour from 105 deg. F. to 80 deg. F. when operating in an ambient wet-bulb temperature of 60 deg. F. A 32-ft. diameter stainless-steel impeller is located in the throat and is driven through a horizontal shaft and a reduction gearbox. An electric motor is fitted at each side of the gearbox and they are capable of supplying full load and two-thirds load, respectively; thus, where climatic conditions are favourable, the smaller motor can be used, with consequent economies in electric power. The cooling medium inside the tower is constructed from unsorted Scandinavian redwood and the water-distribution network consists of a series of rolled asbestos-cement pipes with self-adjusting brass sprayers fitted into them so that they point upwards. This allows any sediment to settle in the bottom of the pipes and prevents the jets from becoming choked. A rubber-sealed brass sluice valve is fitted to the extremity of each pipe range and is operated by levers from the peripheral walkways. To reduce carry-over to a minimum, a timber eliminator screen of the pear-shaped lath type has been installed.

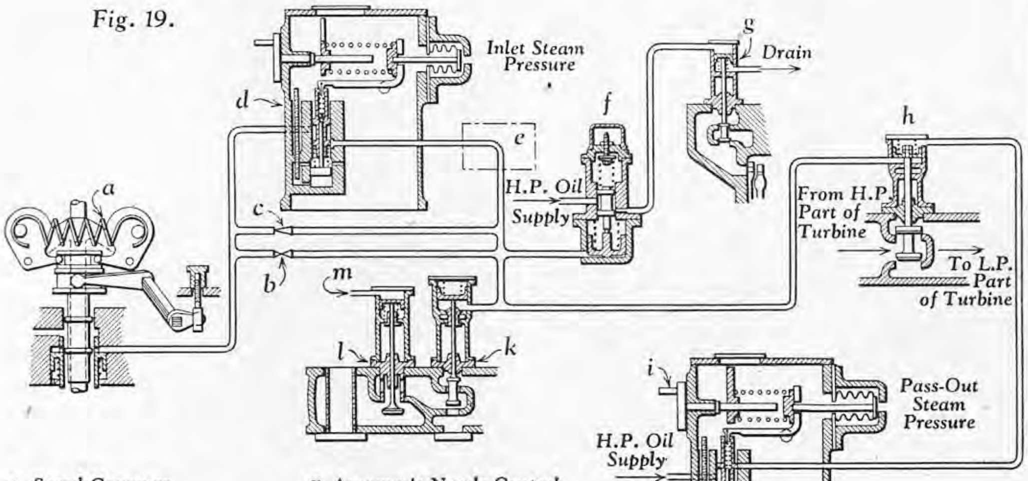
TURBO-ALTERNATOR.

Before the steam generated in the waste-heat boilers is used for process purposes in the plant, it passes through a steam turbine arranged to drive a 530-kW alternator. This set, which normally runs in parallel with the public supply, is illustrated in Fig. 15, on Plate LXIII. With the exception of the alternator and pump motors, which were supplied by Lancashire Dynamo and Crypto, Limited, the unit was designed and built by W. H. Allen, Sons and Company, Limited, Bedford. It comprises a high-speed multi-stage impulse turbine of the pass-out type, running at a speed of 10,000 r.p.m., arranged to drive the alternator through parallel-shaft reduction gearing and exhausting to a surface condenser provided with motor-driven cooling-water and condensate-extraction pumps and a steam-jet air ejector. The turbine is designed to use steam from the waste-heat boilers at 290 lb. per square inch and 459 deg. F. and incorporates automatic nozzle-control valve gear operating in conjunction with an inlet-pressure regulator. Pass-out steam demands up to a maximum of 6,500 lb. per hour at 15 lb. per square inch are catered for by an automatic extraction gear which, to give increased sensitivity, is connected to the main governor gear. The surface condenser is of the conventional four-pass type and, with a barometer reading of 30 in. of mercury, is designed to give a vacuum of $27\frac{1}{2}$ in. of mercury with a steam flow of 7,800 lb. per hour. The alternator is of the salient-pole rotating-field type and is provided with a closed-circuit cooling system with the air cooler built on to the machine above bedplate level. The maximum continuous rating is 530 kW at 0·8 power factor and the operating speed is 1,500 r.p.m.

This unit is of particular interest in that it incorporates a number of features developed recently by the turbine manufacturers for use in connection with gasworks turbo-alternators. It will be appreciated that the steam flow from the waste-heat boilers is liable to constant variation due to fluctuations in the heat supplied to the boilers and the varying demands from blowers, pumps, etc. This means that the usual method of governing a turbo-alternator, in which the steam supply is restricted to suit the electrical load, cannot be used. The electrical load will, of course, fluctuate with the steam flow, and the governor plant used must, therefore, ensure that the alternator generates the maximum output commensurate with the available

HOWDON-ON-TYNE GASWORKS.

Fig. 19.



a Speed Governor
b Inlet Press. Regulator By-Pass
c Non-Return Valve
d Inlet Press. Regulator
e Provision for Electrical Load Limiting Device
f Leverless Auto-Pilot Valve
g Automatic Nozzle Control Valve
h Pass-In Valve
i Pass-Out Press. Regulator
k Throttle Valve
l Emergency Valve
m H.P. Oil Supply from Emergency Trip Cock

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steam supply. The method of governing employed, however, must be independent of the turbo-alternator speed governor since, for running in parallel with the public supply, this governor must be put out of action after paralleling to allow the speed of the set to follow the supply frequency. A solution to this problem is to provide an inlet-pressure regulator which works in association with automatic nozzle control. The inlet-pressure regulator maintains a constant inlet-steam pressure by adjusting automatically, through the nozzle-control gear, the area of high-pressure nozzle open to suit the quantity of steam flowing. This has the effect of maintaining a virtually constant heat drop across the turbine, an essential condition for developing the maximum power possible from varying steam flows. A further advantage is that the turbine cannot overdraw from the boiler plant and rob auxiliary machinery of steam.

Fig. 19, on this page, shows diagrammatically the system of inlet-pressure governing developed by W. H. Allen, Sons and Company, Limited, and fitted to the set installed at Howdon. The spring-opposed bellows at the top of Fig. 19 is connected to the steam supply to the turbine and controls the pilot valve of the inlet-pressure regulator *d*, which is interposed in the governor relay oil system between the pilot valve of the speed governor *a* and the relay cylinder of the main steam throttle valve *k*. After the turbo-alternator has been put in parallel with the public supply, the speed-governor setting is adjusted by the hand mechanism until the governor is incapable of influencing the speed of the machine at normal frequencies. High-pressure relay oil can now pass the speed-governor pilot valve freely, leaving the inlet-pressure regulator-operated pilot valve to control the throttle valve *k* and nozzle valve *g*. Variations of pressure in the steam main alter the load on the bellows and, therefore, affect the position of the pilot valve. These variations are, in turn, reflected in the pressure of the oil under the throttle-valve relay piston and the relay piston of the automatic pilot valve *f*, resulting in appropriate changes in the nozzle-valve opening. Under stable conditions of steam flow, the inlet steam pressure is held constant at the designed figure and the turbo-alternator generates the maximum amount of power possible from the flow because the high-pressure nozzle area is correctly adjusted to suit the flow. A variation in steam flow from the boiler, however, by altering the ratio of nozzle area to flow, alters the inlet pressure which, in turn, causes the regulator to re-adjust the nozzle area until the inlet pressure returns to the designed figure. The final setting of the speed governor is such that, should there be a failure of the public supply and the speed of the alternator, as a consequence, rises an undue amount, the speed governor will come into operation and over-ride the inlet pressure governor, thus acting as a pre-emergency governor to prevent the turbo-alternator from being shut down. If it is required to run the set independently of the public supply, it is only necessary to by-pass the inlet-pressure regulator at the valve *b* and adjust the speed governor to give the required frequency. When inlet-pressure governed, the turbine could, with certain conditions of load and pass-out demand, overload the alternator; an electrical load-limiting device is fitted, therefore, to restrict the output to the continuous maximum rating.

BENZOLE PLANT.

The ancillary plant installed at the Howdon gasworks includes the benzole plant illustrated in Fig. 16, on Plate LXIII. This plant was installed by W. C. Holmes and Company, Limited, and is capable of dealing with 10,000,000 cub. ft. of gas per day, and of recovering at least 85 per cent. of the benzole available in the gas. It is also capable of reducing the naphthalene content to 1 grain per 100 cub. ft. and the organic sulphur content by about 40 per cent. The oil stripping plant is suitable for operating under a vacuum of 10 in. absolute and can be operated entirely on low-pressure steam. The resultant low temperature of the still head ensures that polymerisation of the oil will not take place, and sludging of the oil, as a consequence, is avoided. The general principle of operation follows fairly closely the orthodox method of recovering benzole The plant includes a Holmes "Multifilm" gas washer, a tray-type stripping still fitted with float valves for controlling the volume of the oil stream, four benzole condensers, two vacuum pumps, heat exchangers, oil heaters, oil pumps, etc.

The whole of the electrical equipment was supplied and installed by Lancashire Dynamo and Crypto, Limited. All work at the site was under the immediate direction of Mr. B. L. Fender, A.M.I.C.E., under the supervision of Mr. W. R. Garrett, A.M.I.C.E., the chief constructional engineer of the Northern Gas Board.

LITERATURE.

The Structural Analysis of the Dome of Discovery.

By DR.-Ing. T. O. LAZARIDES. Crosby Lockwood and Son, Limited, Thurloe-street, London, S.W.7. [Price 25s.]

THE fact that the Dome of Discovery in the Festival of Britain South Bank Exhibition was designed, fabricated, and erected before this analysis had been completed, and the further point that it had fulfilled its purpose and was being dismantled before this record of the calculations become available, are considerations which have no bearing on the significance of Dr. Lazarides' book as an exercise in design analysis. The analysts can only begin work where the engineer has finished and their contribution is never particularly significant unless the engineer's design is proved to be unsound or the assumptions on which he has based his calculations are inaccurate or illogical.

To say this is not to discredit design analysis, but to place it in a proper perspective. In the case of the Festival Dome, Mr. Gilbert Roberts, when describing its design and construction to the Institution of Civil Engineers, seemed happy enough to put on record the reasonably close coincidence between his own "shirt-cuff" estimates and Dr. Lazarides' "exact" calculations. Unfortunately, there is no comparison of the two in this treatise. When the author writes that his analysis has shown "that a structure of this type can only be analysed exactly or not at all," he shows also a lack of appreciation of the so-called "exact" analyses, which, in fact, are only justified in the long run by the contribution they make to approximate methods of design.

Engineering design is still largely dependent, and must continue to be, on the shirt-cuff methods, which give reasonably satisfactory results because they represent the refined distillation of all the relevant results obtained by the design analyses of corresponding problems. "Exact," after all, is only a relative term. All analysis, from the crude to the super-exact, is merely the use of mathematical language to describe the physics of a problem, coupled with some mathematical manipulation to simulate loading action. In no engineering analysis, including the most "exact," is it possible to reduce the problem to mathematical terms without making assumptions that would outrage a physicist and would possibly be beyond the purview of a pure mathematician.

In the present analysis, the author, to judge from his Fig. 15, appears to have included torsion among the effects that may properly be neglected in an "exact" analysis, though in a superficial view it would seem that the torsion of the principal members is one of the marks of distinction between a space frame and a plane frame. Unfortunately, he is not content with misconstruing the intention and purpose of an analysis of this kind. He goes out of his way to denigrate the "classical" methods, and yet it is these methods, rather than the piecemeal processes of relaxation techniques, which must be used to interpret the physical parameters of an engineering structure in terms which the electronic computing machines can absorb and use. The fundamental point here is that, for any problem which is amenable to the processes of relaxation, there is a "classical" method which can be depended upon not to involve the user in ill-conditioned equations.

Although this treatise must, of course, be recommended to anyone concerned with a dome of this type, it does not seem to have a very direct application to other space frames, and the author's system would need to be materially altered for it to be applicable to a dome with polar framing instead of the geometrically irregular grid adopted for the Dome of Discovery.

ENGINEERING DEVELOPMENTS IN THE PORT OF DUBLIN.

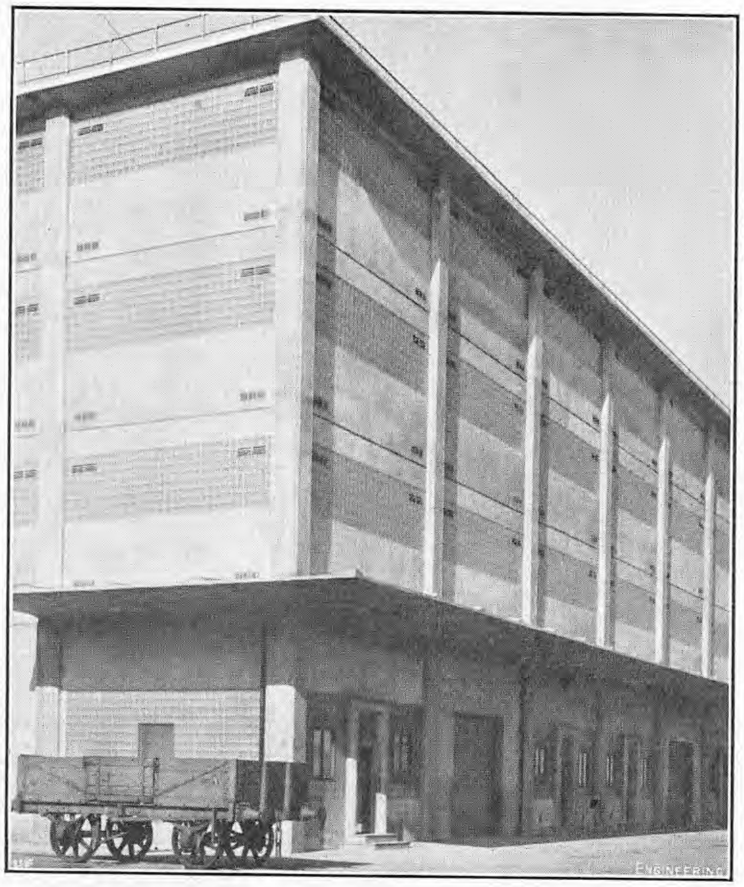

FIG. 6. HARBOUR BOARD'S NEW WAREHOUSE.

FIG. 7. SUPERSTRUCTURE OF DIVING BELL.

ENGINEERING DEVELOPMENTS IN THE PORT OF DUBLIN.

(*Concluded from page* 3.)

A BRIEF outline of the engineering works recently completed and now being undertaken at the port of Dublin, including some notes on the new silos, warehouse and quay construction, was given in our issue of July 4, on page 1, *ante*. The work at present in hand includes the completion of two oil jetties, the extension of the Ocean Pier, (which involves considerable land reclamation, making use of dredged material from new shipping berths and a deepening of the main channel) together with the construction of a new graving dock. The newest warehouse, as noted in the previous article, is a four-storeyed structure of reinforced concrete, and is somewhat unusual in that glass blocks have been used almost exclusively for lights. The siting of the warehouse in relation to the wharf can be seen in Fig. 8, opposite, which shows the warehouse on the left, in the mid-distance. Fig. 6, above, shows the clean appearance that has been achieved in this building.

NEW JETTIES.

Two new oil jetties are being constructed in the extension to the Alexandra Basin, and progress with these is well advanced; similar work of this nature is the extension of the Ocean Pier, which is illustrated in Fig. 13, on page 816. The existing Ocean Pier is being extended along a return line so that the pier will ultimately become the peripheral wall of a wharf that is to be built on filling. The method of construction employed involves the use of concrete caissons of the type now characterised by the term "Mulberry," but which have been used at Dublin, with only minor modification, since 1921. A sectional plan of the caisson, which is 50 ft. long by 30 ft. wide and is divided into eight compartments by diaphragm walls, is shown in Fig. 15, on page 817. The reinforced-concrete floor of the caisson is laid down on a slipway and the walls are built to a height of 9 ft. to 10 ft.; at this stage, the caissons will float. They are then launched, as shown in Fig. 14, page 817, and towed to a convenient place along the wharves where they are built up to their full height of 42 ft. to 45 ft. Until recently, normal bar reinforcement was used in the floor and walls, but this has now been partly replaced by old tramway rails recovered from the Dublin streets. The simplification of the reinforcement has led to very speedy work, and concreting is now being done in 3-ft. lifts on alternate days, the wooden shuttering (some of which is stated to have been used "hundreds of times") being struck and raised on the intermediate day. The construction of these caissons by direct labour is work with which the entire labour force of the dock is familiar, so that men can be drafted to it as circumstances require.

The caissons are sunk into trenches excavated to a depth of at least 2 ft. 6 in. below the dredged level of the berth. The excavation of these trenches is done in three stages by bucket dredging followed by rough levelling by grab, and finally by hand-dressing, by men working in a diving bell. The bell, which was built in 1864, was described on page 3, *ante*. Fig. 7, on this page, shows the top of the 3-ft. diameter access shaft, containing an air-lock which enables men to enter and leave the bell when working at depths up to 38 ft. Originally, the placed caissons were completely filled with a low-grade concrete, but latterly gravel fill, pumped in by the dredger Sandpiper, has been used and surfaced with a layer of concrete. Where the caissons have been placed in a double line, as for the oil jetties described below, only the outer compartments have been filled.

Various layouts of the caissons have been tried, according to the nature of the structure concerned. Thus, for the new oil jetties, they have been placed separately in two rows with a 10-ft. gap between the rows and a 12-ft. spacing between successive caissons so as to allow the harbour water to flow freely through the jetty. The caissons used for this work are being constructed with a reinforced toe and heel, each projecting 2 ft. 6 in. beyond the external walls. Smaller caissons, only 15 ft. long, and floated into position on high tide, are used to bridge the gap between the main units, after which all the walls are brought up to a common level. A heavily-reinforced concrete slab is then laid over the structure and 9 ft. thick quay walls are raised above the slab. Filling is placed between walls to the required depth and the jetty is completed by a top-deck slab. A suitable concrete duct is formed in the deck for the oil main and other service pipes.

Where the new construction work has to retain a filling, as will be the case behind the extended Ocean Pier, the space between successive caissons has to be closed to prevent the continued entry of water, which would eventually wash out the filling. Two methods have been used in such cases. The earlier plan was to drive sheet piling along the face line of the quay wall for the 15-ft. length of the gap between the caissons. The cost of the sheet piling, however, caused the Board to experiment with an alternative arrangement. In this, the caissons are placed close together, so that the external protrusions on the ends to be seen in Fig. 15 butt against each other. A sheet pile is then driven close to each side of the butt so as to form, with the ends of the caissons, a hollow box; this is then packed with clay puddle to complete the seal. Precast hollow concrete boxes, made without a bottom slab, are being used to construct the superstructure of the quay; these boxes are spaced regularly over the foundation caissons and the shuttering is fixed to them so that the walls of the quay can be brought up to the underside of the heavy deck slab. As these boxes cannot be floated into position, they are transported on floats from the slipway where they are made, and slung into position by a derrick on one of the dredgers. The Harbour Board have found these methods to be

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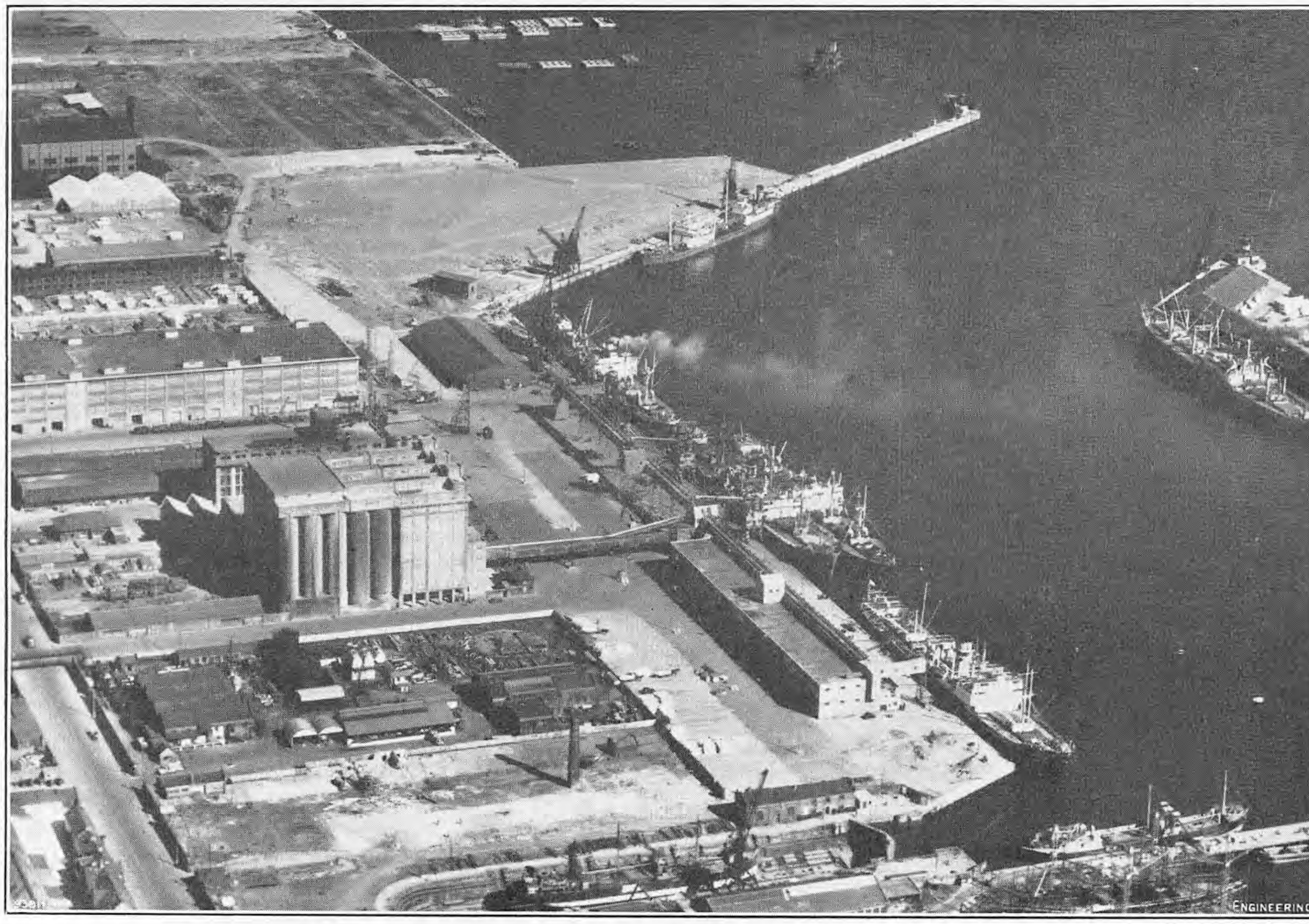
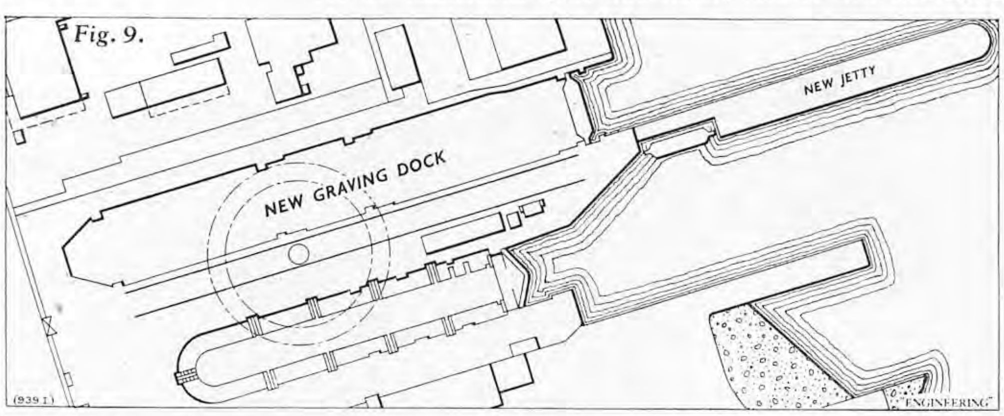


FIG 8. ALEXANDRA QUAY AND BASIN; SITE OF NEW GRAVING DOCK IN FOREGROUND.



economically favourable for the conditions prevailing at Dublin.

SURVEY WORK IN THE HARBOUR.

Dublin was one of the first ports in Europe to use an echo sounder for hydrographic surveying, and the charting of the harbour has been carried out almost entirely by this method since 1934. The provision of deeper channels and of deep-water berths, together with the suction-dredging contract that is in hand to remove over a million cubic yards of spoil to increase the navigable depth over the bar by 2 ft., has necessitated a great amount of accurate survey work. This could not have been accomplished so well by any other method.

The present survey launch, the Depthfinder, has a wooden hull of length 42 ft., beam 10 ft. 6 in., and draught 4 ft. The accommodation comprises the forecastle, the cabin amidships, and the engine room aft. Twin Morris Commodore petrol engines, developing up to 40 h.p., give a top speed of 9 knots, but by using one engine only a sufficiently slow speed for detailed survey work can be maintained. The cabin from which the survey operations are conducted also contains the engine controls and steering wheel to afford close liaison between the surveyor and the helmsman during sounding operations. The compartment is almost completely glass-panelled to enable fix observations to be made from within during bad weather. The echo-sounding machine is the special M.S.10 hydrographic model, with magneto-striction oscillators, made by Messrs. Kelvin and Hughes (Marine), Limited, 99, Fenchurch-street, London, E.C.3. The oscillators, of the inboard type, are housed in small tanks fitted beneath the cabin floor on the bottom of the vessel, where the timbers have been cut away and replaced by a metal plate. Longitudinally, they are slightly forward of the centre of flotation, but their level below the water-line is not seriously affected by moderate changes in trim. The survey observation point is directly above the oscillators.

For hydrographic surveying, the port has been divided into five areas, for which prepared charts are available. The water area regularly surveyed comprises the River Liffey, Dublin bar, the Alexandra Basin and its adjacent extension, the docks and the shipping berths. Those parts of the channel where there is little change from year to year are surveyed on lines of soundings spaced 100 ft. apart. Freshly dredged areas require greater detail, and in the shipping berths the lines of soundings are only 5 ft. to 10 ft. apart. Soundings over sites prepared for the foundations of the new deepwater quays and oil-jetties have received special treatment. Grid charts have now been prepared for each area of the port, and standard cross-fixes have been worked out and compiled into convenient schedules. Numerous objects on the embankment are available for cross-fix transits; these include the lighthouses, perches, chimney stacks and church spires. The layout of the harbour lends itself readily to the system of cross-fixes, as the south side of the fairway is flanked by a training wall, the Great South Wall, along which the front marks of the river ranges have been painted at intervals of 100 ft. The natural prominences of the Dublin Mountains, situated some eight miles to the south, serve as backmarks and the combination gives a series of 143 nearly parallel ranges, permanently set out across the river.*

NEW GRAVING DOCK.

Work was begun in April, 1951, on the construction of a new graving dock, shown in elevation, section and plan in Figs. 10, 11 and 12, on page 816. The site adjoining the existing small graving dock on the northern foreshore of the Alexandra Basin,

* Cf. "Hydrographic Survey Methods in the Port of Dublin," by William F. Staveley, A.M.I.C.E.I., *Trans. Inst. of Civil Engineers, Ireland*, vol. 78, page 17 (1951).

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Fig. 10. LONGITUDINAL SECTION

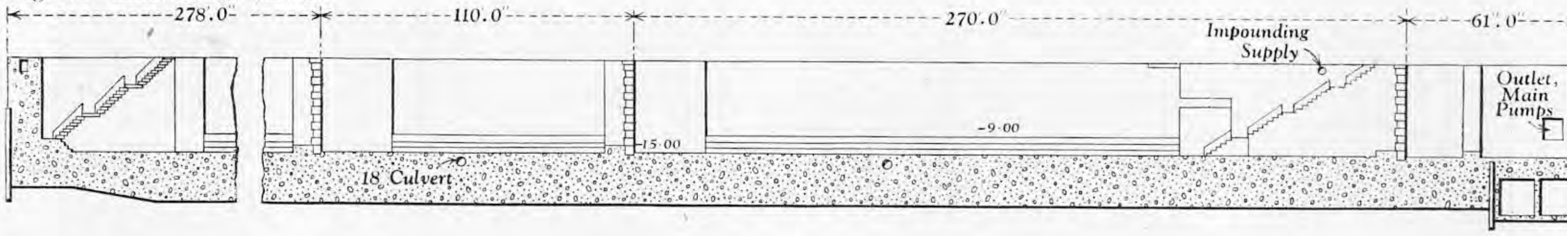


Fig. 11.

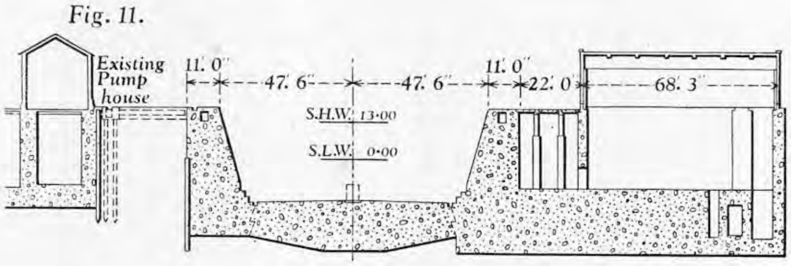
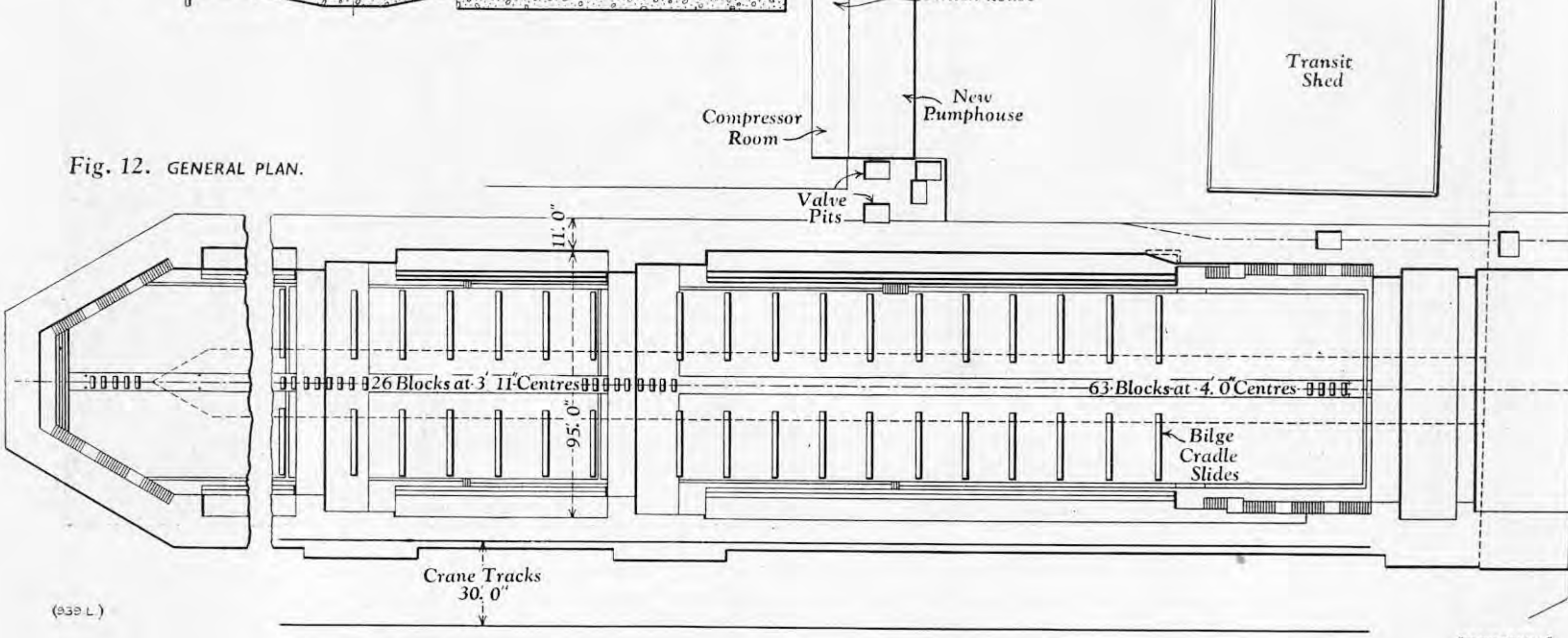


Fig. 12. GENERAL PLAN.



is somewhat restricted, as can be seen in Fig. 9, on page 815, and this has influenced its design and construction to some extent. The dock is to have a length of 630 ft. clear of the entrance gate, a width at the cope of 95 ft., a width at floor level of 80 ft. and a depth of 15 ft. below port datum (low water, ordinary spring tide) to provide docking facilities for vessels of up to 18 ft. draught on 6-ft. blocks at neap tides. A lead-in and fitting-out quay will also be constructed.

The dock will be closed by caisson gates, two of which are included in the contract. Granite-faced gate stops will be constructed at the entrance and at two intermediate sections, so that, by using two gates, it will be possible to divide the dock into two separate compartments. The provision of two intermediate positions for the inner gate will give the dock an adaptability that, the Harbour Board consider, will ensure the most economic working. A fourth gate stop will be constructed near the entrance, for use in case of emergency.

There will be four vertical-spindle main dewatering pumps, any three of which will be capable together of dewatering the dock in $2\frac{3}{4}$ hours. In addition, there will be two drainage pumps, one sump-drainage pump, and two salt-water pumps for fire fighting, etc. The provision of two intermediate gate stops involves a complicated system of culverts and valves. The culverts will be lined with cast iron, and the sluice valves are to be supplied by Glenfield and Kennedy, Limited, Kilmarnock.

Other equipment comprises the usual bollards, keel blocks, bilge cradles and electrically-operated capstans, and there will be an electric travelling crane, to lift 20 tons at 8 ft. 6 in. radius on the main hook and 5 tons at 110 ft. radius on the auxiliary hook. The crane will operate on the wall between the two graving docks and will so be available for servicing either. Services at the dockside, which will be accommodated in a ductway in the dock wall, will include fresh-water and salt-water mains, a compressed air system, and electric power

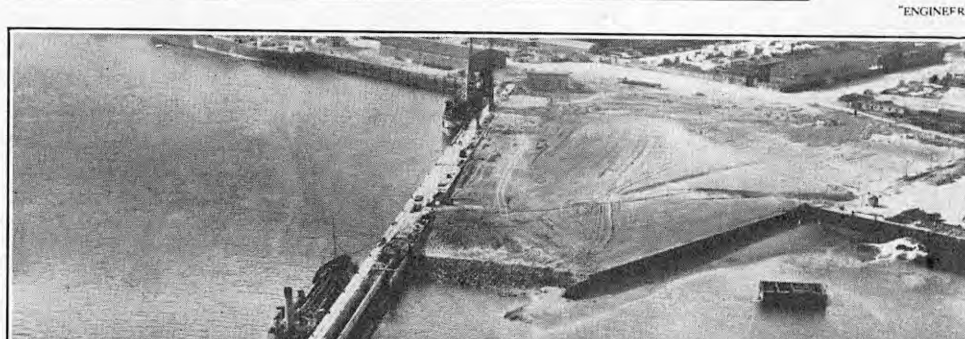


FIG. 13. EXTENDING THE OCEAN PIER.

ENGINEERING DEVELOPMENTS IN THE PORT OF DUBLIN.

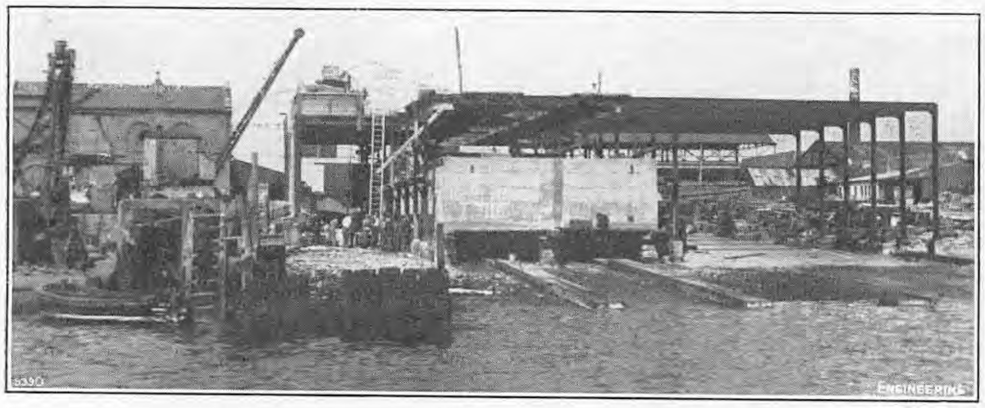


FIG. 14. CAISSON ON SLIPWAY PRIOR TO LAUNCHING.

Fig. 15. PLAN OF CAISSON.

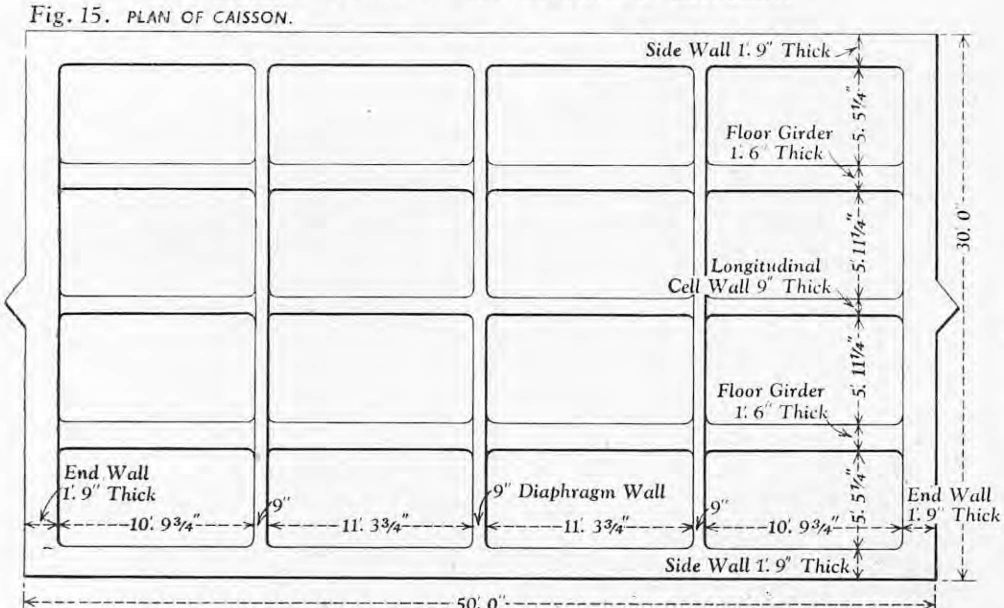
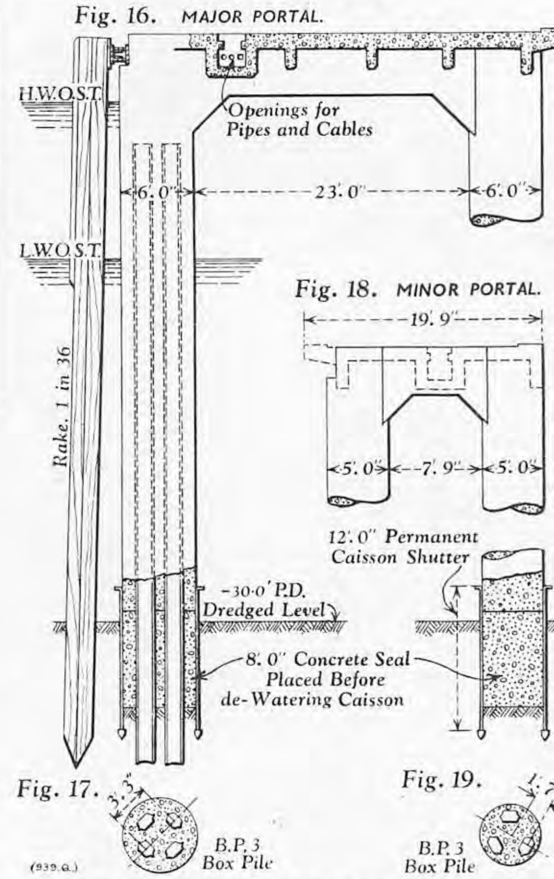


Fig. 16. MAJOR PORTAL.



and lighting supply points. Similar services will be provided on the lead-in jetty.

The dock walls and floor will be of mass concrete, the floor being designed as an inverted arch. It has been estimated that the maximum soil loading of the completed dock under the worst condition will not exceed 2·7 tons per square foot. During construction, the maximum soil loading at the toe of the wall may approach 3·6 tons per square foot. At foundation level, a layer of coarse ballast overlies a deep bed of blue clay, but it is considered that these stresses will not overload the soil. It is estimated that the maximum stress in the concrete will occur in the floor, and that it will be well within safe limits. As bilge cradles have been decided upon in preference to shores, there are no altars in the face of the wall, which is to have a straight batter from cope to floor. Counterforts will be constructed behind the walls where the section has been reduced to make a recess for the caisson gates. The wall is being constructed within a double line of steel sheet piling, the outer line of which will be left in permanently, so isolating the area from the pump-house. These piles have been driven 45·0 ft. below port datum, to prevent " blows " during construction.

The constructional programme has been divided into several stages, of which the first items are now either completed or nearly so. The whole site has been excavated down to zero level on port datum, the sides of the excavation being battered so that they will stand without being shored. Some mass excavation will remain to be done behind the entrance to the dock until the cofferdam for the entrance has been completed and sealed. The outer line of steel sheet piles, and the inner line at the toes of the walls, have now been driven along the greater length of the walls. Excavation for the wall itself within the piled trench has been made round the head of the dock and the first lifts of concrete have been placed in lengths of 50 ft.; strip copper is being used to seal the contraction joints between the adjacent sections of the walls. With the completion of the wall up to zero level port datum, the dumpling will be taken down to 12 ft. below port datum, from which level the bottom will be excavated to foundation level in alternate bays, about 15 ft. wide, across the dock. The sheet piling at the toe of the walls within the width of the bays will then be withdrawn and the floor concreted. Finally, the walls will be raised to cope level and the floor given a top surface.

The lead-in or fitting-out jetty, with a maximum width of 39 ft. and a length of 443 ft., will extend into the Alexandra Basin from the dividing wall between the graving dock, as shown in the plan, Fig. 9. The form of construction to be used will differ from that adopted elsewhere at Dublin. Basically, the new structure, of reinforced concrete, will consist of portal frames at intervals of 25 ft., supporting a system of beams that will carry the deck slab, as shown in Figs. 16 to 19, above. The horizontal forces imposed by the berthing of a ship will be resisted partly by the flexible timber fenders and partly by the portal frames. These portals, which are alternately of heavy and light section, will comprise a heavily reinforced beam, 3 ft. wide by 4 ft. or 3 ft. deep, cast *in situ* above substantial cylindrical legs of either 6 ft. or 5 ft. diameter, formed in mass concrete and surrounding groups of four or three steel box piles, Figs. 17 and 19. The bottom lift of concrete for each portal leg will be placed within a steel cylinder, 12 ft. long, driven into position by weighting it with kentledge, the sinking of the leg being aided by grabbing. This cylinder will be left permanently in position and will act as a springing for the climbing shutter that will be used to form the upper length of the leg of the portal. Divers will be required to slacken the bolts, etc., when the shutter has to be raised.

The new graving dock and jetty have been designed for the Harbour Board by Mr. Nicholas O'Dwyer, B.E., a past President of the Institution of Civil Engineers of Ireland, of 6, Burlington-road, Dublin. The contract for the construction of the dock has been undertaken by the Irish Construction Company, Limited, Dublin. The contracts for the design and construction of the caisson gates, and for other equipment, have yet to be placed. With the exception of the graving dock, the whole of the design and supervision of the construction of the new works is under the direction of the Engineer-in-Chief to the Board, Mr. F. W. Bond, B.A., B.A.I., M.I.C.E.I.

MEASUREMENT OF LIGHTNING CURRENTS.—In a report (S/T57) issued by the British Electrical and Allied Industries Research Association, Messrs. R. H. Golde and T. J. Brown point out that the information available on the amplitudes of lightning currents is subject to a certain ambiguity and that a re-evaluation of available data is therefore advisable. The existing information on the subject is critically examined and it is concluded that additional data are required, particularly on the upper and lower limits of lightning current amplitudes. A new installation of magnetic links on lightning conductors is therefore being undertaken.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW ZEALAND.—A reference book on their activities has been published by the D.S.I.R., New Zealand. Commencing briefly with a historical note on the development of the department since it was founded in 1926, the book continues with details of the organisation and administration of the many divisions into which the department is divided. In respect of engineering, the most important works being undertaken are metrological and investigations into problems of building construction. Allied divisions are those of applied mathematics, geology, geo-physics and the soil bureau, which is concerned with both agricultural and engineering problems. The book concludes with detailed reference to the work of the incorporated research associations that are operating in the Dominion.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 786.)

THREE papers were presented and discussed at the last session of the recent autumn general meeting of the Iron and Steel Institute. This session was held on the morning of Thursday, November 27.

ADDITION OF BORON TO STEEL.

The first paper considered, "Addition of Boron to Steel by Reduction from Boron Oxide," was by Mr. G. E. Speight, of the United Steel Companies, Limited. He stated that previous work on the boron-oxygen equilibrium in liquid iron and evidence of boron pick-up from the fortuitous presence of borates in high-frequency and arc-furnace linings had suggested the possibility of adding boron to steel by reduction from a slag containing boric oxide. This method had been investigated, as an alternative to the commercial boron-addition alloys, in a series of laboratory experiments, and it had been shown that boron could be introduced into steel from a borate and that the boron so added could be made effective in providing the improved mechanical properties of boron steels. The laboratory techniques had yet to be applied on a commercial scale, but practical recommendations for the addition of boron by this method could be given. In basic-lined induction furnaces, after the normal additions of Mn, Si, Mo, etc., the metal should be treated with 1 lb. of Al per ton of charge to effect initial deoxidation. Then should follow the slag treatment with about 2 per cent. of a slag mixture containing 0·5 per cent. of boron, added as Howlite (hydrated calcium silico-borate) or other commercially-available borate. The temperature should be adjusted to 1,600 deg. C., and 5 minutes allowed for the reaction after fusing the slag mixture. Finally, the metal should be treated with 2 lb. of Al per ton and from $3\frac{1}{2}$ lb. to 4 lb. of ferro-titanium (40 per cent.) per ton for final deoxidation and nitrogen stabilisation. In electric-arc furnaces, shortly before tapping, the bath should be deoxidised with Al and the requisite amount of borate added according to the slag bulk. The final additions of Al (about 2 lb. per ton) and low-carbon ferro-titanium (4 lb. per ton), or, alternatively, excess Al, should be made either to the bath or during tapping. In open-hearth furnaces, the additions would be made to the ladle, the Al, ferro-titanium, and borate being mixed and added at the beginning of tapping.

Mr. D. A. Oliver, who opened the discussion, said that he believed that the author was greatly in advance, in his understanding of the subject, even of those authorities in the United States who were so vocal in favour of boron additions. Mr. Speight had been very cautious in referring to what he called the metallic boron, the effective boron, which was acid-soluble. Would he agree that probably this boron would fairly readily form carbides, or perhaps go into solid solution in the carbides? A considerable amount of publicity had been given to boron in relation to alloy economy in the American literature, and this appeared to be based on a minimum of experiment and a maximum of publicity. On the other hand, that was not to say that boron additions had no virtues whatever, and the author had shown the way in which the subject could be dealt with scientifically and a real advance made.

Dr. W. Sachs stated that he understood from the paper that Mr. Speight could make a differentiation between the soluble and the insoluble boron, but he obviously could not make this on the analytical side. He would like to know whether he employed the usual colorimetric method for the determination of boron in these small quantities, and whether that applied to the insoluble as well as to the soluble variety.

Mr. W. E. Bardgett stated that the experience of the United Steel Companies had been almost entirely related to the production of Fortiweld steel,* and it was of interest to mention that this steel had been made in the high-frequency furnace, the arc furnace, and the open-hearth furnace by the cold-metal and the hot-metal processes. Boron could not be added simply as a ferro-alloy and satisfactory results expected, but there was no hit-or-miss about the author's methods, provided that the necessary precautions were taken to ensure that the boron was in the effective form. With experience, it was possible to obtain really surprising control over the boron content, in spite of the very small amount present. The effect of boron decreased with increasing carbon content, and, with the eutectoid composition, the effect was nil, so that there was a greater effect and a greater advantage at the lower carbon levels.

Dr. L. Reeve said that the Appleby-Frodingham Steel Company had seriously discussed the possibility of making Fortiweld steel in the open-hearth furnace by the borax-slag procedure. Theoretically, it was possible, and under tilting-furnace conditions it was more likely to be successful than in fixed-furnace conditions. The method, however, had not been used up till now; the greater part of their steels had been made with ferro-boron and other deoxidisers. Provided that the furnace melting procedure was reasonably standard and that the deoxidation procedure in particular was standardised very carefully, boron steels could be made with reproducible properties, from cast to cast, without any great difficulty, at least for the particular application in which his firm was mainly interested.

Mr. G. E. Speight, in the course of a brief reply, said that Dr. Sachs had mentioned the method of analysis. The method used had been that described by G. A. Rudolph and L. C. Flickinger in *Steel*, vol. 112, page 114 (1943). It was not a very nice method, and the order of accuracy needed could be achieved only after considerable experience.

* A patented molybdenum boron steel containing 0·14 per cent. carbon, about 0·40 per cent. molybdenum and 0·003 per cent. boron.

DIRECTIONAL EFFECTS IN MILD-STEEL PLATE.

An investigation which formed part of a research being carried out on behalf of the Admiralty into the brittleness of structural mild steel, at the Engineering Department of the University of Cambridge, was described in the next paper submitted to the meeting. This was by Mrs. C. F. Tipper and dealt with the "Effect of Direction of Rolling, Direction of Straining, and Ageing on the Mechanical Properties of a Mild-Steel Plate." Dr. Tipper stated that the experiments had been carried out to determine the effect of plastic strain and ageing on the notch-impact results and the yield point of the material, with the special purpose of investigating directional effects. The direction of rolling had been found to be most significant in Izod impact tests, the lowering of these values after pre-strain being chiefly due to work-hardening and strain-ageing. These factors also raised the yield and ultimate tensile stresses and caused loss of ductility. The direction of straining had been found to affect the yield chiefly, both in value and shape. No satisfactory explanation could be found to account for the absence of a recovered yield after ageing.

In the course of the discussion, Mr. M. W. Thring stated that the paper began to make a pier for the bridge which had to be built across the river separating metal physics from metallurgy and engineering, and that bridge was one of the most important things which would have to come into being in the next five years or so. Dr. B. B. Hundy, who spoke next, said that Dr. Tipper had referred to work carried out at the Massachusetts Institute of Technology. He had been associated with that work, and would like to outline their ideas on this point. They believed that a cast metal contained a number of randomly-oriented micro-cracks. As these were not obvious under the microscope, perhaps they should be called sub-micro-cracks, but, it was more convenient to refer to them as micro-cracks. They considered that the deformation of the cast metal would probably cause fresh micro-cracks to form, and all these cracks, regardless of their origin, would be aligned in the direction of metal flow during working. This crack structure could be found in most ductile metals, and handling did not seem to affect the cracks. The true fracture stress and the reduction in area to fracture were affected by the crack structure, but no appreciable effect on the yield-strength or the ultimate tensile strength had been found. Most of their evidence for the cracks was indirect. In her reply, Dr. Tipper said that she was very glad that the work at the Massachusetts Institute of Technology had been mentioned, because so far as she knew, it had not yet been published.

SOFTENING OF STAINLESS STEELS.

The last paper considered at the meeting was by Mr. F. A. Hodierne and Dr. C. E. Homer, of the Department of Development and Research, Tube Investments, Limited, Birmingham. It was on the subject of "The Rapid Softening of Cold-Drawn Austenitic Stainless Steels." The authors stated that the work had been undertaken to provide the metallurgical basis for the rapid softening of cold-drawn austenitic stainless-steel tubes. Specimen tubes of five different steels had been obtained in the cold-drawn condition, and strips cut from them had been heated for a few seconds to temperatures between 500 deg. and 1,350 deg. C. For comparison, other strips had been heated for five minutes. A detailed study had been made of the properties and structure of all the specimens. It had been found that the cold-drawn steels could be softened satisfactorily by heating for from 5 to 6 seconds to temperatures slightly higher than those recommended for ordinary times of heating. The properties and structure were the same as those in specimens which were heated for a longer time.

Mr. J. I. Morley, who was the only speaker in the discussion, said that the authors had shown very well that some of these austenitic steels could apparently be softened adequately by what amounted to a shock or flash heating at 1,150 deg. C. Specimens had been shown to be free from any inter-granular susceptibility in the water-quenched condition, but no sensitising heat-treatment had been given prior to the corrosion test, and so it could not be concluded that these steels softened in this way were necessarily free from intercrystalline corrosion after subsequent heating in the range from 500 deg.C. to, say, 800 deg. C., as might occur in welding. The authors recommended that the 18/8 titanium steel should be treated at 1,100 to 1,150 deg. C. If these temperatures were not exceeded, no serious trouble due to subsequent intergranular corrosion after welding might arise, but the question was how far it was possible to keep within these limits under practical conditions when carrying out induction heating of thin sections.

Dr. C. E. Homer, who replied, stated that they had done some work on titanium-stabilised 18/8 steel when heated up to temperatures higher than those normally recommended. A number of specimens of this steel had been heated up to temperatures of the order of 1,250 deg. C. After a sensitising treatment, they had not found that the specimens were subject, to any extent at all, to weld decay. It was possible, in view of Mr. Morley's remarks, that other casts of steel might have behaved slightly differently, but that was a point which needed to be followed up in the further extension of this work to practical conditions. They had done some induction heating of tubes on a pilot-plant scale and had had some difficulty in controlling the temperature, and a good deal more would need to be done from an engineering point of view before the limits between which the temperature could be maintained might be stated with confidence.

FLAMEPROOF ENCLOSURE OF ELECTRICAL APPARATUS.—A report (G/T265), entitled "Flameproof Enclosure of Electrical Apparatus," has been published by the British Electrical and Allied Industries Research Association. In it Mr. J. A. B. Horsley describes the scientific evidence upon which the routine testing of electric motors, as to flameproof enclosure, was based when the Mines Department of the Board of Trade took over that duty from the Mining Department of the University of Sheffield in 1931. This evidence indicates that routine testing with the motor at rest is justified, although artificial means must be used to simulate the effects of turbulence, such as might be expected to occur during running. In fact, a fan was used to keep the inflammable gas in circulation through the motor casing and the inflowing gas was ignited in a pocket outside the point of entry.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(Concluded from page 798.)

WE conclude below our report of the joint meeting held in Italy from September 25 to October 3 by the Institution of Naval Architects, headed by their President, Viscount Runciman of Doxford, O.B.E., A.F.C., and the corresponding Italian institution, the Associazione Italiana di Tecnica Navale, under their President, Dott. Ing. A. Della Ragione. In last week's issue, we summarised the last of the eight papers presented—that of Mr. A. J. Williams, R.C.N.C., on "An Investigation into the Motion of Ships at Sea"—and commenced a report of the discussion, the rest of which is given below.

THE MOTION OF SHIPS AT SEA (*continued*).

Mr. R. W. L. Gawn, O.B.E., said that the author was to be specially commended for his able and thorough analysis of voluminous and complicated records, which he had condensed into a very few curves. The Institution had had some valuable papers dealing with the oscillation of ship models in regular waves, but Mr. Williams's work gained in importance in that it concerned actual ships at sea. It was instructive to examine the extent to which the lessons learned from model tests and theory were borne out by sea experience. The conditions in the violent storm which the frigate Cygnet had weathered appeared to approximate to those of seas with some approach to regularity, of a length greater than that of the ship and usually steep. The approximate amplitude of pitch, plus or minus 12 deg., was equivalent roughly to about, 70 per cent. of the maximum slope of the surface waves. The period of pitch quoted by the author was $7\frac{1}{2}$ seconds, which, within the limits of accuracy of the data, might be regarded as equal to the period of encounter, estimated as 8 seconds for the length of wave and speed of ship. Both the amplitude and the period accorded with expectations from model tests generally. Though the amplitude of pitch was large, model experiments indicated that, had the seas been longer, even greater amplitudes, commensurate with the wave slope, might have been reached. That that was so could be appreciated from the report that the bow of the Ark Royal moved vertically 56 ft. up and down during the hunt for the Bismarck in the recent war. Making some allowance for heaving, that indicated pitching amplitudes comparable with the wave slope.

Again, the maximum amplitude of rolling occurred, in model tests and theory, at synchronism. It was instructive to have the author's confirmation, from his trials, that the same obtained in heavy weather in the complex seas. Another and more subtle agreement between model and ship was the author's difficulty in obtaining unique values of the a and b coefficients in the extinction equation for still-water rolling. Mr. Gawn suggested, however, that Mr. Williams would never succeed in determining those. He had evolved an attractive method for determining the coefficients, but experience with model tests demonstrated that the assumption of a parabolic law for the extinction equation was no more than a reasonable approximation, with all the consequences, both statistical and physical, including difficulty in determining unique values for a and b. The author's comment on that point would be appreciated. He joined issue with the author in his attribution of the co-periodicity of pitch with the period of encounter in regular waves explicitly to the heavy damping of that motion. Rolling in regular waves also occurred in the period of encounter. That was generally true, even when bilge keels were removed from the model and the damping was comparatively light. If, however, the model was initially inclined, then the rolling was that of the free period in shorter waves; but the wave period was followed in longer waves, depending on the relative amplitude of the free and the forced oscillations. Some confirmatory results were given in the paper by Mr. M. P. Payne in the 1924 *Transactions*, on page 57 of that volume, and those results also showed that the dominant period of rolling in non-uniform waves was that of the model, which was in accord with the author's experience in the ships. A further point in that connection was to be found in Mr. Williams's statement that damping in pitch was much heavier than in roll. That statement, unless qualified, might give an exaggerated impression of pitch damping. For example, curves of the magnification factor could be drawn, additional to those in Fig. 13, for higher values of the damping coefficient, and it would be found that response curves reasonably commensurate with those obtained in pitch, with a maximum amplitude ratio of unity more or less, were obtained for values of the damping coefficient no greater than about four or five times those for rolling. A diagram had been prepared to illustrate that point and would be forwarded for inclusion in the *Transactions*, in the hope that it might assist the author in any further analysis of his valuable records.

Dr. J. F. Allan said that he had done some work in the past in developing stabilisation of the rolling of ships, and he could appreciate fully the amount of work which Mr. Williams had put into the paper, and the ingenuity with which he had presented the data derived from his analysis. In the first of his conclusions, he had stated that the period of rolling of a ship in heavy weather tended to be that of the natural rolling period; no doubt, that was well known. But in conclusion (vi) it was stated that the period of pitching in a seaway approximated to the predominant period of encounter. Dr. Allan thought, however, that the period of roll and the period of pitch were, in general, forced periods; from his own experience, if there was heavy pitching or heavy rolling, it would be at about the natural period of pitching or rolling, but there appeared to be a difference in the sensitivity of ships to tuning. As regards rolling, the sensitivity to the tuning factor was much more sharp than in pitching; thus, in pitching, there was a rising and falling effect up to a maximum and down to a minimum, spreading over a wider range than in rolling. To what extent that was influenced by the difference in the damping effect in pitch and in roll, he would not care to say. It was well to appreciate that the formula given in conclusion (ii), namely, $T_R = 2 \cdot 55\ \Delta^{\frac{1}{6}}$, had a very limited validity. He had checked it against some merchant ship data and it did not fit those data at all well. That did not detract, however, from its value in relation to the ships to which Mr. Williams referred.

Mr. Williams intimated that he would reply to the discussion in writing.

SOCIAL FUNCTIONS.

In addition to the social events at Genoa which, as we have recorded, inaugurated the meeting, there were various other functions and visits interspersed between the technical sessions. On the evening of September 26, the members and their ladies were the guests of the Ansaldo Company and the S.A. di Navigazione "Italia" at a dinner in the Hotel Colombia; and on the following morning the members were received at the Ansaldo shipyard while the ladies visited the Palazzo Bianco Museum. On Sunday, September 28, coaches took the party to the museum, at Lake Nemi, which was built to contain Caligula's so-called "galleys," after Mussolini salved them from the lake. They were burned by the Germans, but large models have since been made and are now housed in the museum. On returning to Rome, the members and ladies attended a reception in the Circolo delle Forze Armate (the naval and military club), where they were received by General Ignazio Alfano and General Icilio d'Esposito; and this was followed by a luncheon, at which they were the guests of the Registro Italiano Navale. The afternoon was spent at the Villa d'Este, Tivoli. In the evening of September 29, they were received at the Capitol by the Mayor of Rome. At Naples, visits were paid to the Mostra d'Oltramare exhibition; to Pompeii, and to Sorrento, where the party was entertained to luncheon by Commendatore J. A. Pattison. They were subsequently received by him at the Navalmeccanica Shipyard, Castellamare. October 2 was spent in the island of Capri. There was a reception in the same evening by the Mayor of Naples.

OVERHEAD EQUIPMENT FOR DIRECT-CURRENT ELECTRIC TRACTION.

IN a paper on "Economic Aspects of Overhead Equipment for Direct-Current Railway Electrification," which was read before the Institution of Electrical Engineers on Thursday, December 4, Mr. O. J. Crompton and Mr. G. A. W. Wallace said that, in several of the communications made to the Convention on Electric Railway Traction in 1950, attention was called to the high cost of the overhead equipment. An examination of the many factors affecting this cost had been made, therefore, taking the 0·75-sq. in. copper equivalent system on the Liverpool Street-Shenfield electrification as standard. As, however, the conditions on this line were abnormal, in that there was 30 per cent. of open line and 70 per cent. of junction work, a hypothetical scheme consisting of 40 per cent. open-line tangent track, 20 per cent. open line curved track and 40 per cent. junction work was also considered. Taking 1952 figures as a basis, the cost of a single track-mile for such a scheme was 10,850*l*., including foundations, structures, wires, fittings, insulation and sectioning and switching apparatus. Special equipment at overbridges and positive and negative feeder cables were also included, but not surveying or bonding.

Four main types of overhead equipment were used on the Liverpool Street-Shenfield scheme,* the costs of which were in the ratio of 100 : 165 to 200 : 330. The most economical of these was a structure in which the span between the masts was limited to 66 ft., and a saving of 150*l*. per single-track mile could well be made on that by slewing or re-arranging the track. Further economies could be obtained by increasing the stresses in the steel members from 9 to 10 tons per square inch and reducing the wind and ice loadings, which would save about 175*l*. per mile on straight open line and 300*l*. at junctions. By reducing the minimum thickness of steel sections from 0·3 to 0·25 in. there would be a further saving of 160*l*. per single-track mile and by cutting down the existing provision for unbalanced loading a further economy of 50*l*. per mile could be attained. In design, it was necessary to weigh standardisation carefully against economy. Nearly 1,500 structures were required in the Shenfield scheme and for these there were 350 drawings, involving over 1,000 combinations of mast and bridge length. Nearly 900 were only used once and only 14 were used ten or more times. If the empirical formulæ used for foundations were modified, about 50*l*. per mile could be saved on a straight four-track open line and about 70*l*. per mile at junctions. The authors also suggested a change in the design of the anchor foundations, which, they considered, would save 75*l*. per mile on the typical scheme.

Dealing with the catenary system, the authors argued that about 570*l*. per single-track mile could be saved by reducing the copper section of the main-line equipment from 0·75 to 0·6 sq. in. Splicing the catenary would show a saving of 325*l*. per single-catenary overlap and of 350*l*. per two-track compound catenary overlap. Insulators could be cheapened by using the solid-core or cap-and-pin patterns. Simpler dropper assemblies would reduce the cost by 100*l*. per single-track mile on compound catenary construction, and by 160*l*. per mile on single-catenary construction.

If all the recommendations made in the paper were adopted, in addition to span-wire registration and reduced sectioning, there would, the authors considered, be a saving of 1,350*l*. per single-track mile. There might be a further saving of about 600*l*. per single-track mile if the vigorous planning now being carried out was continued to an advanced stage and if there was continuity of work in the field. In fact, the measures indicated in the paper pointed to a reduction from 10,850*l*. to 8,900*l*. per single-track line, and with copper at 231*l*. per ton the cost could be further decreased to 8,450*l*. per single-track mile by reducing the copper section on main lines from 0·7 to 0·6 sq. in.

* See ENGINEERING, vol. 168, page 325 (1949).

60-MW POWER STATION AT THE WILTON WORKS OF IMPERIAL CHEMICAL INDUSTRIES.

THE Wilton works of Imperial Chemical Industries, Limited, between Middlesbrough and Redcar, comprise factories which are operated by the Billingham, Dyestuffs, Plastics, and Alkali Divisions of that organisation. The site covers some 2,000 acres, much of which is suitable for industrial development, and lies about two miles from the sea and south of the River Tees. A further area of some 400 acres, with a direct frontage to the river, is connected to the main area by a " corridor " 500 ft. wide. This additional plot will be used for tipping waste products, including boiler ash, and probably for further industrial purposes. Parts of the factory are shown in Figs. 4 and 5, on page 824.

CHEMICAL PLANTS.

The Billingham Division is responsible for the operation of the olefine, ethylene oxide, ethylene glycol and formaldehyde plants at Wilton. The raw material for the first of these is light distillate oil, which is brought by tankers to Teesport and pumped thence to Wilton, where it is cracked or decomposed at high temperature and pressure to produce a mixture of olefine gases, some light petroleum spirit and tail gases. This process takes place in the Pyrolysis Section area, the equipment of which comprises steam and oil heaters, quench boilers and coolers and a primary fractionator. Operation of this part of the plant is effected from a control room. The gases produced by pyrolysis are passed to the Gas Separation Section of the plant, which includes electrically-driven compressors for the gas and refrigeration systems. The latter employ ammonia, three stages of ethylene and methane, in cascade. Apparatus for drying and purifying the process gas is also installed. A small treatment section converts the crude debutanised gasoline into marketable motor spirit.

The main products of the plant are ethylene and propylene, in addition to which hydrogen/methane, petrol and butylenes are also recovered. The propylene is passed through pipe-lines, which have been laid in a 9-ft. diameter tunnel 1,750 ft. long under the Tees, to the isopropanol, acetone and butanol plants at Billingham. The hydrogen/methane, petrol and butylenes are also transported by pipe-line to the ammonia and oil works at Billingham.

The ethylene-oxide plant receives ethylene from the olefine plant through two Hortonspheres. The ethylene is reacted with chlorine and lime slurry, using the chlorhydrin process, and the resulting ethylene oxide is stored in horizontal tanks. It is subsequently used to manufacture ethylene glycol and the detergent Lissapol N, while a subsidiary product is ethylene dichloride, which is available for direct sale. The ethylene glycol is made by reacting ethylene oxide with water at a pressure of 300 lb. per square inch and a temperature of about 200 deg. C. The aqueous glycol is first concentrated in triple-effect evaporators and then purified by distillation. Ethylene glycol will be one of the main raw materials to be used in the new Terylene plant which is now under construction at Wilton. It is also sold, as is the subsidiary product—diglycol—which is manufactured in a plant operated by the Dyestuffs Division from ethylene oxide and alkyl phenol drawn from Billingham. At a later date, the chlorine used in this process will be manufactured electrolytically at Wilton and so will increase the demand on the station described below. Finally, propylene from the olefine plant, as well as compressed carbon monoxide and hydrogen, are taken to Billingham and are there converted into isopropanol, butanol and acetone.

In addition, an independent plant has been erected at Wilton for the manufacture of formaldehyde. This employs refined methanol, which is brought from Billingham as a raw material. A single large burner is used to oxidise the methanol, silver granules being employed as a catalyst. Part of the product is employed in phenol-formaldehyde and

60-MW PASS-OUT POWER STATION AT WILTON.

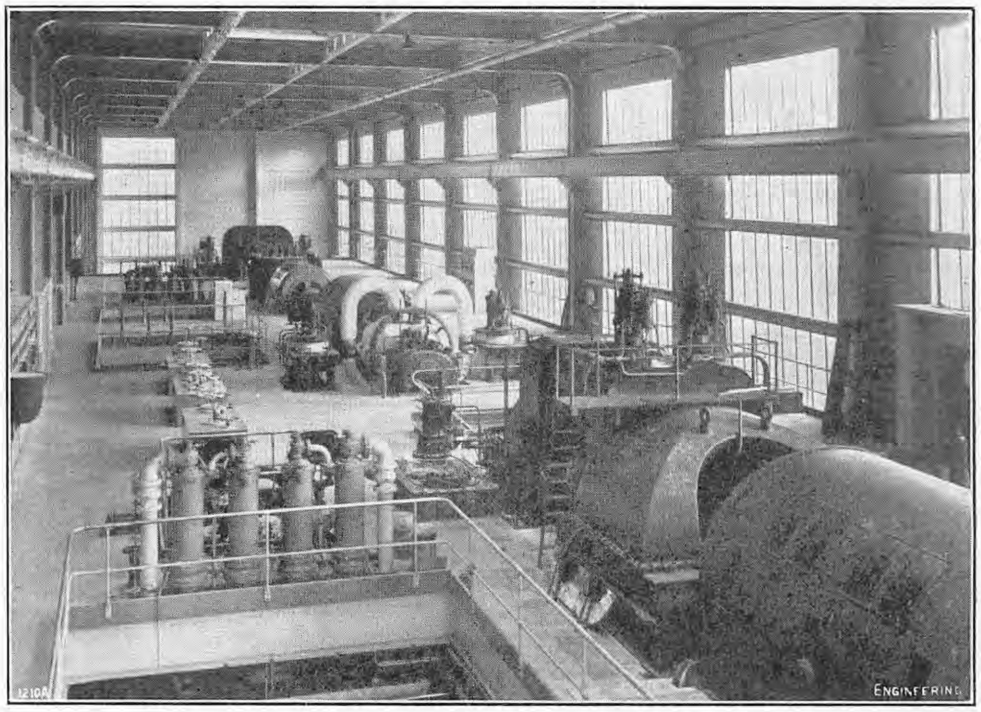


FIG. 1. VIEW IN TURBINE ROOM.

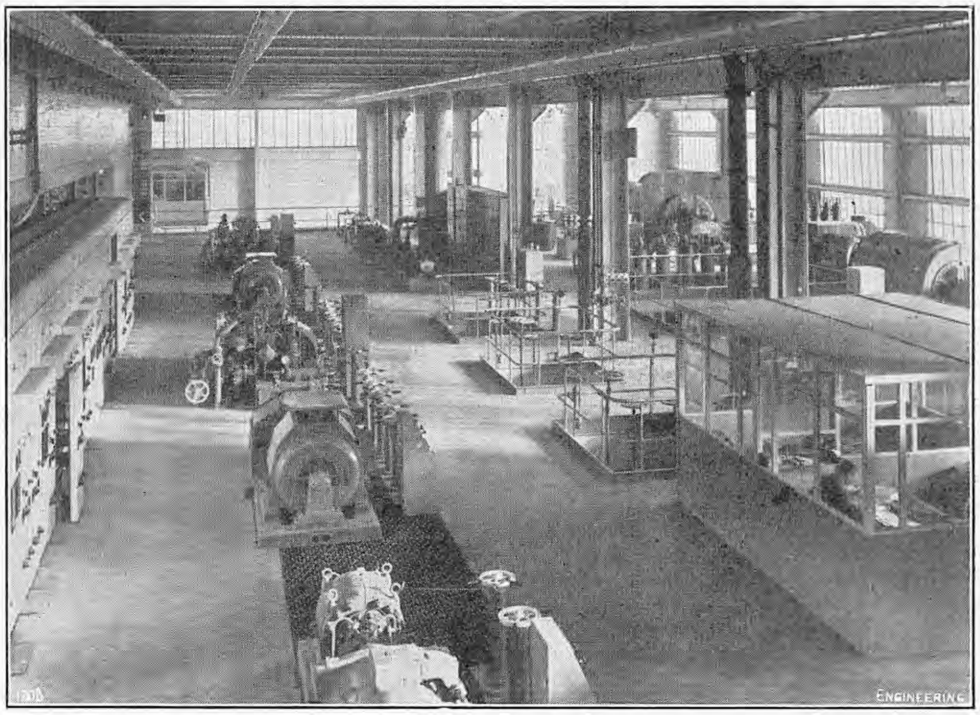


FIG. 2. FEED HEATER BAY.

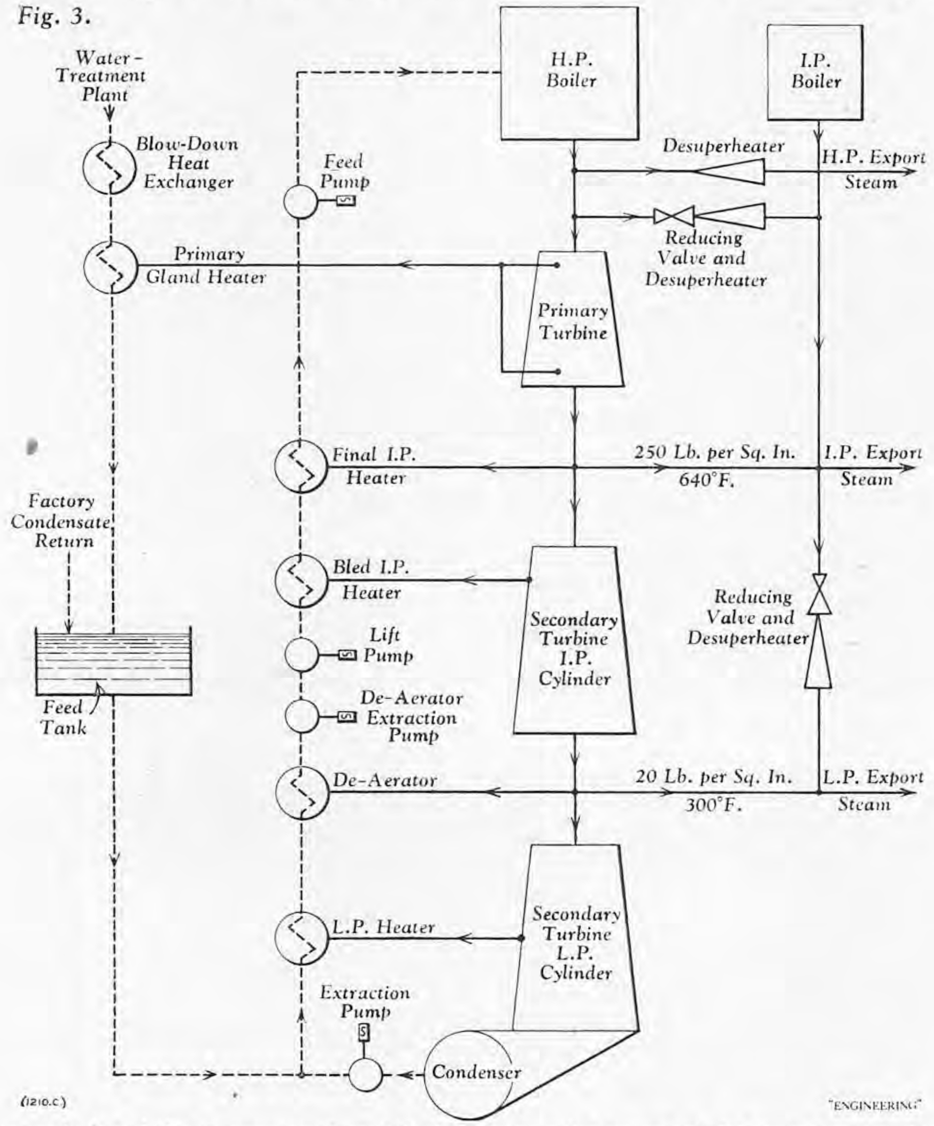
urea-formaldehyde resin plants, which are operated by the Plastics Division at Wilton, and the rest is sent to other factories. A considerable portion of these extensive plants is installed in the open air, ample space being generally allowed between them. A complete system of instrumentation has been installed in all cases and great attention has been paid to the design and layout of the necessary control rooms.

STEAM-RAISING PLANT.

Steam, electricity, water, compressed air and town's and inert gas are all required to operate the plants. The water and town's gas are obtained from the local authorities, while the steam, electricity and compressed air are generated on site. In addition, there is some interchange of electricity between the private power station described below and the North Eastern Electricity Board's system. For economic reasons, steam is generated at high pressure in two Babcock and Wilcox "high-head" boilers, each of which has an output of 265,000 lb. per hour at a pressure of 950 lb. per square inch and a temperature of 950 deg. F. These boilers, the firing floor of which is shown in Fig. 6, on page 824, have a heating surface of 4,620 sq. ft. and a combustion-chamber volume of 16,500 cub. ft. They are designed to burn either pulverised coal, oil or gas, or a combination of the three. The first of these fuels is brought in by rail and is discharged by a tippler on to a conveyor system which takes it to the boiler-house bunkers. It passes thence to pulverisers, of which there are three for each boiler, and each of which has an output of 13,500 lb. per hour. Oil firing is effected from two units, each of which is capable of supplying the maximum load of one boiler. Associated with the boilers are the usual superheaters, economisers and air heaters. The draught is provided by induced-draught, forced-draught and primary-air fans made by Messrs. James Howden and Company, Limited, Glasgow. There are three primary desuperheaters, each of which is capable of reducing the pressure of 264,000 lb. of steam per hour from 900 lb. to 253 lb.

60-MW PASS-OUT POWER STATION AT WILTON.

Fig. 3.



per square inch and the temperature from 900 deg. to 640 deg. F. Dust is extracted by 16 Buell units, which are about 4 ft. in diameter, and by Sturtevant electrostatic precipitators, of which there is one on each boiler. The supply at 45 kV for these precipitators is obtained from a mechanical rectifier, which is connected to a 50-kV transformer, a regulating transformer and control equipment manufactured by the British Thomson-Houston Company, Limited, Rugby. The dust and the boiler ash is conveyed by the Babcock and Wilcox Hydrojet system to a sump at the west end of the station and is then pumped into lagoons.

TURBINES AND FEED-HEATING.

Steam is supplied from the boilers to two primary back-pressure turbines, which were constructed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, and of which an illustration is given in Fig. 1. One of these machines is directly coupled to an 8·3-MW alternator and the other to a 17·5-MW alternator; both generate three-phase current at 11 kV when running at 3,000 r.p.m. These turbines exhaust about 50 tons of steam per hour at a pressure of 250 lb. per square inch and a temperature of 640 deg. F. Some of this steam is distributed round the site, principally for the evaporation of organic materials, while the rest is passed into two secondary pass-out condensing turbines, the proportions being determined by the factory demand. In order that a supply of process steam can be given when any set is out of action, reducing valves and desuperheaters are connected across the primary turbines and the low-pressure cylinders of the secondary turbines. These secondary turbines are in turn coupled one to an 11·35-MW generator and the other to a 23·5-MW alternator, which also generate at 11 kV when running at 3,000 r.p.m. Most of the exhaust from these secondary turbines is passed out at a pressure of 20 lb. per square inch for evaporating water and for space heating, about 50 tons per hour being required for this purpose. The remainder, amounting to about 25 per cent. of the 360 metric tons per hour supplied to the primary sets, is passed to condensers, thus allowing the electrical load to be met when the process steam requirements are less than normal. This arrangement obviously has the advantage of permitting a certain flexibility in operation, which is further secured by connecting the station to the Electricity Board's system through a 66-kV link and thus avoiding the installation of spare plant. This incoming voltage is stepped down to 11 kV, at which pressure a connection is made to the station 'bus-bars. It is thus possible both to export or to import power, as conditions require.

As only about 50 per cent. of the condensed steam is returned to the power station, a more than usually large amount of make-up water is required. This is obtained from the Tees Valley Water Board, the raw water being treated in a Permutit demineralisation plant with an output of 105 cubic metres per hour and consisting of three Deacidite and three hydrogen ion units. It is then fed to a degassing tower (where the carbon dioxide is removed), heated and passed to three Hick Hargreaves de-aerators, each of which has an output of 600,000 lb. per hour. It is subsequently treated by continuously dosing it with caustic soda, sodium sulphate and sodium sulphite; it is then heated further and pumped into the boilers, where it is intermittently dosed with disodium phosphate and tannin.

The turbine condensers are supplied with cooling water from a cooling tower of the induced-draught type, constructed by Film Cooling Towers (1925), Limited, this has a capacity of 4,200 cubic metres per hour. The three circulating pumps installed for this purpose have a combined output of 23,400 gallons per minute and were constructed by Messrs. Mather and Platt, Limited, Manchester. The feed-heating system through which the condensate is passed back to the boilers is arranged in seven stages: blow-down, two stages of gland-heating, low-pressure feed heaters, de-aerator, feed heaters supplied by intermediate-pressure bled steam, and final intermediate-pressure steam heaters. It incorporates three electrically-driven lift pumps, each with an output of 300,000 lb. per hour at a pressure of 375 lb. per square inch, a steam-driven lift pump with an output of 450,000 lb. per hour at the same pressure, three electrically-driven feed pumps with an output of 300,000 lb. per hour at a pressure of 1,205 lb. per square inch, and one steam-driven feed pump with an output of 300,000 lb. per hour at the same pressure. The arrangement of this part of the plant is shown diagrammatically in Fig. 3 and a view in the feed-heater bay is given in Fig. 2, on the opposite page. As regards operation, the boiler-house staff are responsible for maintaining the steam pressure at 900 lb. per square inch. The staff in the electrical control room, of which a view appears in Fig. 7, then adjust the setting of the primary turbine governor so that the pressure at the exhausts of these machines is 250 lb. per square inch.

In addition to the main high-pressure boilers mentioned above, the station contains two oil-fired boilers each of which has an output of 132,000 lb. of steam per hour at a pressure of 250 lb. per square inch and a temperature of 640 deg. F. These were originally installed to provide steam on the site until the main boilers were ready, but are now used as a stand-by.

ELECTRICAL SYSTEM.

As already mentioned, the station 'bus-bars are inter-connected with the system of the North Eastern Electricity Board by two 30-MVA feeders. These feeders supply two 66/11·5-kV Parsons transformers with tap-changing gear. The main switchgear is of the Reyrolle double 'bus-bar type, and is arranged in two sections. Each section controls two alternators and one incoming feeder, a 'bus-bar reactor being connected between them. Outgoing feeders to the works are connected to each section. The various station auxiliaries are supplied through two 5-MVA 11/3·3-kV Parsons transformers, one of which is connected to each section of the main 'bus-bars. The low-tension sides of these transformers are, in turn, connected to 3·3-kV double 'bus-bar airbreak switchgear of English Electric manufacture, by which the larger motors are controlled. The smaller motors and the lighting system are controlled by Metropolitan-Vickers airbreak switchgear, and are supplied from three 1,000-kVA 3,300/415-volt Lindley Thompson transformers. Squirrel-cage induction motors of Messrs. Mather and Platt manufacture are used throughout the station, those operating at 3·3-kV being individually controlled by direct-on English Electric circuit-breakers. The 415-volt motors are controlled by direct-on contactor or oil-break starters. The station equipment is completed by two Chloride batteries, one of which has a capacity of 600 ampere-hours at 110 volts and supplies current for closing and tripping the switchgear to the governor and valve motors and for emergency lighting. This battery floats across a Cycloc charger which operates in conjunction with a Hewittic mercury-arc rectifier. The other battery has an output of 120 ampere-hours at 50 volts and supplies the alarms and the house telephone system. The cables through which power is distributed through the works are run on concrete sleepers laid in shallow trenches, as shown in Fig. 5, on page 824.

FERGUSON TRACTORS TO BE MADE IN FRANCE.—Sir John Black, deputy chairman and managing director of the Standard Motor Co., Ltd., Coventry, announced at the annual general meeting of the company, on December 17, that arrangements had been made to make Ferguson tractors in France. The Standard Company are forming, in conjunction with the French Hotchkiss Company, a new concern, to be known as the Société Standard-Hotchkiss, which will produce 25,000 tractors a year. Parts supplied from the Standard Company's factory at Banner-lane, Coventry, will be assembled in France at first, but eventually the whole of the production will be carried out there.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

THE COAL INDUSTRY.—The Scottish coal production in 1952 has been officially estimated by Mr. H. R. King, the divisional production director, as likely to reach about 23,300,000 tons. This will compare with 23,605,000 tons last year. Man-power at the face rose from 36,200 to 37,400 during the year, while the total number of wage-earners increased from 82,100 to 85,700, the highest level in each category since nationalisation.

RIVER CLYDE IN PAST CENTURIES.—A comprehensive survey of the history and development of the river Clyde was given by Mr. W. F. Robertson, river surveyor of the Clyde Navigation Trust, at a meeting of the Glasgow branch of the Engineers' Guild on December 16. Until the latter half of the Eighteenth Century, he said, only small vessels used the river; the tonnage in 1597, for example, was given as between 21½ and 92. The first quay was built at the Broomielaw in 1663, and Port Glasgow was established in 1668.

ELECTRONICS RESEARCH LABORATORY, EDINBURGH.—Building work on the new electronics research laboratory of Ferranti, Ltd., Edinburgh, is expected to begin next month. Plans for the building were approved by the Edinburgh Dean of Guild Court on December 12. The new laboratory, which has been estimated to cost 190,000*l*., is a Government capitally-assisted scheme. It has been sponsored mainly by the Scottish Council (Development and Industry).

ELECTRICAL FAIR, GLASGOW.—Much interest has been shown in a special "Electrical Fair," at the Engineering Centre, Glasgow, designed to outline the opportunities offered by careers in the electrical-engineering industry. The fair, which closes on December 27, was organised by the Centre and the South-West Scotland Electricity Board. Mr. William Hutton, deputy chairman of the Board, said at the opening that they hoped to stir the imagination of young visitors and to encourage them to enter the engineering industry.

INVERNESS ROAD BRIDGE.—Inverness Corporation Works Committee are to have plans prepared for a new road bridge to replace the suspension bridge spanning the river Ness below Inverness Castle. The new bridge is to be designed by Sir Murdoch Macdonald and Partners, consulting engineers. The plans are being prepared at the invitation of the Ministry of Transport after discussions between their officials and representatives of the town council, and are to be submitted to the Fine Arts Council.

WATER SUPPLY FOR RIVER ENDRICK.—Stirlingshire and Falkirk Water Board are to promote a Provisional Order to give them powers to take in the waters of the river Endrick to add to the storage capacity of their Carron Valley reservoir. The present capacity of the reservoir is 4,300,000,000 gallons. When it was built in 1939, provision was made for tapping the watershed of the Endrick by constructing a weir on the river and building an embankment 1,560 ft. long to a maximum height of 36 ft.

RENFREW OIL REFINERY TO BE REBUILT.—Plans were made on December 9 for the rebuilding, in the near future, of the oil refinery of J. O. Buchanan & Co., Ltd., at Renfrew, which was destroyed by fire on December 8. Other oil firms in the West of Scotland have agreed to co-operate in the treatment of oils for the firm.

CLEVELAND AND THE NORTHERN COUNTIES.

TRADE ON THE TYNE.—At the monthly meeting of the Tyne Improvement Commission, at Newcastle-on-Tyne, it was reported that for the first eleven months of this year, coal and coke shipments from the Tyne amounted to 8,511,783 tons, compared with 7,944,500 tons last year. Shipments in November, however, were down on last year, the figures being 740,370 tons against 771,777 tons in 1951. So far this year, 1,528,344 tons of coal and coke have been sent overseas, against 1,176,027 tons in 1951. Exports of general merchandise for the first ten months of the year amounted to 327,162 tons, an increase of 7,805 tons on last year. General merchandise imports totalled 2,209,534 tons, an increase of 125,971 tons.

HEAVY STEELWORKS TRAFFIC AND ROAD DAMAGE.—The Consett Iron Co., Ltd., it is stated, have refused to contribute towards the repair of streets at Jarrow-on-Tyne, which, the Jarrow Corporation contend, are being damaged by lorries carrying steel billets from the firm's Consett works to the Jarrow rolling mills. The Consett company have also stated that no useful purpose would be served by meeting the Corporation to discuss the matter.

AN OMNIBUS-BODY TENDER.—A Sunderland firm, Associated Coachbuilders, Ltd., have protested against the action of the Sunderland Corporation Transport Committee in accepting the tender of Charles H. Roe, Ltd., Leeds, for the supply of eight omnibus bodies, when the Sunderland firm's tender was 75*l*. per body less. It is understood that the Transport Committee's decision was based on the fact that Associated Coachbuilders have not built omnibuses before. When the question was discussed at a meeting of Sunderland Town Council it was stated that the tender of the Sunderland firm was not in accordance with the specification, and the acceptance of the tender of the Leeds firm was confirmed.

MAN-POWER PROBLEM IN DARLINGTON.—Darlington District Employment Committee are to ascertain the number of local residents who work outside the town. Mr. Forrester Paton stated at a meeting of the Committee that he thought there was a danger of new industries, started on Tees-side, taking Darlington workpeople.

WATER-SUPPLY QUESTION IN LAKE DISTRICT.—At the annual meeting of the Cumberland Development Council at Whitehaven, Lord Adams asserted that, during the past six months, four large industries had been turned away from Cumberland because of inadequate water supplies. He added that Whitehaven Corporation were faced with an additional expenditure of 100,000*l*. on water supplies because of interference from the Friends of the Lake District "and other cranks."

COAL PROJECT AT MARYPORT.—When an inquiry was held at Cockermouth by the Ministry of Housing and Local Government into Cumberland County Council's 20 years' development plan, reference was made to the possibility of a new pit being sunk at Risehow, Maryport, by the National Coal Board. Mr. John Thompson, estate manager and surveyor to the Coal Board, said that the plan depended upon underground exploration to the north of what was known as the Maryport Fault.

THE LATE MR. A. H. DICKINSON.—The death has taken place at Newcastle-on-Tyne, at the age of 55, of Mr. Alfred Harold Dickinson, a director of the now absorbed Sunderland marine-engineering firm of John Dickinson and Sons. He was a grandson of the founder of the company, which was taken over by William Doxford and Sons, Sunderland, some years ago.

LANCASHIRE AND SOUTH YORKSHIRE.

RAILWAY SPEEDS.—Mr. K. A. Kindon, District Passenger Superintendent of British Railways (Eastern Division) has announced that a reasonably fast train service was more use, on the whole, to the public than a very fast train at one particular time. It was difficult to say if very high-speed trains would be re-introduced; they were expensive to provide, not only in money, but in line capacity, and they restricted the facilities for the rest of the traffic.

NEW BRITISH RAILWAY LOCOMOTIVES.—A new series of British Railways standard locomotives has been designed at the Doncaster works and built under the direction of Mr. R. A. Riddles. The Doncaster and Horwich locomotives works are to construct 25 of the engines and the first, built at Horwich, has been brought into service in the Scottish Region.

TRAINING SCHEME FOR FOREMEN.—Mr. H. Humphries, deputy chairman and managing director of Hadfields, Ltd., Sheffield, has announced that the company are introducing a new scheme for the intensive training of their foremen. Tuition will be given on such subjects as work study, productivity, quality control, and the conservation of man-power, materials and machine tools. The foremen will attend residential courses at the firm's Hecla Works, commencing on Monday, January 12, 1953, and will later attend a continuation course at the company's East Hecla Works. Local directors and other senior officials of the company will give the lectures, and time has been set aside for discussions and visits to operating departments.

THE MIDLANDS.

HOLLY BANK COLLIERY TO CLOSE.—Holly Bank Colliery, Essington, near Wolverhampton, is to close down at the end of Christmas week. The colliery is one of the oldest existing pits on Cannock Chase, and has reached the end of its economic life. The original owners established the nearby Hilton Main Colliery in 1920, but a few years later, owing to trade depression, Holly Bank Colliery was closed, and production was concentrated at Hilton Main. In 1938, however, Holly Bank Colliery was modernised and electrified, and has worked from that date until now. All the 214 underground workers will be transferred to pits in the Cannock Chase area.

OFFER OF LICENCES FOR AMERICAN PROCESSES.—The National Union of Manufacturers have sent to 300 firms in the East and South Midlands details of offers from about 250 American companies to license the use of their processes, patents, and techniques. The offers relate chiefly to the engineering industries at present, though the Union intend to approach American firms in other trades in the future. Considerable interest has been aroused in the area where the offers have been circulated, and it is expected that the proposals will be made known nationally.

ROAD TRANSPORT OF PRESSURE VESSEL.—A large pressure vessel, for use in wind-tunnel investigations at the National Physical Laboratory, left the works of John Thompson (Wolverhampton), Ltd., Ettingshall, Wolverhampton, by road for Teddington on December 16. It is of welded construction, 78 ft. long by 9 ft. in diameter, and is designed for a working pressure of 400 lb. per square inch.

FUEL EFFICIENCY PANEL.—The Midland Regional Board for Industry have set up a fuel efficiency panel, comprising representatives of managements, trade unions, and the Coal, Gas and Electricity Boards. The panel will act in an advisory capacity, and will, on request, give advice according to individual circumstances. Special attention will be given to the question of improving the efficiency of existing plant.

FLUORESCENT-TUBE PLANT FOR SMETHWICK.—The fluorescent-tube plant opened in Glasgow last January by Chance Brothers, Ltd., is to be transferred to the company's main works at Smethwick. The move has resulted from a reduction in the demand for fluorescent tubes. It will be possible to operate the plant on a reduced scale more economically in conjunction with other equipment at Smethwick.

AN OLD PETROL ENGINE.—The Villiers Engineering Co., Ltd., Wolverhampton, have received at their works a four-stroke petrol engine which was made by them and exported to Australia 40 years ago. It was originally built into an Australian-made motor-cycle frame, and after some years was converted to drive a circular saw. It is one of the first engines made by the company, and will be preserved by them as a historical relic.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SOUTH-WALES INDUSTRIAL IMPORTS AND EXPORTS.—Imports of iron ore into the South Wales ports in the first eleven months of this year amounted to 2,036,225 tons, compared with 1,829,480 tons in the corresponding period of last year. There was also a considerable rise in arrivals of partly-manufactured iron and steel goods, from 476,426 tons last year to 700,166 tons in 1952 and in oil and spirits from 3,441,388 to 4,120,987 tons. Imports of non-ferrous metal ores were little changed, at 240,068 tons this year, against 236,455 tons in the first eleven months of 1951. One of the best features of this year's trade at the South Wales ports, however, has been the expansion in the coal export trade. Shipments to the end of November this year, to foreign countries, totalled 3,462,655 tons, compared with 2,757,673 tons in the corresponding period of last year.

THREATENED SLOW-DOWN IN ENGINEERING WORKS.—Efforts are to be made to avert the embargo on piecework and overtime in the foundries and engineering works throughout West Wales, resolved upon by some 70,000 men employed by members of the Welsh Engineers and Founders Association, who recently rejected the men's application for a substantial wage increase. A meeting of the West Wales Engineering Trades Committee, at Swansea, considered the threatened embargo, which is due to come into effect from December 31, and decided to approach the industrial-relations officer of the Ministry of Labour with a view to requesting the employers to meet the men again at an early date to consider the claim for increased wages.

USKMOUTH POWER STATION.—The first generator at the new Uskmouth power station, near Newport, has now been fully synchronised and is generating electricity for the national grid. The building of this station, which cost between 30,000,000*l*. to 40,000,000*l*., took three years to complete.

NOTICES OF MEETINGS.

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

INSTITUTION OF CIVIL ENGINEERS.—*Airport Division:* Tuesday, December 30, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Reconciliation of Civil Engineering Problems with International Standards in the Siting and Planning of Airports," by Mr. A. S. Maclaren. *Maritime Division:* Tuesday, January 6, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Reconstruction of Greenwell's No. 1 Dry Dock and Ancillary Works at Sunderland," by Mr. Harry Ridehalgh. *Midlands Association:* Thursday, January 8, 6 p.m., James Watt Memorial Institute, Birmingham. "Prestressed Concrete in Civil Engineering Works," by Mr. A. J. Harris.

INSTITUTION OF ENGINEERING INSPECTION.—*London Branch:* Thursday, January 1, 6 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Standardisation and Inspection," Dip.-Ing. E. G. Brisch. *Coventry Branch:* Tuesday, January 6, 7.30 p.m., Technical College, Coventry. "Developments in the Manufacture and Use of Glass," by Dr. R. E. Bastick. *South-Western Branch:* Tuesday, January 6, 7.30 p.m., Grand Hotel, Broad-street, Bristol. Film Display. *Birmingham Branch:* Wednesday, January 7, 7.30 p.m., 95, New-street, Birmingham. Film Display.

INCORPORATED PLANT ENGINEERS.—*Peterborough Branch:* Thursday, January 1, 7.30 p.m., Offices of the Eastern Gas Board, Church-street, Peterborough. Open Discussion on "Automobiles." *Birmingham Branch:* Friday, January 2, 7.30 p.m., Imperial Hotel, Birmingham. (i) "Metal Spraying for Protection," by Mr. W. E. Ballard; and (ii) "Reclamation of Worn Parts by Metal Spraying," by Mr. R. Wallwork. *London Branch:* Tuesday, January 6, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Discussion on "The National Fuel Policy." *Edinburgh Branch:* Tuesday, January 6, 7 p.m., 25, Charlotte-square, Edinburgh. Open Meeting. *South Wales Branch:* Tuesday, January 6, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "A Plant Engineer Tours America," by Mr. G. E. Halter. *Southampton Branch:* Wednesday, January 7, 7.30 p.m., Polygon Hotel, Southampton. "Metallising in Relation to Plant Maintenance," by Mr. J. Porter.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 2, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Industrial Administration and Engineering Production Group.* "Principles and Practice Governing Interchangeability and the Specification of Manufacturing Limits of Size as Influenced by Statistical Considerations," by Captain G. C. Adams. *South Wales Branch:* Tuesday, January 6, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Contemporary Methods of Watch Production," by Mr. R. A. Fell and Mr. P. Indermuhle. *London Graduates' Section:* Tuesday, January 6, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Industrial Power Transmission Clutches and Couplings," by Mr. K. J. Freeman. *Institution:* Friday, January 9, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Thomas Lowe Gray Lecture on "Welding in Marine Engineering," by Mr. H. N. Pemberton. *Automobile Division:* Tuesday, January 13, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Life Assessment Tests for Commercial Vehicles," by Mr. J. H. Alden. *East Midlands Branch:* Wednesday, January 14, 7.30 p.m., County Technical College, Newark-on-Trent. Repetition of the Thomas Hawksley Lecture on "The Mechanism of Work-Hardening in Metals," by Professor N. F. Mott.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Western Counties Branch:* Friday, January 2, 6 p.m., The University, Bristol. "Unusual Design for a Large Constructional Shop," by Mr. F. R. Bullen. *Northern Counties Branch:* Tuesday, January 6, 6.30 p.m., Cleveland Scientific and Technical Institution, Middlesbrough. Open Meeting. *Institution:* Thursday, January 8, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Construction of Eight Prestressed-Concrete Tanks," by Colonel A. R. Mais and Mr. A. C. Little.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 2, 7 p.m., Townsend House, Greycoat-place, S.W.1. Film on "Packaged Power," introduced by Mr. H. M. Louch. *Midland Section:* Wednesday, January 7, 7 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address on "Some Aspects of Modern Materials Handling," by Mr. O. J. B. Orwin. *Institution:* Friday, January 9, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Automatic Feed Pressworking," by Mr. C. H. Crawford. *Sheffield Section:* Monday, January 12, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. "Science Looks at Works Corrosion," by Mr. H. G. Gow.

INSTITUTION OF PRODUCTION ENGINEERS.—*Liverpool Graduate Section:* Friday, January 2, 7.30 p.m., Exchange Hotel, Tithebarn-street, Liverpool. Discussion on "Industrial Administration." *Nottingham Section:* Tuesday, January 6, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Economics in Production Engineering," by Dr. F. A. Wells. *South Wales Section:* Thursday, January 8, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Precision with Production," by Mr. G. H. Clements. *Leicester Section:* Thursday, January 8, 7 p.m., Bell Hotel, Leicester. "Planing Machines and Practice," by Mr. G. Butler. *London Section:* Thursday, January 8, 7 p.m., Old Ship Hotel, Brighton. Film Display. *Reading Section:* Thursday, January 8, 7.15 p.m., Great Western Hotel, Reading. "The Use of Rubber as an Engineering Material," by Mr. G. W. Trobridge. *West Wales Section:* Friday, January 9, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Electronics in Industry," by Mr. A. G. Hickman. *Eastern Counties Section:* Friday, January 9, 7.30 p.m., Public Library Ipswich. "Motion Study: Some Practical Applications," by Mr. R. Craven.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, January 5, 6 p.m., James Watt Memorial Institute, Birmingham. "Post-Graduate Activities in Electrical Engineering," by Mr. W. J. Gibbs and others. *Merseyside and North Wales Centre:* Monday, January 5, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Uses of Earthed Signal Conductors on Transmission Circuits," by Mr. W. Casson. *District Meeting:* Monday, January 5, 6.30 p.m., Crown and Anchor Hotel, Ipswich. "275-kV Developments on the British Grid," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *Measurements and Radio Sections:* Tuesday, January 6, 5.30 p.m., Victoria-embankment, W.C.2. "An Improved Scanning Electron Microscope for Opaque Specimens," by Mr. D. McMullan. *North-Western Centre:* Tuesday, January 6, 6.15 p.m., Engineers' Club, Manchester. "The Characteristics and Control of Rectifier-Motor Variable-Speed Drives," by Mr. P. Bingley. *North Midlands Centre:* Tuesday, January 6, 6.30 p.m., 1, Whitehall-road, Leeds. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. *Southern Centre:* Wednesday, January 7, 6.30 p.m., Technical College, Brighton. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *Institution:* Thursday, January 8, Victoria-embankment, W.C.2., 4.30 p.m., "Nuclear Reactors and Applications," by Sir John Cockcroft, F.R.S. 6 p.m., Symposium on "Nuclear Reactor Instrumentation."

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Monday, January 5, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "The Modern Single-Layer Selenium Photocell," by Dr. G. A. Veszi. *Scottish Section:* Thursday, January 8, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. Film Display.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, January 5, 7.30 p.m., College of Commerce and Technology, Pond-street, Sheffield, 1. Discussion on "Methods of Making a Typical Casting in Iron, Steel and Non-Ferrous Metal." *West Riding of Yorkshire Branch:* Wednesday, January 7, 6.30 p.m., Technical College, Bradford. "Economical Use of Metal in Foundry Practice," by Mr. D. W. Hammond. *Burnley Section:* Wednesday, January 7, 7.30 p.m., Municipal College, Ormerod-road, Burnley. "Production of Heavy Castings," by Mr. C. F. Lawson. *Lincolnshire Branch:* Thursday, January 8, 7.15 p.m., Technical College, Lincoln. Report on "Flow of Metal," presented by Mr. E. M. Currie. Also at the *Scottish Branch:* Saturday, January 10, 3 p.m., Royal Technical College, Glasgow. *Newcastle Branch:* Saturday, January 10, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Ultrasonic Methods of Inspection," by Mr. N. H. Baddeley.

ENGINEERS' GUILD.—*West Midlands Branch:* Tuesday, January 6, 6.30 p.m., Imperial Hotel, Birmingham. "Presentation of Technical Information," by Professor R. O. Kapp.

INSTITUTE OF FUEL.—*Scottish Section:* Tuesday, January 6, 7 p.m., Royal Technical College, Glasgow. "The Ridley Report and After," by Mr. Gerald Nabarro. *North-Western Section:* Thursday, January 8, 6.30 p.m., Engineers' Club, Manchester. Various papers on "Fuel and Fuel Efficiency." *East Midland Section:* Wednesday, January 14, 7 p.m., Welbeck Hotel, Nottingham. "Peak Steam Demands and Thermal Storage," by Dr. E. G. Ritchie.

INSTITUTE OF METALS.—*Oxford Section:* Tuesday, January 6, 7 p.m., Black Hall, St. Giles, Oxford. "Recent Advances in Alloy Chemistry," by Dr. J. W. Christian. *Birmingham Meeting:* Thursday, January 8, 2.30 p.m., The University, Edgbaston, Birmingham. Informal Discussion on "Rolls and Their Maintenance in the Non-Ferrous Metals Industry."

NEWCOMEN SOCIETY.—Wednesday, January 7, 5.30 p.m., Institution of Civil Engineers, Great George-street, Westminster, S.W.1. Ordinary General Meeting. "Some Factors in the Early Development of the Centrifugal Pump, between 1689 and 1851," by Mr. L. E. Harris.

PERSONAL.

The honorary degree of Doctor of Science has been conferred upon PROFESSOR J. F. BAKER, O.B.E., M.A., D.Sc., M.I.C.E., M.I.Struct.E., by the Court of the University of Leeds. MR. J. WILKINSON, chairman of a corrosion research committee of the British Non-Ferrous Metals Research Association, has received an honorary M.Sc. degree of the University.

The Council of the Institute of Metals, 4, Grosvenor-gardens, London, S.W.1, have awarded the Institute Platinum Medal for 1953 to PROFESSOR G. MASING, of the Institut für Allgmeine Metallkunde, Universitat Göttingen, in recognition of his contributions in the field of metallography. The Rosenhain Medal for 1953 has been awarded to DR. C. E. RANSLEY, of the research laboratories of the British Aluminium Co. Ltd., in recognition of his work on gas-metal equilibria.

The Court of the University of Durham have appointed DR. W. S. PATTERSON, M.Sc., at present lecturer in fuel technology at Newcastle-upon-Tyne, to be a Reader in fuel science at Newcastle. LORD RUNCIMAN OF DOXFORD has been elected a representative of King's College on the University Court until July, 1955.

Vickers Ltd., Vickers House, Broadway, London, S.W.1, announce that, for reasons of health, MR. A. J. PALMER, C.B.E., is vacating his seat on the board of directors on December 31. He also retires from the boards of Vickers-Armstrongs Ltd., and other companies in the Group.

MR. G. T. SHOOSMITH, M.A., M.I.C.E., M.I.Mech.E., M.I.Mar.E., has resigned his position as engineer to Wm. Cory and Son, Ltd., Cory Buildings, Fenchurch-street, London, E.C.3, and, on January 1, 1953, takes up an appointment as joint managing director of Plenty and Son, Ltd., Newbury, Berkshire.

MR. WILLIAM CASSON, M.I.E.E., technical engineer, Eastern Division, British Electricity Authority, has been appointed system design and development engineer in the transmission design branch at headquarters.

MR. SIDNEY B. HASLAM, O.B.E., M.I.Mech.E., M.I.E.E., 93, St. Mary-street, Cardiff, retires from the position of South Wales agent for the Power Plant Co. Ltd., West Drayton, Middlesex, on December 31. MR. G. H. PEARSON, A.M.I.Mech.E., 56, Bridge-street, Newport, Monmouthshire, has been appointed as Mr. Haslam's successor.

MR. B. H. HATTON, of Bank House, Windsor Bank, Boston, Lincolnshire, is retiring on account of ill-health after nearly 50 years of association with land-drainage reclamation, and aerodrome-construction works. He joined Mornement and Ray, drainage and constructional engineers, East Harling, Norwich, Norfolk, in 1905, and eventually became general manager. When the company was wound up in 1949, he started on his own account.

CAPTAIN R. T. PAUL, C.B.E., R.N. (ret.), A.M.I.E.E., has joined the equipment division of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2, as commercial manager, co-ordinating the activities of the three product groups, namely, radio, telephone and electronic equipment.

MR. G. A. PARKER has been elected President of the British Association of Machine Tool Merchants, West India House, 96-98, Leadenhall-street, London, E.C.3, for the ensuing year. He succeeds MR. G. E. WHITTAKER, who remains on the Council as the immediate past-president. MR. A. W. V. AGUTTER has been elected vice-president and MR. E. J. F. BRADLEY, honorary treasurer.

MR. FRASER YORKSTON, outdoor commercial representative for Jones and Campbell, Ltd., Torwood Foundry, Larbert, Stirlingshire, has retired after 51 years of service.

MR. W. J. YOUNG, B.Sc., for the past five years assistant to the borough engineer, Luton, Bedfordshire, has been appointed to the Colonial Engineering Service in Fiji.

MR. H. SHAW, who retired from the staff of the Shell Petroleum Co. Ltd., on November 30, is joining the de Havilland Aircraft Co. Ltd., Hatfield, Hertfordshire, on January 1, 1953, to undertake duties of liaison with world airline operators.

MATERIALS HANDLING EQUIPMENT (GREAT BRITAIN) LTD., 7, Chesterfield-gardens, Curzon-street, Mayfair, London, W.1, have been appointed export managers for the $7\frac{1}{2}$-ton capacity "Timber Wolf" straddle carrier, by PEST CONTROL LTD., Harston, Cambridge, and for the "Merton Overhead Loader," by the MERTON ENGINEERING CO. LTD., Feltham, Middlesex.

ALEXANDER DUCKHAM & CO. LTD., inform us that the address of their head office and sales department is now: Hammersmith, London, W.6. (Telephone: FULham 3300.)

JONES AND NICHOLSON LTD., have removed from Nos. 40-43 to No. 3, Fleet-street, London, E.C.4. (Telephone: CENtral 8488, is unchanged.)

60-MW PASS-OUT POWER STATION OF IMPERIAL CHEMICAL INDUSTRIES, LIMITED, WILTON.

(*For Description, see Page* 820.)

Fig. 4. Wilton Factory from the South-West.

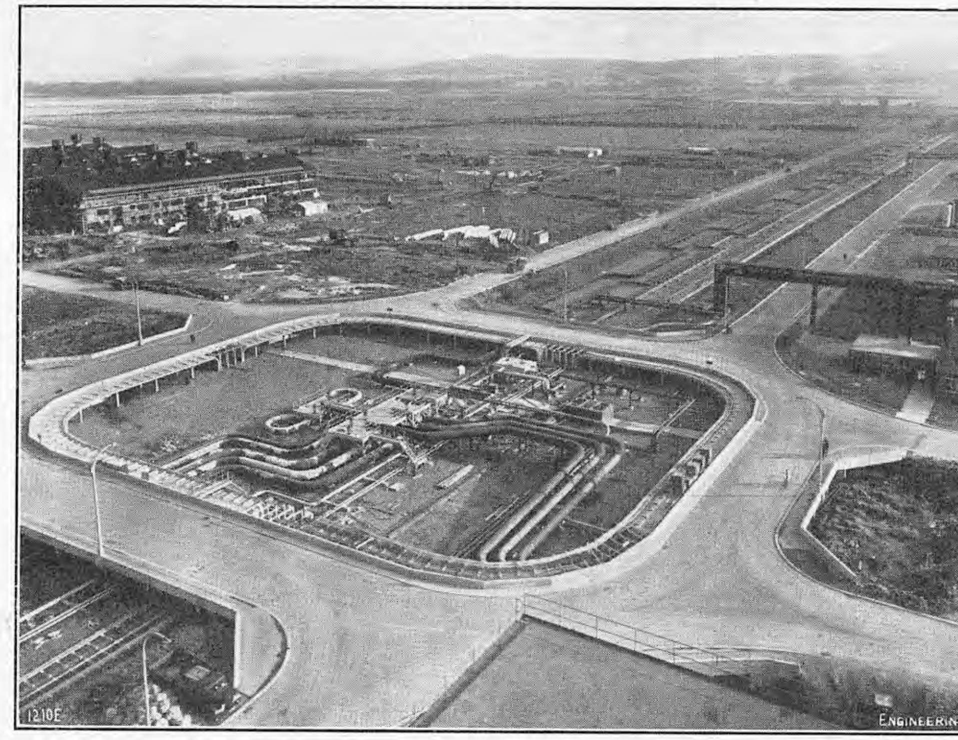


Fig. 5. Trenches for Steam Piping and Electric Services.

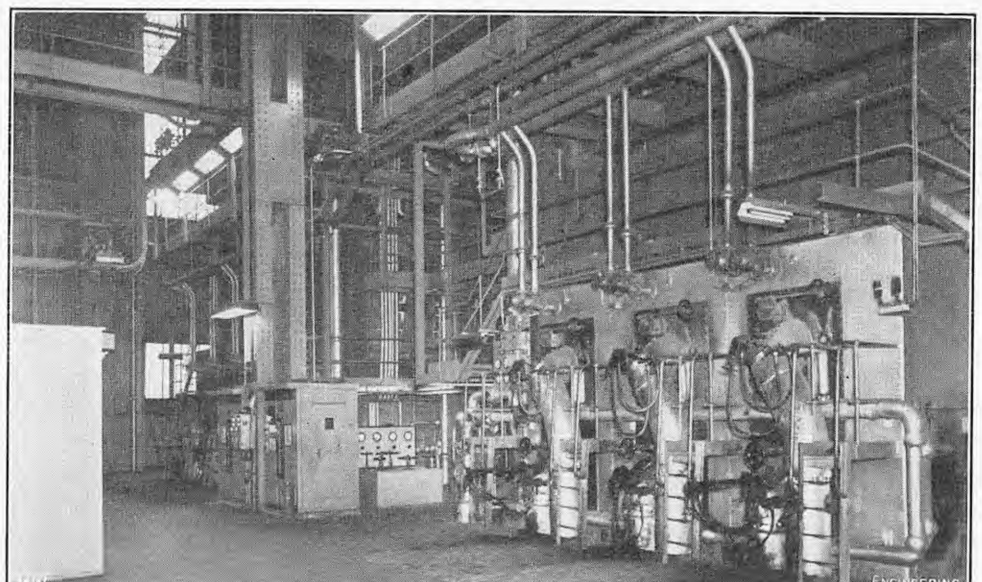


Fig. 6. Boiler-House Firing Floor.

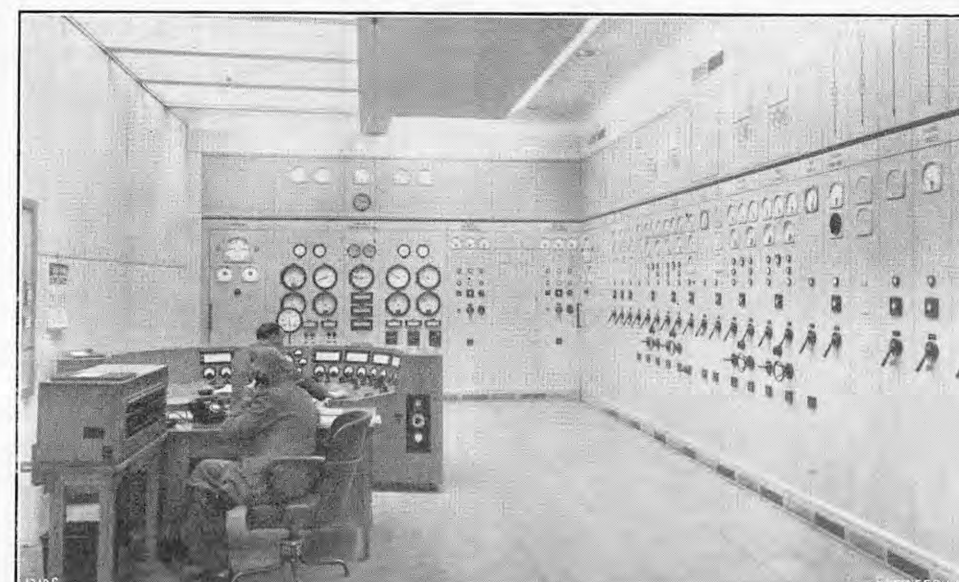


Fig. 7. Control Room.

ENGINEERING

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

INDEX TO VOL. 173.

The Index to Vol. 173 of ENGINEERING (January-June, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

CONTENTS.

ENGINEERING

FRIDAY, DECEMBER 26, 1952.

VOL. 174. No. 4535.

HYDRAULICS RESEARCH.

FOR many years past, hydraulics research has formed part of the curriculum of most British universities and engineering colleges, but, until comparatively recently, it was carried on only to a limited extent. The increasing interest shown in the subject on the Continent, however, and in the United States, eventually brought home to those directly concerned, both on the teaching and the design sides, the desirability and even necessity of establishing a hydraulics research station specifically laid out for the purpose of resolving, by means of models, problems affecting, in particular, coast erosion and the behaviour of rivers and estuaries. In 1945, therefore, the Institution of Civil Engineers submitted a memorandum to the Department of Scientific and Industrial Research, pointing out the need for a hydraulics research station which could deal with the less exact side of the science, namely, that part of it relating to "loose-boundary" conditions and the effects of flowing water. Such a station was established in India more than 30 years ago, mainly to investigate subsoil flows and the scouring, silting and training of rivers. That station, situated at Poona, appears to have been the forerunner of various similar establishments subsequently set up in Europe and in the United States, where to-day almost every hydraulic project is tested by means of a model before finality in the design is reached and actual construction begins.

The outcome of the memorandum prepared by the Institution of Civil Engineers was the appointment, by the Lord President of the Council, of the Hydraulics Research Board, with Sir William Halcrow as chairman and Sir Claude Inglis, previously Director of the Indian Waterways Experimental Station at Poona, as Director of Hydraulics Research. Work was begun at once on the co-ordination of the relevant research activities at the universities and elsewhere, and concurrently a site was sought for a central research station. The finding of a suitable site proved to be a long task, however, and it was not until the summer of 1951 that the one eventually selected, at Howbery Park, near Wallingford, Berkshire, was sufficiently developed to enable the headquarters of the organisation to be transferred there from its temporary premises in London. Nevertheless, and despite the difficulties and delays attendant upon the adaptation of the existing building—a former country house—and the design and construction of the requisite channels and model basins, a considerable amount of research has been carried out ; chiefly, however, by making use of accommodation placed at the disposal of the Board by the National Physical Laboratory at Teddington. A report on what has been accomplished, between 1947 and 1951, has been published recently by H.M. Stationery Office.*

The principal investigations recorded in the report are those on the Thames estuary, the Forth estuary, the river Wyre, and the Eden at Carlisle. Reference has been made in our pages to the first three of these, and the models of the Thames, built by the staff of the Port of London Authority with the assistance of the Director and staff of the Hydraulics Research Station, were described in some detail, with illustrations, in our issue of February 1, 1952 (vol. 173, page 139) ; the article also outlined the principle of operation of the pneumatic displacer, designed in the Research Station, which produces the tidal ebb and flow in the model. The case of the river Eden presented some peculiarities. The aim was to regrade the river with the object of reducing the flood level at Carlisle by 2 ft. 3 in. ; but this introduced complications because of the need to maintain the level at the cooling-water intake of the Willow Holme power station. Various designs were investigated, embodying a weir to maintain the level, but tests with models indicated that severe scouring would result in time of flood. The Director suggested the use of submerged gates, which would open automatically and could be closed by hand gear or electrically ; but these could not be obtained, and therefore experiments are in hand for their design. Other work in progress includes an investigation on behalf of the Lyttelton Harbour Board, New Zealand, to ensure that a proposed enlargement of the present harbour will not involve increased wave wave action, or additional silting and consequent dredging ; and the construction of a model of a dock entrance at Freetown, Sierra Leone, where strong currents must be taken into account in the design.

What is expected to be the most important part of the Research Station's work, however, is that concerned with coast erosion, a field in which, at present, little scientific guidance is available. At present, as the report observes and many instances confirm, coast-protection works may well aggravate the effects that they are intended to remedy. Examples cited are the construction of groynes to prevent local erosion of beaches, which often do so at the expense of adjacent stretches of coast ; and the effect of seawalls in deflecting wave energy and so promoting turbulence which may cause serious degradation of a beach. These problems urgently need systematic study, to ensure that intended protective works will, in fact, give the desired protection to the coast as a whole, and at a reasonable cost. As a start, a tank has been constructed at Howbery Park, 54 ft. long and 10 ft. wide, and pro-

* *Report of the Hydraulics Research Board for the Years* 1947-1951, *with the Report of the Director of Hydraulics Research for the Years* 1948-1951. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 3*s*. net.]

vided with a wave generator of the oscillating-paddle type. It is being used, in the first place, to study the long-term effect of seawalls on the beaches in front of them. Concurrently, field surveys will be carried out; and in a second tank, measuring 120 ft. long and 80 ft. wide, in which it will be possible to study the effects of currents and tides, an investigation will be made of the velocity and direction of movement of water on beaches, and the modification to the flow induced by the erection of groynes. The movement of bed material will also be examined, and it is hoped to obtain a quantitative relationship between the rate at which the material is shifted by bed movement and suspension in the model, with the rates at which it is moved by the same means in the sea.

THE WAY OF A SHIP.

THE first book ever to be reviewed in ENGINEERING—on page 2 of Vol. 1, in the issue of January 5, 1866—was that monumental work, *The Modern System of Naval Architecture*, by John Scott Russell, F.R.S., the builder of the Great Eastern. If one book rather than another deserved to be described as a *magnum opus*, that was the one. Of it we expressed the opinion that "We shall do no injustice whatever to previous writers on Naval Architecture when we say that this is, in every sense, the greatest work on that subject which has appeared." Those who have handled it will appreciate, no doubt, the point of "in every sense," for it consisted of three large volumes, weighed 30 lb. at the least, and cost 30 guineas to subscribers and 40 guineas to other purchasers. Even at that price, it is said, the publishers were badly out of pocket. In the plain language of the mid-Twentieth Century, it was a flop. To-day, its interest is chiefly for the historian and the lover of mid-Victorian technical engravings, for Scott Russell evidently had some fine draughtsmen; but even these possible purchasers do not seem to have set much store by it, for it could be bought immediately before the recent war for a mere three guineas. To-day it probably costs a little more, but the possible market must be still more restricted. Modern houses are not built to accommodate such ponderous works.

There are some branches of technology which have never developed an extensive literature; the design of watertube boilers, for example, and even of machine tools, though this latter field has been receiving more attention in recent years. Naval architecture is in the same category, probably because, although the tonnage of shipping in the world is higher to-day than it has ever been, the design requirements of the shipbuilding industry can still be met by a comparatively small number of practising naval architects—too small a number to offer any strong inducement to publishers to embark upon the production of books which, from their nature, must be expensive to print and to illustrate. The appearance of a new book on the subject, therefore, is something of an event, and for this reason, if for no other, naval architects have awaited with more than usual interest the publication of the text-book which Professor A. M. Robb was known to have had in preparation for several years. It has now appeared* and, while of much more manageable dimensions and cost than that of Scott Russell, may still be described as "the greatest work" of its kind, in this country, at any rate, and possibly without that qualification, since his massive publication was launched nearly 90 years ago.

The author, who is well known as the John Elder Professor of Naval Architecture in the University of Glasgow, defines his purpose in writing the book as that of providing a background for a course of lectures to university students. Throughout, as he states in the preface, he has placed the main emphasis on the elucidation of principles rather than the application of methods; in other words, he is not writing for the ship constructor, but for the potential ship designer. To achieve his object within the compass of a single volume, albeit a demy quarto of 760 pages, with eight plates and no fewer than 637 admirably-drawn illustrations in the text, is an ambitious project, and it is not altogether surprising that there should be one or two omissions—for instance, the steering of ships; though it should be noted, *per contra*, that so recent a development as the effective stabilisation of ships is the subject of a lengthy and detailed chapter.

In the major portion of the book, containing the orthodox presentation of the theory of naval architecture, Professor Robb's treatment is thorough, and noteworthy for its historical precision. He goes to considerable trouble to give the reader the classical references necessary for a sound basic appreciation of the many facets that must be comprehended, and supports the theory with numerous fully-worked examples. It is when he enters the field of controversy—and, inevitably, there is still much that is controversial in naval architecture, as students of the transactions of any of the institutions concerned with the subject well know—that some of his expressed views may provoke criticism from his fellow practitioners. He has much to say in opposition to the current techniques in ship-model experiments, stating his firm conviction, for instance, that the tank techniques for evaluating the resistance of ships are unsound in principle; though he does admit that the results "are justified by experience, provided that factors from that experience are brought into account."

This is a sound maxim for the student in judging the assistance that he can get from all the theoretical and experimental aids now available, though some may feel that any technique of which so much can be said should be passed on to the student without unduly disturbing his faith until something better is forthcoming—as, possibly, it may be when the results of the Lucy Ashton trials are fully collated and digested. That the Froudes broke through the major obstacles in harnessing scale-model experiments to the service of the ship designer cannot be doubted by very many; and even they would probably admit the desirability that, in matters of naval-architectural controversy, the student would do well to retain a reasonably open mind, remembering always that the function of education is to train him to do his own thinking and not merely to indoctrinate him with ready-made ideas. From that point of view, it is infinitely better that a text-book should be provocative as well as instructive; a desideratum which this one certainly fulfils, as witness—to cite only a single example—Professor Robb's forthright criticism of the growing practice of the artificial stimulation of turbulence on the immersed surface of ship models.

The conscientious reader of the book will certainly find in it a great deal that is of value and which will repay his careful study; and as a work of reference it will undoubtedly prove its worth in many branches of naval architecture, to the designer and the consultant as well as to those entrants upon its highly specialised field of experiment and applied science to whom it is primarily addressed. We contrasted the book initially with that of Scott Russell, but in fact there is no real comparison. It is a more useful book than his ever was, and, bearing in mind the progressive decline in the value of money, probably costs no more than a twentieth of the equivalent price. It may not represent the last word on its subject, but that is readily understandable; for, despite the great advances that have been made in instrumentation in recent years, naval architecture is still a long way from being an exact science.

* *Theory of Naval Architecture.* By Professor Andrew McCance Robb, D.Sc. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 8 gns.]

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE subject index to the *Proceedings of the Institution of Mechanical Engineers* contains no references to horology or clocks and only one to watches—and that refers to a paper on the manufacture of standard screws for machine-made watches, presented in 1894. This virtually complete absence of papers on a branch of mechanical engineering to which Englishmen, many years ago, made important contributions, was rectified by a paper entitled "Contemporary Methods of Watch Production" which Mr. R. A. Fell, M.A., and Mr. P. Indermuhle, A.M.I.Mech.E., presented to the Institution on Friday, December 19. The dearth of published information was emphasised in the synopsis: "There is at present no written matter in the English language on watch production, the industry having died out in Britain some thirty years ago." It has been re-established, however, and, as Mr. K. J. Hume said in opening the discussion, it is now quite an important part of the engineering industry. In their paper, the authors described the design and production of a 15-jewelled man's wrist-watch with lever escapement. Owing to the restricted space in such a watch, a special type of gearing is used. The smallest pinion, they said, had seven leaves of about 0·11-mm. module, giving a tip diameter of about 0·9 mm. The tip diameter of a six-leaf pinion for a very small watch for a lady was about 0·5 mm. Describing the techniques of production, they explained that holes drilled in the bottom plate (or "pillar" plate) by an automatic machine were accurately located to within about 0·0004 in. This was sufficient for screw holes, but it was not satisfactory for the location of the train-wheel centres, motion-work centres, steady pins, etc. Steady-pin holes, which had to be very accurately located, to within 0·0001 in., were drilled about 0·1 mm. undersize and subsequently brought to their final position and size by shaving on a special press tool. Flat-faced punches of the exact size of the finished hole were located in a punch plate made with the greatest care. After describing the use of a timing machine—which has an accuracy of one or two seconds per day and with which a watch can quickly be adjusted—the authors said that a commercial wrist-watch of the best grade should run to within about 20 seconds per day in five positions and over a range of about 30 deg. C. It should retain its accuracy for up to two years, when it should be cleaned and oiled by a thoroughly competent repairer.

REPORT ON "COMET" AIR-LINER ACCIDENT AT ROME.

On October 26, a Comet I air liner, G-ALYZ, taking off on the second stage of a scheduled passenger flight operated by British Overseas Airways Corporation, from London to Johannesburg, crashed at Ciampino Airport, Rome. The aircraft was severely damaged, and two passengers received slight injuries, but, although there was a large spill of fuel from the port-wing integral tanks, no fire broke out. It is probably fair to say that, had the Comet tanks been filled with petrol instead of kerosine, a disastrous fire would almost certainly have occurred. After the accident, and before the official investigation, B.O.A.C. issued a statement that the crash had resulted from a loss of engine thrust. This was subsequently contradicted by the de Havilland company, and later by the Chief Inspector of Accidents, in an interim statement. The full report of the Chief Inspector of Accidents has now been issued by the Ministry of Civil Aviation, and copies will shortly be available from H.M. Stationery Office. The report reveals that the accident occurred as a result of an error of judgment by the pilot in putting the aircraft into an excessively nose-up attitude during the take-off, and thus allowing a partial stall and high drag to develop, so that the aircraft's normal acceleration did not build up. An examination of the runway revealed that the tail bumper had touched the ground at intervals extending along the last 650 yards of the runway; in order to do this, the fuselage must have been held at an angle of at least $11\frac{1}{2}$ deg. A ground witness who observed the take-off from about half-way along the runway stated that the nose was exceptionally high and that he was not aware of the aircraft becoming airborne. The report includes a passage quoted from the B.O.A.C. training manual which states that "take-off tests by the manufacturers have shown that a constant 6 deg. incidence of fuselage during the ground run gives good results for distance run and for climb-away behaviour. They have also shown that an increase of incidence to 9 deg. results in a partially stalled wing giving high drag which appreciably affects the aircraft's acceleration, and that the symptoms are noticeable to the pilot as a low-frequency buffet. The aircraft recovers from its semi-stalled position if the nose is pushed well down."

CORROSION OF BURIED ARTICLES INHIBITED BY TANNATES.

Information obtained from the examination of iron implements 2,000 years old may lead to a new method of protecting underground pipes from corrosion. Although the articles were buried in an exceedingly aggressive soil from the corrosion point of view, they were found to be perfectly preserved. The fortuitous presence of tannates in the soil appears to have completely prevented action by sulphate-reducing bacteria, which, as is now well known, are responsible for most cases of rapid corrosion in water-logged clay soils, such as that in which the articles were found. The iron specimens, ranging from hob-nails to knives, were dug up during excavations by the Inspectorate of Ancient Monuments, Ministry of Works, on a site at Hungate, York, and it was on account of their excellent state of preservation that samples of the soil in which they had been buried were examined by the Chemical Research Laboratory of the Department of Scientific and Industrial Research, at Teddington. Sulphate-reducing bacteria were, indeed, found to be present, but they were not active, and scrapings from a Roman knife showed that there were traces of tannate in the slight surface corrosion which existed. The soil on the site is peaty and has been found to contain many leather cuttings, as well as several mediæval shoes. Moreover, it is believed that a cordwainers' hall stood nearby in the Middle Ages and that the area was the centre of a leather industry. This is the obvious explanation of the presence of tannin in the ground at Hungate. Cultures of sulphate-reducing bacteria were made and inoculated with soil from the site, with the result that the activity of the bacteria ceased when more than 5 per cent. of the soil was added. This result suggests that extracts from the leather cuttings on the site are at least partly responsible, and other experiments using solutions prepared from leather specimens have confirmed this. Subsequent work has shown that tannic acid in concentrations greater than 0·01 per cent. stops the action of sulphate-reducing bacteria, a discovery which may have far-reaching consequences in combating underground corrosion.

EVALUATION OF RESTRIKING VOLTAGE SEVERITY.

The restriking voltage severity of a circuit is one of the factors that must be considered when judging the short-circuit performance of a circuit-breaker. The importance of this factor has, indeed, been recognised for many years and it has been the subject of many investigations. A difficulty, however, arises when it becomes necessary to compare the severity of circuits producing restriking-voltage transients of widely differing wave form. It is therefore interesting to learn that a method of overcoming this drawback has been evolved by the Association of Short-Circuit Testing Authorities and is being considered by the International Electrotechnical Commission for inclusion in the next edition of their specification for alternating-current circuit-breakers. In the meantime, a method of evaluation of restriking voltage is set out in a series of interim rules which have been published by the Association and can be obtained from 36, Kingsway, London, W.C.2, at a price of 5*s*. These provide a means whereby comparisons may be made on a uniform basis during testing.

LETTER TO THE EDITOR.

TEN YEARS OF R.E.M.E.

TO THE EDITOR OF ENGINEERING.

SIR,—I regret that Brigadier Howard, in the letter on page 732 of your issue of December 5, construes my remarks (page 539 of the issue of October 24) as an attack on R.E.M.E., whereas my enemy, and that of all right-minded people, is over-centralisation, particularly in the sphere of weapons.

As I asserted, no force commanded by a Whitehall general, administered by Whitehall and equipped with weapons evolved by Whitehall has ever, except at Maida in 1806, been successful in an independent campaign since 1793. The first two matters are not, but the third most emphatically is, the concern of those in the engineering industry, who ought to interest themselves in making good weapons rather than bad ones, which cost just as much. Whitehall sustained, between 1793 and 1809, when the "Sepoy General" took over, no less than 21 defeats out of 22 tries, all of which coincided with weapon deficiencies. Wellington, however, used effectively two novel weapons, the Baker rifle and Lieutenant Henry Shrapnel's spherical case-shot, and won every battle up to Waterloo. In 1815, Whitehall relapsed into the smooth-bore, and then Andrew Jackson, with rifles, soundly trounced the wretched Pakenham. This finally lost us North America.

In 1882, as Brigadier Howard rightly claims, Sir Garnet Wolseley chased away Colonel Arabi's rabble of fellahin at Tel-el-Kebir, but soldiers back from real battles in Afghanistan considered that a division of Metropolitan constabulary might have done it as easily. Whitehall's 1882 campaign terminated in the shameful failure to save Gordon, about which Queen Victoria said much and bitterly to Gladstone. Then a young officer from Sligo, in Turkish uniform, deriving his authority from the Sultan, whose artillery was Krupp's, and whose Bimbashias drilled their battalions in Turkish, reconquered the Soudan and purged the shame of Khartoum. While Roberts, of Waterford, with Punjab troops, was defeating Russian threats in Afghanistan, Whitehall was embroidering on its colours Isandlhwana, Tofrek, Tamaii, Bronkhurst Spruit, Majuba and Maiwand. In all were weapon defects, but in that last battle, Whitehall's artillery was entirely muzzle-loading and of very official design, while all the Afghan guns were rifled breech-loaders, from private enterprise.

The sorry story repeats itself in 1899, when the Boers, with private-enterprise Mausers, pom-poms, Nordenfeldt quick-firing field guns and 155-mm. Creusot medium guns, defeated Whitehall's general with his box-magazine Lee-Metfords and his miserable and official 15-pdr. breech-loaders. Roberts again, who was first a Company's officer and later Commander-in-Chief of the Punjab Irregular Force, cleaned up Whitehall's mess in six weeks.

From 1914 to 1918, Whitehall beat all its own records in creating blood baths for Tommy Atkins and John Bull. Then Monsieur Ferdinand Foch took over, employing certain "land-ships" for which Mr. Winston Churchill provided the momentum and private enterprise the cerebration, with results vividly described by Ludendorff, after Cambrai.

Why did British shot not pierce German armour at Jutland? What did Chrysler Motors, Inc., do at Alamein? Had private enterprise been allowed to evolve modern tanks in about 1935, as the Spitfire was under Lady Houston's beneficence, and the Hurricane, Hitler might not have tweaked John Bull's nose in the Rhineland or the Duce in Ethiopia. The Centurion tank would have been a magnificent weapon for North Africa in 1939 or 1940. I wonder if Brigadier Howard would really like to ride in one, under fire from modern infantry small-arm projectiles? Where are the heavy armoured ships, even the mighty Yamato which met the torpedo? Perhaps one of your readers will suggest a land-soldier's synonym for "Davy Jones's locker"?

I am, Sir,
Your obedient servant,
STEWART BLACKER.

Liss, Hampshire.
December 14, 1952.

SCIENTIFIC RESEARCH IN AUSTRALIA.

(*Concluded from page* 785.)

A REVERIFICATION of the Australian metric standards of mass, begun in 1950, was completed by the middle of 1951 and revealed that all the more important standards had remained constant to within 2 parts in 10^7. A very gratifying result demonstrated was the stability of four weights, made in 1947 of 25/20 stainless steel, none of which had altered by as much as 3 parts in 10^7. By contrast, two weights made abroad in 1944, of nickel-chrome alloy, have shown irregular changes up to 6 parts in 10^7 during the six years that they have been in use. This is the reason, perhaps—notwithstanding the fact that other weights, received from overseas, have exhibited good stability over at least two years—why the Commonwealth is undertaking the manufacture of its own mass standards to fulfil statutory obligations. The machining of weights to cover the metric series is now complete, and equipment for adjusting them is being made. The importance of bearing surfaces of the highest attainable quality in microbalances, especially when small differences between relatively large masses are the main issue, is exemplified by the behaviour of two of the balances used for the inter-comparison of standards. Erratic variation in their readings was eventually traced, in each case, to the stirrup-bearing planes, which had distorted in their mounts and had departed from true flatness by about 2 microns.

An important function of the Metrology Division of the National Standards Laboratory is that of examining and verifying the instruments and materials-testing machines used in the engineering and allied industries. Improved facilities for this work include a variety of apparatus for precise measurements of force, pressure, speed of rotation, mechanical strain and hardness. Special vibrometers are also being developed for the measurement of vibratory disturbances capable of adversely affecting precise machinery and delicate apparatus. A significant increase in the examination of industrial testing equipment has been due to laboratories seeking registration with the National Association of Testing Authorities, while a large number and variety of machines and apparatus have been examined on behalf of private firms, Government departments and the Services.

To improve the accuracy of testing pressure gauges, a new instrument of the piston-in-cylinder type has been designed, so that the diameter of the cylinder bore can be very accurately determined. Construction has also been started of a highly-accurate hardness-testing machine, intended to serve as a reference instrument for hardness testing in general, and, in particular, for the calibration of hardness test blocks. In connection with the verification of commercial hardness-testing machines, two methods have been studied for checking, *in situ*, the depth-indicating element of a Rockwell-type tester. One method employs a vibrating reed and slip gauges, and the other entails the use of an optical comparator. For measuring indenter loads, a miniature proving ring, 1 in. in diameter, to which wire resistance strain gauges are attached, has been constructed and is now being calibrated. An alternative apparatus for checking indenter loading, embodying an electrical capacitance gauge, has also been tried, with promising results.

The Physics Division of the National Standards Laboratory has been occupied with the changes necessitated by the adoption of the revised International Temperature Scale, with the satisfactory result that both the International and thermodynamic scales can now be established and maintained. The temperature-measuring techniques now available include resistance thermometers, thermocouples and optical pyrometers for the higher temperature ranges, and gas or vapour-pressure thermometers for temperatures below −183 deg. C. Bearing on this work, while also of considerable industrial value, is an investigation of the effects, on the indications of a thermocouple, of chemical or physical inhomogeneity in the wires of which it is comprised.

More direct assistance to Australian industry has been given in connection with problems of thermal insulation and high-temperature refractories. For more fundamental research in low-temperature physics, the department has a cryostat in which temperatures as low as 20 deg. K. (−253 deg. C.) have been attained, albeit with some difficulty, since the efficiency of the plant at that temperature was insufficient to make the final stage of refrigeration effective. Some modifications to improve its performance are now in progress. When the equipment is eventually satisfactory, it will be used for measuring specific heats, thermal conductivities, and electrical characteristics of materials at very low temperatures. Among many such matters to be tested is a theory, evolved in the Physics Division, that the deviations of electrical conductivity of solids should be small, and should occur only in a small temperature interval at about 10 deg. K. The results are awaited with the more interest in that the usual conservation theorem suggests that the deviation of electrical conductivity should be marked, and should occur in the region below 50 deg. K. Physical research on light, and on optical apparatus, has included some valuable developments in the applications of object lenses having spherical surfaces. Objectives incorporating non-refracting fused-quartz immersion lenses have been used with such success for ultraviolet work that a 50 per cent. increase of resolving power is reported. A non-immersion objective, incorporating two concentric spherical reflectors, has been made with a focal length of 0·89 in. for observing the surfaces of metal at high temperature.

Some of the most interesting and novel work in electro-technology has been concerned with the physico-chemical aspects of dielectrics, in the endeavour to relate the molecular and crystal structure of materials with their dielectric loss. More specifically, the study of dielectric after-effect, known as charge "soaking," has been extended to paraffin wax, docosane and polytetrafluoroethylene plastic, mixed, in each case, with a small proportion of liquid alcohol. The present position, resulting from testing these materials at frequencies up to 50,000 c/s under various conditions of temperature, alcohol concentration, specimen thickness, and gradient of applied voltage, is that the fundamental causes of dielectric after-effect are gradually coming to light, though it has not been possible yet to develop a quantitative theory. In a closely related investigation, some special dielectric cells have been constructed for experiments designed to reveal the mechanism underlying the abnormally large dielectric absorption exhibited by secondary alcohols at audio and radio frequencies.

Research in radio technology and extra-terrestrial physics is actively pursued in Australia and includes attempts to measure the temperature of the D-layer of the ionosphere, situated some 70 to 75 km. above the Earth, and to discover the causes of "fade-outs" which influence the reflection of very long radio waves, having wavelengths of the order of 7 km. Similar investigations in progress at Cambridge University have demonstrated that the increased attenuation on short wavelengths during a fade-out is accompanied by a reduction of 10 to 20 km. in the height of the ionospheric layer which reflects long waves. The Australian observations agree with the English ones in this respect, but the discovery in Australia of a diurnal height variation and of some polarisation effects cannot, as yet, be satisfactorily explained. In a somewhat related field of investigation, the Australian Radio Research Board's scientists have developed a theory, which has attracted wide attention, explaining how radiation from the Sun produces on the Earth such phenomena as magnetic disturbances, interference with radio propagation, and auroral displays. Observations of travelling disturbances in the ionosphere have led to the conclusion that these effects systematically change direction during the day and may well be the result of tides in the atmosphere. They occur during the night as well as during the day, the direction of movement being different at layers about 100 and 250 km. high.

Phenomena at more moderate heights, well within the Earth's atmosphere, are the concern of meteorological physics, in which branch of science some recent explorations of the air currents prevailing in the Southern Hemisphere, at altitudes of the order of 30,000 ft., are now being made by radar tracking of special reflecting balloons, with the object of accumulating data for use in aeronautical navigation. In the measurement of meteorological conditions other than the speed and direction of winds at great heights, some use is made of powered aircraft, but most of the work is done by means of instruments and radio transmitters carried by balloons filled with hydrogen. With this procedure, the apparatus is rarely recovered. To avoid these considerable losses, a radio-controlled glider is being designed, to be lifted by a balloon and released at the desired height. Carrying the recording instruments and radio apparatus, it will be directed automatically in its slow descent towards a transmitter on the ground, so that the glider as well as its load of instruments will, with ordinary luck, be recoverable undamaged. The development of the necessary homing apparatus is well advanced for two model gliders of the flying-wing type, of 5 ft. span, each capable of carrying a "pay load" of 12 lb.

An important proportion of the Organisation's meteorological investigations are deliberately intended to benefit the Commonwealth's agricultural and similar industries. With this object, work on a considerable scale is now being started in the field of micro-meteorology, to study fundamentally the detailed structure of wind, temperature and humidity in the air near ground level, where these factors have a profound influence on such practical matters as the warming of the atmosphere near the Earth's surface, the evaporation of water from land and sea, the transport of air-borne seeds, and the dispersal of smoke and chemical fumes from urban and factory areas. Instruments developed for the purpose are being used to record all the factors known to determine the heat balance at the Earth's surface and the frictional aspects of the interaction between air currents and the ground. An observation tower, 96 ft. high, is used for this work on land, and research was also carried out on the Royal research ship Discovery II.

With the same general objects of benefiting agriculture, the science of rain physics is being actively pursued by experiments with radar, to discover the mechanism involved in the formation of natural rain. In this connection, a method has been devised for ascertaining the size distribution of natural raindrops arriving at ground level. The raindrops are allowed to fall through a small hole in the top of a horizontal wind tunnel, where they are carried forward in the air stream to a distance which is an inverse function of their size, and are eventually deposited on paper dusted with water-soluble red dye. The paper is moved continuously across the tunnel, and thus records the distribution of raindrop sizes at any instant and also how the distribution varies with time. Since 1948, artificial rain-making experiments have been in progress with appropriate substances such as solid CO_2 or silver iodide, sprayed into clouds from aircraft. Trials with silver iodide indicate that this material is a feasible rain-maker, but that it is more critically dependent on cloud condition than carbon dioxide. New experiments are being made with water spray, the theory being that the drops will promote coalescence of the minute water droplets in the cloud. On four out of eleven occasions when this technique has been attempted on non-freezing clouds, rain or hail appeared shortly after the spray was released.

Further examples of the applications of physical and engineering science to agriculture appear in the Organisation's researches into irrigation, soil mechanics, and the preservation and transport of food. They are, however, relatively of a very incidental character and none is of more interest to engineers than a series of trials to discover the principles governing the performance of refrigerated and ventilated railroad cars, so that the effects of changes in design and operation can be predicted with a useful accuracy. Tests on cars refrigerated by basket bunkers mounted at the ends have led to a clearer understanding of the way in which end bunkers function, and a corresponding series of trials, on the New South Wales Railways, is now in progress on new cars refrigerated by roof tanks.

SYMPOSIUM ON THE PROPERTIES OF METALLIC SURFACES.

(*Concluded from page* 797.)

We now conclude our report of the general meeting of the Institute of Metals, held in London on November 19, to discuss 13 papers contained in a symposium on "Properties of Metallic Surfaces." The discussion given below follows the introduction of the last six papers by the *rapporteur*, Mr. D. A. Oliver, M.Sc., at the afternoon session.

Dr. H. Wilman, who opened the discussion, referred to the shape of the swarf from turned surfaces. He stated that, at the lower speeds, spiral coils were the usual form. The change to the straight or nearly straight strips might be due, possibly, to the increased temperature of the turning as it left the tool. With regard to Dr. F. T. Barwell's paper, the use of thick phosphate coatings on steel seemed to be very helpful in avoiding pick-up in bearing surfaces. He would like to know, however, whether the period during which they were actively present and not entirely worn away was an appreciable part of the running-in period. Mr. Oliver had referred to the importance of interpretation in the case of the amorphous nature or otherwise of the Beilby layer. Many persons were quite convinced that the surface could exist in an amorphous state, but the oxidation of the surface of metals was difficult to avoid. In the case of non-metals such as silica and carborundum, which were oxides already, an amorphous, glass-like state was certainly formed on their surfaces as a result of polishing. Dr. F. T. Barwell, in answer to Dr. Wilman, stated that the phosphate coatings persisted throughout the running-in period, and, even after that, the surface was left in a condition which resisted wear for a reasonable period. Provided, therefore, that the conditions were favourable, the phosphate layer was of a sufficiently permanent character to be of benefit.

Dr. F. P. Bowden, referring to the question of the structure of the Beilby layer, made by polishing a metal, stated that if a solid had surface irregularities which were large compared with the molecular dimensions, when the metal and the polisher were put together they only touched locally at a few regions of contact, and when the one was slid over the other heat was generated at a few points, and the local rubbing areas became very hot. It was simple to measure the temperature of these rubbing contacts by using two different metals in a thermo-couple, and it would be found that, under quite moderate conditions of sliding, temperatures in the region of 1,000 deg. C. were generated; in fact the temperature was limited by the melting point of the material. The actual high temperature, therefore, played a very important part in the polishing process, and it could cause either high-temperature softening, or, in some cases, actual melting of the surface. Metallurgists must not, however, generalise too much concerning the Beilby layer, because it was very different on different metals and its physical, chemical and mechanical properties were quite different from those of the underlying metal.

Professor B. Lunn said that in order to test the interaction between bearing metals and lubricants, a simple apparatus had been set up at the Technical University of Copenhagen. This comprised a plain test-piece of bearing metal and a steel ball fixed in a chuck, and this chuck was moved with a constant pressure on the test-piece. The whole specimen was in an oil bath. By imposing a low voltage over the contact point between the ball and the test-piece a method of investigating the oil film and how it was formed had been obtained. The oil film had been found not to be constant with the same degree of resistance, but a film which existed in very thin layers and possessed very high resistance. The film was interrupted by porosities, and as the test proceeded the porosities closed more and more. It has been possible to follow the development of the oil film, with time, and obtain a record. The test was very simple to perform, and it took only an hour to make five or six recordings in a bearing-oil-metal combination. Over 200 different alloys and different structures and some

25 lubricants had been tested. It was found that the attainment of fluid lubrication was conditioned by the formation of a film through boundary-lubrication processes in which the lubricant, the bearing metal and the atmosphere all took part.

A subsequent speaker, Dr. T. P. Hoar, stated that, in connection with electro-polishing, a very simple technique had been recently developed at Cambridge for deciding whether invisible oxide films were present on the surface of metals or not. The technique gave a "Yes or No" answer. It consisted merely of allowing little drops of mercury to fall on the electro-polishing anode during the electro-polishing process. If it were producing an etched surface the mercury would "wet," in one of many methods tried, within half a second or so. If the metal were passive, with the formation of the passive oxide film, there was no wetting.

Dr. J. C. Chaston said that the possible effect of surface films on mechanical properties was an extraordinarily interesting question. Professor C. A. F. Benedicks, in 1948, at a Pittsburgh Conference on Surface Reactions, had produced an effect which he called "liquistriction." He found that if he put a film of water on a piece of steel he reduced the strength by 14 per cent., but if instead of water he wetted it with 10 per cent. caustic soda, he increased the strength by 21 per cent. He had also said that when he wetted thin wires of platinum they grew slightly longer and when they dried out they became shorter. He thought that it was the effect of penetration of liquid into surface pores.

Mr. P. Grodzinski, who spoke next, stated that the micro-hardness technique was much used at present in testing very small samples, thin layers and hard materials which could not be subjected to any other mechanical test. During the last 15 years a number of methods have been developed, but, unfortunately, they had not yet been standardised, and this might have kept quite a number of persons from using them. One of the most important matters encountered in micro-hardness testing was the dependence of the so-called hardness on the load. A frequent observation was that, at first, with very low loads, the hardness increased apparently in proportion to the load, and then reached a maximum and later dropped down and came to a balanced state.

Dr. G. Salomon stated that Mr. Grodzinski had suggested that the micro-hardness testing technique should be standardised. It would be dangerous to do this because it would mean having yet another figure in technological work attached to a name. Its value would be uncertain because, in micro-hardness testing, such factors as rate of loading and small surrounding effects had an influence.

A subsequent speaker, Mr. R. W. Wilson, said that to obtain fairly consistent results over the whole range of load in micro-hardness testing, it seemed to be necessary to have an absolutely pure specimen, to anneal it perfectly, to handle it with extreme care before and during the testing, and to use a diamond which was as nearly perfect as possible.

Mr. N. I. Bond-Williams stated that in practice the conclusions of Dr. Bowden and Dr. Tabor, and others, on the importance of an oxide film in the reduction of friction was confirmed. In the ordinary way, in industrial practice, it was, of course, regarded as important to reduce the amount of oxide present, particularly on a wire. This, however, reached a point when, having removed the principal obstruction to wire drawing, namely, the oxide particles, it was discovered that by getting the material too clean the life of the wire-drawing dies was being reduced. The next speaker, Mr. J. G. Wistreich, referred to a discussion in America, a short time ago, concerning the use of mechanical descalers on ferrous wires. Owing to the recent sulphuric-acid shortage, a number of firms had been experimenting with the mechanical removal of scale, and one method was to put a scale-breaker immediately in front of the wire-drawing machine. There had been a good deal of trouble with lubrication in these circumstances. One speaker in the discussion had said that, by an oversight, he had left two rods, which had been mechanically descaled overnight, and they were slightly rusty in the morning. He had had them drawn, and had found that, thereby all his troubles were at an end. Since then he had adopted this procedure.

CENTENARY OF THE PATENT OFFICE.

FOR the very brief period of three days—December 17 to 19—there has been on view in the Patent Office Library, London, a small exhibition of Letters Patent, books, documents, etc., designed to mark the centenary of the present Patent Office, which was opened in December, 1852, at 25, Southampton Buildings, Chancery-lane, where it is still situated. At that time, it was known as the Great Seal Patent Office, the practice having been, before that date, to issue Letters Patent under the Great Seal of the United Kingdom. The exhibition traced the evolution of patents for inventions from 1852 to the present day, by stages which have been excellently summarised in a historical survey prepared by the staff of the Office, from which the following notes have been abstracted.

Prior to 1852, the granting of patents was exceedingly complicated, involving visits to seven different offices, the preparation of numerous documents, and payment of fees totalling about 100*l*. for a patent for England alone, or attendance at about 16 offices and payment of over 300*l*. for a United Kingdom patent. The application had to pass through ten separate stages, at two of which the personal signature of the Sovereign was required. In all this procedure, the only person who took any real responsibility was the Law Officer, who had to report whether or not the petition should be granted and, in case of opposition to the grant, had to hear the parties and decide the issues between them.

The system was attacked by Dickens in his story, "A Poor Man's Tale of a Patent," published in *Household Words* in 1850, and its reform was demanded by inventors, industrialists, engineers, lawyers, social reformers, scientists, and bodies such as the Society of Arts. As a result, the Patent Law Amendment Act was passed in 1852. It placed the granting of patents in the hands of Commissioners consisting of the Lord Chancellor, the Master of the Rolls, and the Law Officers of the three Kingdoms. In practice, however, only the English Law Officers served in this capacity, so that the Commissioners numbered four. The Act made great changes in the mode or practice of granting patents but did not materially alter the existing law, built on the basis of the Statute of Monopolies of 1624. The 1852 Act reduced the initial fees for obtaining a patent for the United Kingdom to 25*l*., but renewal fees of 50*l*. and 100*l*. became payable at the end of the third and seventh years. A register of patents was established, and arrangements were made for printing and publishing specifications and indexes, and for their presentation to public libraries and museums.

Mr. Bennet Woodcroft, F.R.S. (1803-79), who had had a wide experience in textiles and engineering as a manufacturer and an inventor, and who became professor of machinery at University College, London, was appointed Superintendent of the Specifications for the duties of classification, indexing, printing, and publishing. With remarkable energy, he organised the printing of some 13,000 specifications, new and old; the preparation of indexes and abridgment volumes; and the establishment of the library, which was opened in 1855. The Patent Office soon encountered difficulties, however, because the Commissioners all held other appointments, and found themselves unable to perform the duties allotted to them by the Act.

A new Patent Act was passed in 1883 under the leadership of Mr. Joseph Chamberlain. This Act transferred the responsibility for Patents to the Board of Trade and set up the Patent Office in its present form, under the control of a Comptroller-General, the only connection with the former Commissioners being that the Law Officers of the Crown were made the appeal authority for the legal decisions of the Comptroller, with the duty of advising him in matters of law or procedure. Under this new regime, the task of examining specifications was entrusted to the examining staff, a body of scientific officers; Mr. Rhys Jenkins, M.I.Mech.E., now 92 years of age, was one of their original number and is possibly the last direct link with that important change in procedure. Apart from checking documents for clarity and consistency, their main work was to revise the indexing and classification systems and to prepare illustrated abridgments of specifications by which the public could make their own searches. They were not required themselves to investigate whether the inventions submitted were, in fact, novel.

In 1901, a committee presided over by Sir Edward Fry and including Lord Alverstone, Sir Edward Carson, and Mr. J. Fletcher Moulton, recommended that the Patent Office should investigate the novelty of all inventions for which patents were sought. Effect was given to this recommendation by the Patents Act of 1902. The investigation involved scrutiny of the accumulated documents of 50 years. When the work was eventually brought up to date in 1907, 375,000 patent records had been summarised in 1,168 volumes, containing 200,000 pages, 610,000 abridgments and 475,000 illustrations. Another Patents Act, in 1907, extended the investigation as to novelty to include overlapping concurrent applications, thus accomplishing what had unsuccessfully been attempted under the 1883 Act and abandoned in 1888, namely, the avoidance of granting patents for the same invention concurrently to different applicants without warning the parties. A determined effort was made by Mr. Lloyd George, who was in charge of the Bill, to ensure adequate working of patents by enabling the Board of Trade to grant compulsory licences if the reasonable requirements of the public were not being met, and by giving the Comptroller power to revoke a patent if the patented article or process was manufactured or carried on exclusively or mainly abroad.

Due largely to dispersal of staff, work began to fall behind at the end of the first World War and by 1930 arrears had reached the record number of 11,000 complete specifications. These difficulties were intensified by the 1932 Act, which widened the area of search to include publications of every kind in all languages, and by the second World War, which resulted in the permanent loss of many scientifically-trained staff. In consequence, by 1947, the accumulation of specifications awaiting examinations had reached nearly three times the previous peak figure of 1930. Additional staff have been recruited and trained in the past five years, however, bringing the total to nearly 1,000, and the number of outstanding specifications has now been reduced to about 22,000.

The Patent Office remained in London throughout the recent war, and suffered no major damage until August, 1944, when a flying bomb severely damaged the frontage to Staple Inn. Throughout the war, however, there was no loss of any irreplaceable document; but one serious effect, from which the Office and the public still suffer, was that it became necessary to suspend the printing of abridgments of patent specifications, a loss which is only now being made good. Apart from the examination of patent applications, the war brought much additional work to the Office in connection with the licensing of enemy-owned patents, trade marks, and copyright, and also with security measures with regard to avoiding publication of information which might be of value to the enemy.

During the years 1944-47, the patent system was again reviewed by a departmental committee, under the chairmanship of Sir Kenneth Swan, O.B.E., Q.C. They found that there was no indication of any general desire for fundamental change in the present system of encouraging and rewarding invention by the grants of patents, and that most of its recommendations had already been implemented by the Patents Act, 1949, and the Registered Designs Act, 1949. The Patent Office and the Industrial Property Department of the Board of Trade (which is located at the Patent Office, under the Comptroller) now deal not only with the granting of patents and other matters connected with patents, but also with the registration of Trade Marks (Trade Marks Act, 1938), Designs (Registered Design Act, 1949) and with questions relating to literary and artistic copyright (Copyright Act, 1911). It is only the patents side of the Office, however, which is now 100 years old.

FORTY YEARS OF SULZER DIESEL RAIL TRACTION.

FORTY years ago, in the summer of 1912, the first Diesel locomotive to operate on a public railway ran its trials on the Winterthur-Romanshorn line in Switzerland. It was equipped with a single-acting reversible four-cylinder Sulzer engine of the two-stroke type, which developed a maximum output of 1,600 horse-power at 304 revolutions per minute, and transmitted its power directly to the driving axles. The nominal rating of the locomotive was 1,000 b.h.p. It is shown in Fig. 1, herewith. It had two four-wheel carrying bogies and two driving axles supported in the frame. The length was 16·6 m. (54 ft. 6 in.) over the buffers and its weight, in working order, was about 85 tons. In March, 1913, the locomotive travelled by way of Basle, Strasbourg, Worms, and Nordhausen to Berlin, where it was taken over by the Prussian State Railways.

Forty years after this event, it is interesting to look back over the developments which have since taken place and to consider the present situation of Diesel traction. The idea of employing the Diesel engine for rail traction is as old as the engine itself. As early as 1897, when the first practical Diesel engine was completed, its use in rail vehicles was seriously considered, in accordance with the plan which Dr. Rudolf Diesel himself had had in mind from the outset. More than ten years passed, however, before the idea took material form. Foremost among the numerous difficulties were the problems of weight and space, as the limits imposed by the dimensions of rail vehicles are so narrow that no satisfactory solution to the problem was feasible until the Diesel engine itself had made considerable progress. Other difficulties which confronted the designer were those of starting, manœuvring and governing, which are much more complicated in the traction field than in any other Diesel application.

Messrs. Sulzer Brothers, of Winterthur, tackled these problems at a very early stage and made an outstanding contribution to their solution. In collaboration with Diesel and with A. Klose, of Berlin, they founded in 1906 a Society for Thermo-locomotives, for the study and design of large Diesel locomotives. In the following years, the engine for the first Diesel locomotive was constructed to Sulzer designs in their works at Winterthur, undergoing its first trials on the test-bed there in April, 1912. The design and construction of the mechanical part of the locomotive had been entrusted to Messrs. A. Borsig, of Berlin, but the main responsibility for the success of the undertaking lay with Sulzer Brothers, who not only designed and constructed the engine, but also installed it in the locomotive with all the necessary auxiliaries and apparatus. Thus, the first Sulzer Diesel locomotive came into existence.

Although this prototype, with its direct power transmission to the driving wheels, did not give full satisfaction, it did enable valuable experience to be acquired, which was turned to account later in the further development of the Diesel locomotive. The next important advance was the adoption of electric transmission between the Diesel engine and the driving wheels, the Diesel engine driving a generator which supplied the traction motors. A few railcars equipped with 200-h.p. Sulzer Diesel engines and with electric power transmission were supplied to German railway companies before the outbreak of the first World War. One of these, for the State Railways of Saxony, is illustrated in Fig. 2, on this page.

From this point onwards, the evolution of the Diesel locomotive and of the railcar went forward without intermission. Sulzer Brothers from the first took a special interest in the development of high-powered units, assuming that this would be a particularly promising application of the Diesel locomotive, and found that Diesel locomotives of over 4,000 brake-horse-power could be built with weights not much in excess of those of steam locomotives of the same power, so that their employment on an equal footing with steam and electric locomotives depended solely on considerations of economy and traffic requirements. Diesel traction offered special advantages in regions where water was scarce, or on lines on which fuel must be carried over long distances, its low water and fuel consumption, and the much easier transport of its oil fuel as compared with coal, making it highly suitable for such conditions.

40 YEARS OF DIESEL RAIL TRACTION.

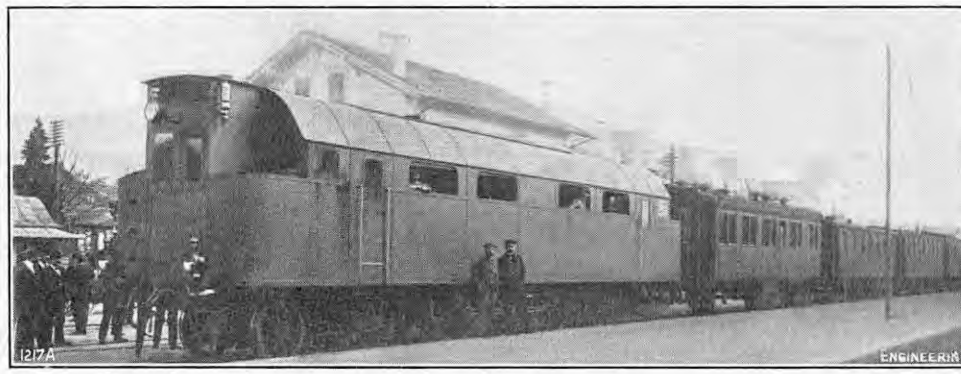


FIG. 1. THE FIRST DIESEL LOCOMOTIVE IN PUBLIC SERVICE; PRUSSIAN STATE RAILWAYS (1912).

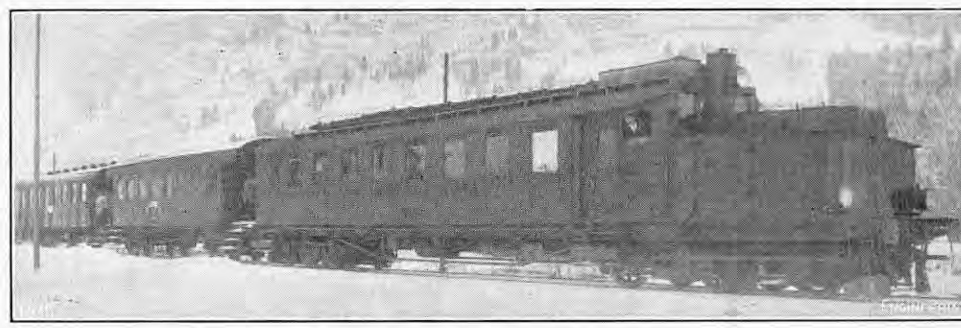


FIG. 2. DIESEL-ELECTRIC RAILCAR; STATE RAILWAYS OF SAXONY (1914).

SERVICE RESULTS.

One of the earliest Sulzer Diesel railcars, which went into service in Germany in 1914, and later, after conversion, came into the possession of a Swiss private railway, is still running to-day. Throughout this period, no major repairs have been necessary to the Diesel engine, nor have any important components been replaced.

Two travelling "power houses" of 1,200 h.p. each, illustrated in Fig. 3, on Plate LXIV, have been running on the suburban lines of the Ferrocarril Sud de Buenos Aires since 1930. Each contains two Diesel engines of a type employing pre-combustion chambers and developing 600 h.p. at 700 r.p.m. The vehicles weigh 87 metric tons each and have a maximum speed of 87 km. (47 miles) an hour. In addition to the motors in the power-station vehicle itself, the generators feed traction motors fitted in five of the coaches; this arrangement ensures the high acceleration needed for suburban service. When required, the two power stations can be combined with their carriages to form a 730-ton train seating 1,100 passengers. These vehicles have covered 60,000 and 65,000 km. (37,500 and 40,500 miles) a year, respectively, at the low average speed typical of suburban service. About the middle of 1933, the same railway company commissioned three further more powerful travelling power houses, each equipped with two engines of 850 h.p. They weigh 132 tons and are normally used with eight carriages, fitted with two traction motors each. The weight of the train is then 570 tons, and the maximum speed is 112 km. (70 miles) an hour. The higher output per ton of train weight and the higher maximum speed permit a better utilisation of these vehicles, each of which has now covered about 2 million km. (1,250,000 miles). They receive a general overhaul after each 300,000 km.

Detailed data are available on the service of four railcars which Sulzer Brothers supplied in 1936 to the Ferrocarril Provincial de Buenos Aires. These railcars (Fig. 4, Plate LXIV), each fitted with a six-cylinder engine having a one-hour rating of 270 h.p. at 1,100 r.p.m., weigh 37 tons and are able to seat 62 passengers. Their maximum speed is 80 km. (50 miles) an hour. In their 16 years of service up to and including 1951, they had averaged 1,600,000 km. (1 million miles) each. During the whole service period of these Diesel engines, they have given no trouble of a serious nature. No connecting rods, cylinder covers, liners or fuel pumps have been replaced, though the engines are of a comparatively fast-running type.

Locomotives equipped with Sulzer Diesel engines have been adopted widely in France and the French Colonies. Some of these units were put into service in 1933 by the Compagnie des Chemins de Fer Paris-Lyon-Méditerranée, as it was then designated, and by its Algerian lines, as well as by the Syndicat des Chemins de Fer de Ceinture de Paris. A series of shunting locomotives (Fig. 5, Plate LXIV) was also supplied, each having a six-cylinder engine developing 735 h.p. at 850 r.p.m. This engine is a standard type, of which 117 units have so far been supplied. The locomotives in question were purchased by the Société Nationale des Chemins de Fer Française. They weigh 71 tons each and have a maximum speed of 50 km. (31 miles) an hour.

The same engine type is fitted in the locomotives of the Compagnie des Phosphates de Constantine (Fig. 6, Plate LXIV), which weigh 67 tons and have the same maximum speed of 50 km. an hour. These narrow-gauge locomotives were used for the first three years for pulling heavy train loads of minerals, on which duty they covered a total of 150,000 km. and 200,000 km. (94,000 miles and 125,000 miles), respectively. Since 1941, they have been employed on the lines of the Chemins de Fer Algériens and the Chemins de Fer Tunisiens. The results obtained under the most unfavourable climatic conditions, including high air temperatures, sand storms, etc., greatly influenced other railways in tropical and sub-tropical countries to purchase similar Diesel locomotives.

The 4,400-h.p. locomotive of the Société Nationale des Chemins de Fer Français, shown in Fig. 7, on Plate LXIV, is of particular interest. It has a length of 33·05 m. (108 ft. 5 in.) over the buffers and a weight in working order of 228 tons; its maximum speed is 130 km. (81 miles) an hour. This locomotive went into service in the summer of 1938, covered 222,700 km. (139,200 miles) before the outbreak of war, and was then taken out of service till the middle of 1945. From this date till the summer of 1952 it again covered 1,300,000 km. (810,000 miles). The maximum wear on the piston.

40 YEARS OF DIESEL RAIL TRACTION.

SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 830.)

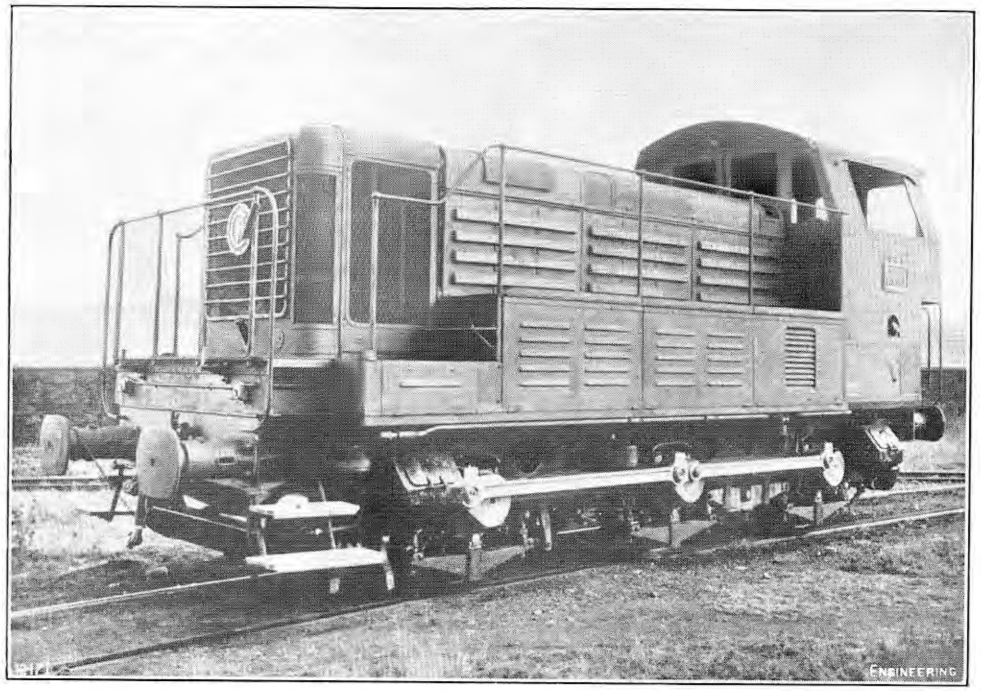


Fig. 9. 570-H.P. Diesel-Electric Shunting Locomotive; French Railways.

Fig. 10. 730-H.P. Diesel-Electric Locomotive for Bolivia.

Fig. 11. 960-H.P. Diesel-Electric Locomotive; Thai State Railways.

Fig. 12. 1,470-H.P. Diesel-Electric Luggage Railcar; Chemins de Fer Algériens.

ENGINEERING, December 26, 1952.

40 YEARS OF DIESEL RAIL TRACTION.

SULZER BROTHERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 830.)

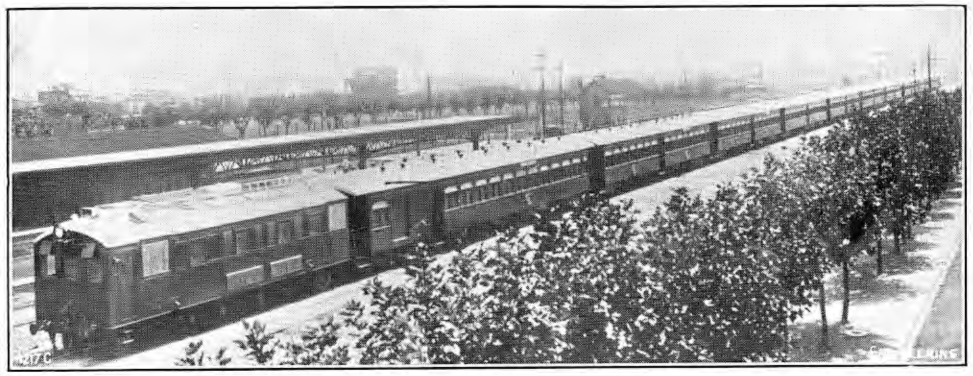


FIG. 3. SUBURBAN TRAIN; FERROCARRIL SUD DE BUENOS AIRES.

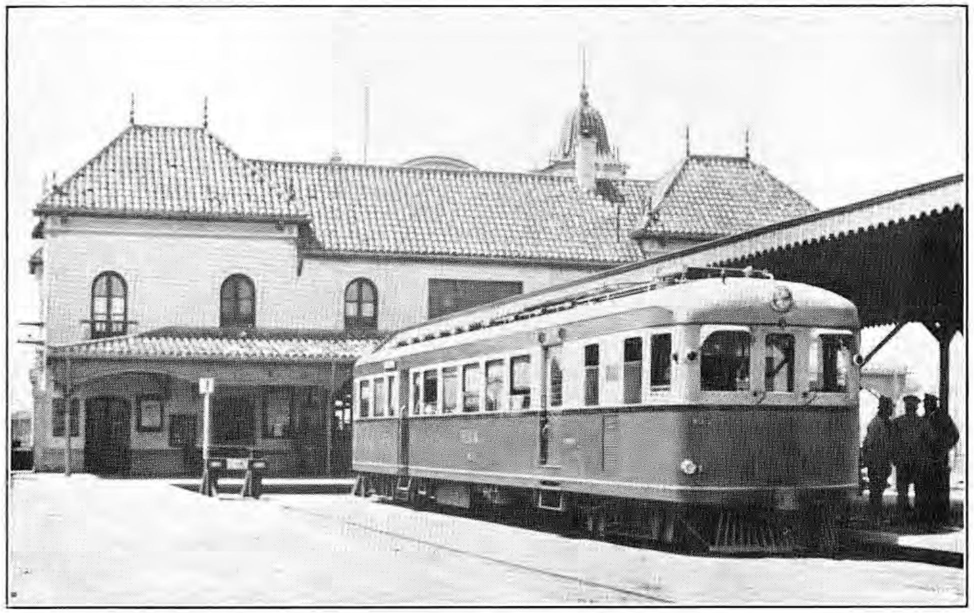


FIG. 4. RAILCAR; FERROCARRIL PROVINCIAL DE BUENOS AIRES.

FIG. 5. 735-H.P. DIESEL-ELECTRIC SHUNTING LOCOMOTIVE; FRENCH RAILWAYS.

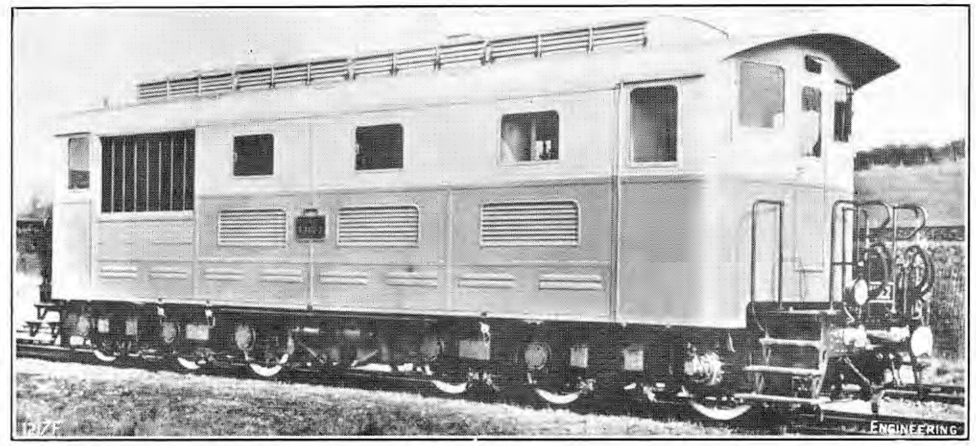


FIG. 6. DIESEL-ELECTRIC FREIGHT LOCOMOTIVE; CIE. DES PHOSPHATES DE CONSTANTINE.

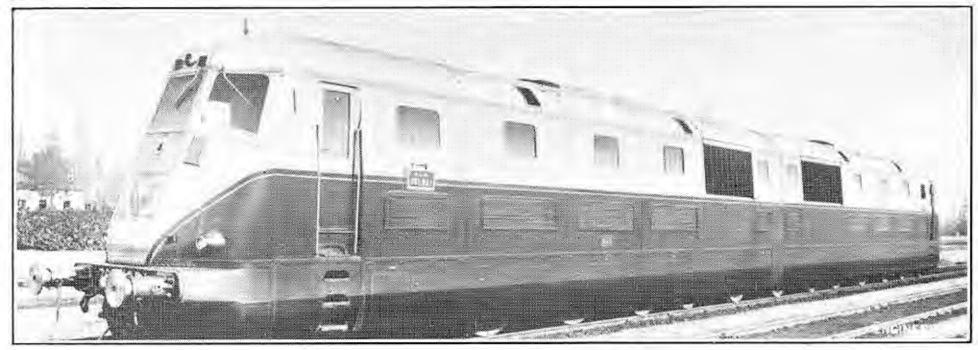


FIG. 7. 4,400-H.P. DIESEL-ELECTRIC LOCOMOTIVE; FRENCH RAILWAYS.

FIG. 8. 1,200-H.P. DIESEL-ELECTRIC LOCOMOTIVE; SWISS FEDERAL RAILWAYS.

40 YEARS OF DIESEL RAIL TRACTION.

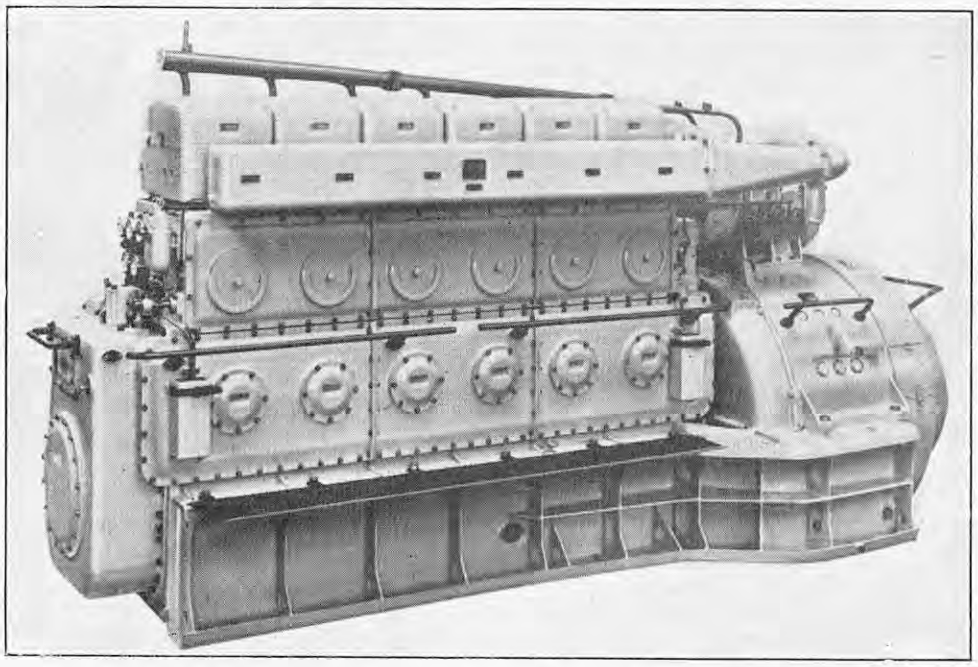


FIG. 13. 735-H.P. PRESSURE-CHARGED SULZER DIESEL ENGINE FOR RAIL TRACTION.

ring grooves after a total of 966,478 km. (about 600,000 miles) was 1·5 mm.

Owing to the events of the war, little information has been received on the service results of the 4,400-h.p. express locomotive of the Rumanian State Railways, which is 29·3 m. (96 ft. 4 in.) long, weighs 230 tons in working order, has a maximum speed of 100 km. (62 miles) an hour, and was employed on a difficult mountain line. When put into service, it was the most powerful Diesel locomotive in the world. It is fairly certain that this successful design would have resulted in numerous repeat orders if the war had not intervened. The locomotive escaped the severe bombardments of the Rumanian railways, since, as it was less dependent on depots than steam locomotives, it was always in active service, while its halts at points exposed to air attack were kept to a minimum. After the end of the war it was used for a considerable period as a mobile power station, supplying current during the reconstruction of railway workshops.

The 1,200-h.p. locomotives of the Swiss Federal Railways (Fig. 8, Plate LXIV), with a service weight of 65 tons and a maximum speed of 110 km. (69 miles) an hour, are fitted with an eight-cylinder engine running at 750 r.p.m. They were the prototypes of vehicles which the Swiss Federal Railways wished to employ on lines with little traffic, for hauling light express trains. They were put into service at the outbreak of war, but shortly afterwards had to be taken out of service because of the shortage of fuel. They are now employed for local traffic on the few lines not yet electrified, where they had covered about 600,000 and 700,000 km. (375,000 and 450,000 miles), respectively, by the end of 1951.

RECENT UNITS.

Prompted by the results obtained with their other Diesel-electric locomotives, the S.N.C.F. decided, in 1945, to order 48 Diesel-electric shunting locomotives, with six-cylinder Sulzer Diesel engines of 570 h.p. The first of these went into service in July, 1950. They were intended not only for the usual shunting duties, but also for handling heavy trains at comparatively low speeds and for hauling trains of all kinds on branch lines at speeds up to a maximum of 60 km. (37 miles) an hour. Fig. 9, on Plate LXV, shows one of these engines. They are used either alone or in pairs, according to requirements. On the particularly difficult line from St. Etienne to Roanne, which has gradients up to 1 in 55, two units coupled together were able to handle 600-ton trains without any trouble at an average speed of 50 km. (31 miles) an hour. During shunting trials in the Lyons-Guillotière station, trains of 600 and 850 tons were moved from rest by a single locomotive.

Fig. 10, on Plate LXV, illustrates a Sulzer Diesel-electric locomotive of 730 h.p., supplied to Bolivia a few years ago. The Patiño Mines and Enterprise Consolidated (Incorporated) ordered this locomotive from Sulzer Brothers, Winterthur, with a view to improving the through passenger and goods services on their own winding narrow-gauge line from Machacamarca to Uncía. Sulzer Brothers, who acted as general contractors for the locomotive, built the Diesel engine and its accessories in their own shops while the Maschinenfabrik Oerlikon, of Zürich, dealt with the electrical equipment and the Ateliers Métallurgiques S.A., of Nivelle, Belgium, with the mechanical part. The total length of the locomotive is 15·404 metres (50 ft. 8 in.), and the maximum service weight is 70·4 metric tons. It is driven by a Sulzer six-cylinder Diesel engine with a one-hour rating of 730 h.p. at 750 r.p.m. and 4,000 m. (13,000 ft.) above sea level, and a continuous rating of 650 h.p. at 700 r.p.m. at the same altitude.

To supplement their fleet of Sulzer locomotives, the Thai State Railways have ordered three further Diesel-electric locomotives of 960 h.p. (Fig. 11, Plate LXV), mainly for service on the 1,200-km. Bangkok-Penang line, the northern section of the run of the "Southern Express" from Bangkok to Singapore. These locomotives, however, will also be used on the mountainous northern line, 750 km. in length, from Bangkok to Chieng Mai. In this instance also, the electrical equipment was ordered from the Maschinenfabrik Oerlikon, of Zürich. The mechanical parts are being supplied by Messrs. Henschel and Sohn, of Cassel. The locomotives are propelled by eight-cylinder Sulzer Diesel engines, developing 960 h.p. at 850 r.p.m. Finally, Fig. 12, on Plate LXV, shows a Diesel-electric luggage railcar of 1,470 h.p. for the Chemins de Fer Algériens. This unit is fitted with two six-cylinder Sulzer Diesel engines of 735 h.p. each.

In the course of four decades the Diesel engine has earned a reputation as a traction power unit which assures it of an ever-widening field of application, thanks to the collaboration of engineers from three different branches—the locomotive builder, the Diesel-engine designer, and the electrical supplier. The characteristics of the single-row traction Diesel engine as built to-day can be seen in the general view in Fig. 13, herewith. The crankcase, carried up well above the centre line of the shaft to ensure rigidity, also incorporates the members which support the whole engine-generator group on the underframe. The generator is directly coupled to the Diesel engine. Crankcases were originally made of cast steel, the bars supporting the Diesel-generator group being designed as a sub-frame. To-day, however, the sub-frame and the crankcase are welded to form a single unit. The transverse walls are of cast steel in the larger engines. In the smaller units, they are of steel plate, like all the other parts of the crankcase. This combined design permits the wall thicknesses to be more accurately adapted to the strength calculations than would be possible with an exclusively cast-iron or cast-steel design.

Vibrationless running of the engine depends partly, of course, on effective balancing of the reciprocating and rotating parts, but partly also on the rigidity of the crankcase. It has been found, in this connection, that steel construction is superior to light-alloy designs, which are liable to plastic deformation and are not entirely satisfactory in their resistance to vibration.

The cylinder block is constructed on the same principles, the transverse walls—which are of steel plate in the smaller sizes and cast steel in the larger engines—being welded to the steel-plate longitudinal walls to form a solid block. The water-cooled and interchangeable cylinder liners are inserted in the cylinder block in the usual way. Each cylinder has its own cylinder cover with one admission and one exhaust valve. The light-alloy piston can be readily removed from above after taking off the cylinder cover and unscrewing the connecting-rod bolts.

The fuel pumps are fitted with delivery plungers which are rotated to regulate the quantity of fuel injected and are arranged so that all the supply pipes running to the injection valves in the cylinder covers are of equal length, thus ensuring uniform distribution of the output over the individual cylinders at all loads. The plungers have oblique control edges both for the beginning and for the end of injection. As a definite torque, and thus a definite delivery quantity of the fuel pumps is allocated to every engine speed, the preliminary injection can be readily adapted to the speed. All moving parts of the Diesel engine being force-lubricated, the engine can be completely enclosed and dust-tight. Vibration dampers of the Sarazin type have given excellent service in the control of critical vibrations of the crankshaft.

CONTROL SYSTEM.

The control system developed for Diesel-electric vehicles enables the engine to be run at the most favourable speed for the required traction performance at all times, while setting the load by regulation of the generator excitation in such a way that due account is taken of variations in the thermal conditions of the engine. This is done simply and effectively by taking the control impulse from the governor of the Diesel engine. The allocation of a definite torque to each engine speed, a feature introduced by Sulzer Brothers, has made it possible to fix the beginning of delivery by a second oblique control edge on the pump plunger, a great simplification; and the inclusion of a pressure-charging safety device, in conjunction with a spring member fitted between the governor and fuel pumps, has enabled the advantages of this output control system to be secured in the pressure-charged engine.

The field regulator keeps the output of the engine constant on every controller notch within a given range, in spite of changes in the resistance to motion (e.g., due to changing gradients), the temperature of the electric machines, or the load on the auxiliary generator. The load on the engine is reduced, while its speed is kept constant, if the pressure-charging safety device comes into action or the output of the engine falls off temporarily for any exceptional reason, such as, for instance, a leak in one of the fuel pipes. The safety device takes effect when the charging pressure is too low for the fuel quantity injected, as may happen during acceleration of the engine or the pressure-charging group, or when the resistance in the suction-air filter is excessive as a result of fouling. Supplementary protective equipment has been developed for lines running at great altitudes or subject to widely varying temperature conditions.

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.

Ramsay Centenary Exhibition.—Open until Saturday, January 3, 1953, at the Science Museum. Arranged, in collaboration with University College, London, by the Science Museum, South Kensington, London, S.W.7. (Telephone: KENsington 6371.) See also page 475, *ante*.

Netherlands Packaging Fair.—Thursday, January 8, to Friday, January 16, 1953, at Amsterdam. Apply to N.V. Het Raedhuys, Tesselschadestraat 5, Amsterdam, Holland.

43rd National Motor Boat Show.—Friday, January 9, to Saturday, January 17, 1953, at Grand Central Palace, New York. Details obtainable from W. H. Pearsall, H. A. Bruno and Associates, 30, Rockefeller Plaza, New York 20, U.S.A.

8th Annual Farm Equipment Show.—Tuesday, January 20, to Friday, January 23, 1953, at Canadian National Exhibition Grounds, Toronto. Further information obtainable from Ontario Retail Farm Equipment Dealers' Association, 81, King-street East, Toronto.

Packaging Exhibition.—Tuesday, January 20, to Friday, January 30, 1953, at Olympia, London, W.14. Held in collaboration with the Institute of Packaging. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363.) Apply as above, or to London office, 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANdyke 5635.)

Third National Power Farming Conference.—Tuesday, Wednesday and Thursday, February 10, 11 and 12, 1953, at the Town Hall, Cheltenham. Held under the auspices of the *Power Farmer*, Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

Fifth Annual Pakistan Science Conference.—Monday, February 16, to Saturday, February 21, 1953, at Lahore. Applications to be made to Dr. Bashir Ahmad, Pakistan Association for the Advancement of Science, The Mall, Lahore, Pakistan.

Frankfurt International Spring Fair.—Sunday, February 22, to Thursday, February 26, 1953, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. (Telephone: CENtral 5050.)

Radio and Television Exhibition.—Friday, February 27, to Sunday, March 8, 1953, at Düsseldorf. *Agents:* John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

Indian Railways Centenary Exhibition.—Saturday, February 28, to Thursday, April 16, 1953, at Purana Quila, India. Additional particulars obtainable from the joint director, Indian Railways Centenary Exhibition, Ministry of Railways, New Delhi.

Hanover Fair.—*Light Industries Fair:* Sunday, March 1, to Thursday, March 5, 1953, at Hanover. *Heavy Industries Fair:* Sunday, April 26, to Tuesday, May 5, 1953, at Hanover. *Agents:* Schenkers, Ltd., 27, Chancery-lane, London, W.C.2. (Telephone: HOLborn 5595.)

33rd International Spring Fair.—Sunday, March 15, to Sunday, March 22, 1953, at Vienna. Apply to the British-Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

Royal Netherlands Industries Spring Fair.—Tuesday, March 17, to Thursday, March 26, 1953, at Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10, Gloucester-place, London, W.1. (Telephone: WELbeck 9971.)

Conference on Static Electrification.—Wednesday, Thursday and Friday, March 25, 26 and 27, 1953, at Bedford College for Women, Regent's Park, London, N.W.1. Organised by the Institute of Physics. Applications should be addressed to the conference secretary, Mr. N. Clarke, Institute of Physics, 47, Belgrave-square, London, S.W.1. (Telephone: SLOane 9806.) See also page 751, *ante*.

Liége International Fair.—Saturday, April 25, to Sunday, May 10, 1953, at Liége. Apply to the manager, Foire Internationale de Liége, 17, Boulevard d'Avroy, Liége, Belgium.

Cycle and Motor Cycle Show.—Saturday, November 14, to Saturday, November 21, 1953, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, The Towers, Warwick-road, Coventry. (Telephone: Coventry 62511.)

LABOUR NOTES.

The considerable improvement in production which has taken place in the iron and steel industry during the past year, and especially during the last few months, is commented upon in the December issue of *Man and Metal,* the official journal of the Iron and Steel Trades Confederation. The editor states that not so long ago it had begun to be taken for granted that each succeeding month would show another record in the industry broken. Last year, however, the handicaps created by shortages of raw material were so severe that production, instead of reaching new heights, began to decline. But the tide had turned again and, at the industry's existing pace, there was every reason to believe that the target of 16 million tons would be reached, and passed, before the end of the year. All the signs pointed in the direction of this higher rate of production being not only maintained, but increased. The forecasts were that the industry's record production, of 16,250,000 tons, during 1950, would be beaten by a substantial margin in 1953.

The steady production of pig iron, the editor points out, had been the most important single factor contributing to the rapid improvement in the output of steel. Due mainly to the blowing-in of seven new blast furnaces since the middle of 1951, pig-iron production had increased by nearly 10 per cent. during the past year. Additional supplies of blast-furnace coke had helped considerably in the attainment of that result. Another major contribution had been made by the industry's successful drive for the collection of scrap. An advertising campaign to that end had been well organised and vigorously conducted, and a series of films, which could not fail to be effective, had been produced and distributed throughout the country. It was pleasing to note, therefore, that the collection of scrap had been at a higher level during the past year than in 1951.

Warnings that the shortage of steel will not last for ever, and that the time will come when the industry will have to seek new outlets for its products are contained in the article. The editor states that lack of steel has intensified greatly the search for alternative materials. He emphasises that, where capital has been employed to set up plant and machinery to produce such materials, it may not always be easy to persuade manufacturers to revert to the use of steel. The final aim must be to extend the use of steel in every possible direction. The industry must be organised and equipped in such a way that it will be able to meet competition from any quarter on a sound economic basis and be capable of continuing to provide an "adequate and satisfactory" livelihood for those engaged in it.

The strike of winding enginemen employed at collieries in the Yorkshire coalfield, which began on December 13, came to a somewhat abrupt end on December 17. On that date, the executive committee of the Yorkshire Winding Enginemen's Association, to which the men concerned belong, decided that the winders should resume work immediately. The men had gone on strike in support of their demands for an increase of 3*s.* a shift in their pay rates. There had been a considerable amount of opposition to the strike from the other miners, owing to the severe cuts in wages which the stoppage brought about during the pre-Christmas period of all-out effort for large pay packets. The National Union of Mineworkers, of which the enginemen are members through the Yorkshire Winding Enginemen's Association, condemned the strikers and declared their action to be in defiance of the national rules.

Sir William Lawther, the President of the N.U.M., stated shortly after the strike commenced that both the national officials of the union and those in the Yorkshire area had urged the winding enginemen's organisation to follow the advice of the Divisional and National Coal Boards and submit the application for an increase in shift pay to the industry's proper negotiating machinery. On December 17, the union's executive committee took a further step to resolve the dispute and set up a special sub-committee to investigate the circumstances which brought about the stoppage. At one stage in the dispute, 479 colliery winders in the North Eastern Division were on strike, 28 pits were at a standstill, and a further 27 pits were partly idle. It was estimated that about 230,000 tons of coal were lost as a result of the disagreement.

Sir Noel Holmes, chairman of the North Eastern Divisional Coal Board, stated on December 17 that the question of advances of pay to miners whose earnings were diminished by the winders' strike was being considered by the Board and representatives of the N.U.M. He added that these discussions would also cover the loss of production at the affected collieries, in which connection it would be suggested by the Board that some extra shifts should be worked. All miners taking part in such shifts would be paid at full overtime rates.

A national delegate conference of the National Union of Mineworkers met specially in London on December 18 to consider an offer by the National Coal Board to increase the wages of certain day-wage miners by 6*s.* a week. It was estimated that some 150,000 of the lowest-paid men in this category would benefit from the concession. On a card vote, however, the delegates decided by a majority of 471,000 to 260,000 to reject the Board's offer. This decision was taken on the recommendation of the union's executive committee, and, by the resolution, the committee was instructed to intensify its negotiations with the Board for new national rates for all miners employed on a day-wage basis.

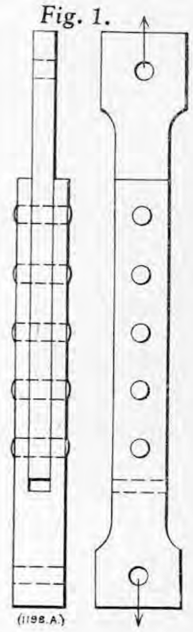
The Board's offer was conditional on the union agreeing that local piece rates, which have been stabilised for a year from December 31, 1951, should be stabilised for a further year, with the exception that where the local price gave an average of less than 35*s.* a shift, it might be subject to revision. The Board also asked that the union should accept now a further extension of the Saturday working agreement which is due to terminate in April, 1953. Opposition to the executive committee's motion came, in the main, from delegates representing miners in Scotland, South Wales, Cumberland and Northumberland. All wanted more drastic action. Some asked that strike notices should be presented immediately, some that Saturday shifts should be stopped at once, and others, it is understood, that there should be no further co-operation with the Board. The union expects to resume negotiations with the Board on the wages structure next week.

There were, in all, 58,111 disabled persons in the employment of Government Departments and services on October 1, 1952, according to a White Paper issued on December 16 (Cmd. 8696, H.M. Stationery Office, price 2*d.* net). It is shown that, of this total, 38,075 persons were employed as non-industrial civil servants. They amounted to about 5·7 per cent. of all Government employees in that category. The remaining 20,036 disabled persons were industrial civil servants and amounted to some 4·8 per cent. of the total industrial staffs. It is interesting to note that approximately nine out of every eleven lift attendants in the Government's service were disabled persons.

Male clerical and administrative employees in the engineering and cognate industries, earning up to 600*l.* a year, received an increase of 7*s.* 6*d.* a week as from December 22 last, according to an agreement reached in London between representatives of the Engineering and Allied Employers' National Federation and the Clerical and Administrative Workers' Union on December 16. Women staffs earning up to 450*l* a year received 6*s.* 6*d.* a week more. Juveniles obtained increases ranging from 1*s.* 9*d.* a week at 15, to 5*s.* 6*d.* a week at the age of 20. In all, some 180,000 persons benefited.

SCOPE AND LIMITATIONS OF PHOTO-ELASTIC ANALYSIS.

Fig. 1.



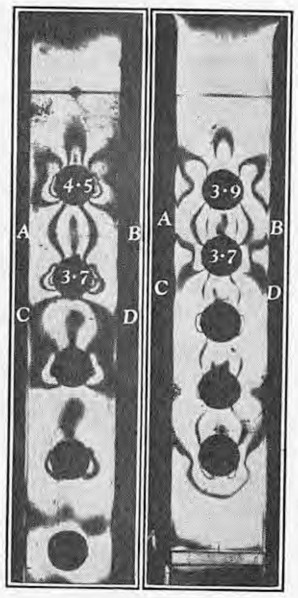
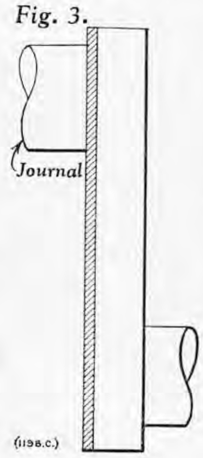


FIG. 2.

Fig. 3.



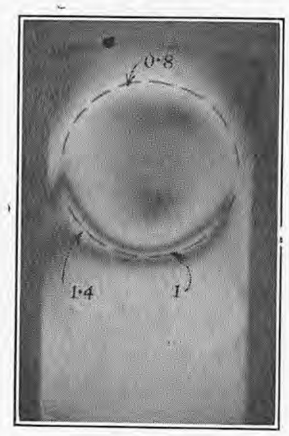


FIG. 4.

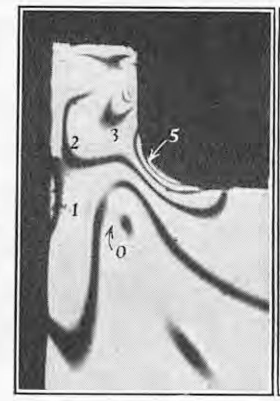
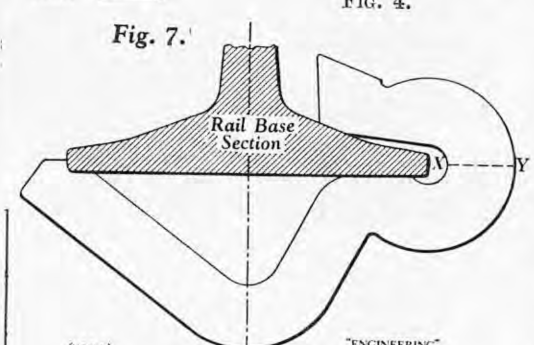


FIG. 5.

FIG. 6.

Fig. 7.



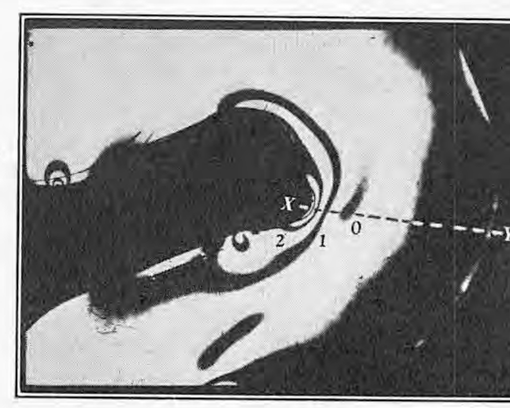
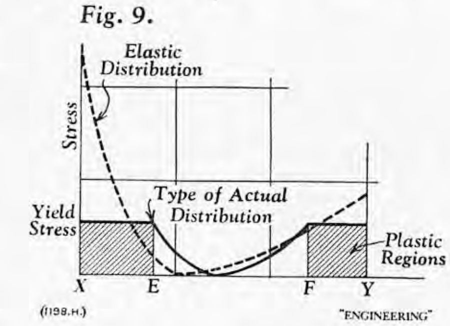


FIG. 8.

Fig. 9.



SCOPE AND LIMITATIONS OF PHOTO-ELASTIC STRESS ANALYSIS.*

By H. T. JESSOP, M.Sc., F.Inst.P.

IN comparison with other methods, the photo-elastic method of stress analysis is rapid and inexpensive. It is the only method by which the stresses in highly localised stress-concentrations can be determined with any degree of accuracy; it is also the only one which gives any information on the internal stress-distribution.

TWO-DIMENSIONAL TECHNIQUES.

The two-dimensional method is strictly applicable only to flat plates of uniform small thickness to which the loads are all applied at the edges, and all act in the plane of the plate. For such components the photo-elastic model is generally examined under load in an ordinary polariscope, and the complete stress-distribution is obtained in most cases rapidly and accurately. Measurements of the fringe-pattern seen in the polariscope yield directly the magnitude of the stress at all points on the free boundary, and the magnitude and direction of the greatest shear-stress at all internal points.

Figs. 1 and 2 illustrate a bolted or riveted cleat joint in which the cleat is made of Perspex, the photo-elastic sensitivity of which is very small, so that the pattern observed through the whole model is sensibly that due to the stresses in the middle bar. This gives a qualitative comparison of the stresses in such a bar with the two different bolt spacings shown and shows that the mean stress across each of the corresponding sections AB, CD is greater in the model with more closely-spaced rivets, and that the load is therefore more equally shared by these rivets. The greatest shear stress in each bar occurs at the boundary in the first hole, and is less in the model with the closer spacing.

The two-dimensional technique may also be employed in many cases in which the stress-distribution is not strictly two-dimensional, such as an I-section spar in which the loading is in the mid-plane of the spar and parallel to the plane of the web. Here the stresses in the web will be sensibly two-dimensional and may be deduced with good accuracy from the fringe-pattern, while the pattern in the flanges will allow the estimation of the mean stresses through the thickness of the flange. The stresses in the fillets between flange and web would need a full three-dimensional exploration. In tests made recently on such a spar model by Vickers-Armstrongs Limited, photo-elastic tests, occupying three weeks, yielded better information than was obtained from calculations which had taken a much longer time.

* Lecture given before the Royal Aeronautical Society on Thursday, November 27. Abridged.

THREE-DIMENSIONAL TECHNIQUES: THE FROZEN-STRESS METHOD.

The basis of the frozen-stress effect is, firstly, that the "frozen" photo-elastic fringe-pattern shall correspond with the stress-distribution in the model under direct load, and secondly, that no change in the "frozen" stress shall be produced by cutting the model. The method renders it possible to freeze the stresses into a model of any shape and, by cutting thin slices and examining them photo-elastically, to explore the stresses at all points of the model.

Three main methods of examination are available: (1) A thin slice of the model may be examined in the polariscope using the ordinary two-dimensional technique, with the light passing through the slice either normally or obliquely (Figs. 3 and 4). (2) A narrow pencil of light may be passed through the incut model (or any part of it) and the stresses at points on the path of the pencil explored by measurement of the fringes which are observed by scattered light. (Since this method does not involve slicing the model it may equally well be employed on a model under load, and in certain cases it will give all the information required without necessitating the "freezing" of the model.) (3) A thin slice of the model may be examined in polarised light on a universal tilting stage. By making a systematic series of small displacements about two perpendicular axes the directions in space of the three principal axes at any chosen point of the slice may be determined. In most cases the quickest and most accurate approach will be by a combination of two, or all, of these methods of examination and will lead to the determination of the principal stress-differences. As in the two-dimensional case the separation of the stresses will, in general, require an integration process.

A complete exploration of the stresses at all points of even a simple model would be a very long process, probably involving the "freezing" and slicing of two or three models, but for practical purposes the engineer is interested mainly in the stresses in certain specified regions in which the solution is comparatively simple. The regions may be classified as follows:—

(*a*) *Free boundaries in a plane of symmetry.*—Here, only the magnitudes of two stresses have to be found, and this may be done most easily by a combination of methods 1 and 2, or in some cases by two observations by method 2 without slicing the model. (*b*) *Free boundary not in a plane of symmetry.*—This involves finding the direction of the two stresses, as well as their magnitudes, but the solution is very little more complex than for case (*a*). (*c*) *Interior regions in a plane of symmetry.*—Here, the direction of one stress is known. The directions of the stresses in the plane of symmetry and the magnitude of the stress-difference are obtained by method 1. The second stress-difference is obtained by combining observations by method 2 with those of method 1. A comparatively simple integration leads to the values of the separate stresses. (*d*) *Interior regions not in a plane of symmetry.*—In this case the directions of the stresses at any point have first to be found by method 3. The slice used for this purpose will probably be found to have been cut in a plane which is not suitable for accurate measurement of both stress-differences, and this will necessitate the use of a second model. Another slice may be cut from this, and the stress-differences found. The separation of the stresses in this case involves the integration of measurements taken in two perpendicular planes, and, in general, will involve the use of two more models. In cases (*c*) and (*d*) the most troublesome part of the solution is in the separation of the stresses. In problems where a knowledge of the principal shear-stresses at a point is all that is required, these cases present little more difficulty than do the previous ones.

There are available, therefore, the means of measuring the stresses at practically any point of a "frozen" model. In order to apply these means to determining the stresses in an engineering component, it must be possible to construct a scale model of the component in a homogeneous photo-elastic material, to reproduce the loading conditions of the prototype in an annealing oven and to keep these conditions constant during the "freezing" period (16 hours or more), and to cut from the model slices sufficiently thin for the stresses in them not to vary appreciably through their thickness.

The available data on stress-concentration factors in fillets are all based on experiments or calculations in which the fillet is an isolated "stress-raiser" in a test-bar in which the stress-distribution in the absence of the fillet is known. In practice, the critical cases generally occur in regions near to points of load application where no basic stress is known to which a concentration factor can be applied. Figs. 5 and 6 show a comparison of the stresses in fillets of different radii in a loaded bracket. Doubling the fillet radius has reduced the peak stress from 6 units to 5. Two-dimensional models have been used in this illustration in order to obtain fringe-patterns from which the stresses may be compared by inspection, but equally good information may be obtained for three-dimensional models by taking accurate measurements of the smaller optical effects which appear in thin slices cut from the models.

Transferring Results from Model to Prototype.

The stress-distribution given by photo-elastic methods in both two- and three-dimensional investigations, is that which would occur in the prototype if it was made in material which had a linear stress-strain relation throughout the range indicated by the photo-elastic method, are higher than the yield stress of the prototype material, then the latter will undergo plastic yield in the most highly stressed regions, with a consequent redistribution of stress which can only be estimated. The magnitude and extent of the high stresses in the elastic distribution, however, give some measure of the amount of plastic yield which will occur in the prototype.

The rail-anchor illustrated in Fig. 7 provides a good example of such a case. The anchor clips on to the base of the flat-bottomed rail where it is held by the spring grip of its jaws. The face of the lower part of the anchor bears against a sleeper, preventing longitudinal creep of the rail. It was found necessary to modify the shape of the anchor and a photo-elastic test was undertaken to determine the type of modification which would produce the best "grip" on the rail. Fig. 8 shows a photograph of the fringe-pattern in the curved portion of one of the models examined. On scaling up the stresses observed in the model it was found that the peak stress in the anchor, on the basis of an elastic distribution, would be very much greater than the yield-stress of the steel used. The distribution across the critical section X Y of the anchor would therefore be of the type indicated by the continuous graph in Fig. 9, in which only the stresses in the portion E F of the section would contribute to the grip. The crucial factor, therefore, was the amount of plastic yield which would occur and, since the criterion of yield might be taken to be the magnitude of the shear-stress, it was necessary only to compare the shear-stress distributions in different models.

In two-dimensional problems the stress-distribution is a function of Poisson's ratio only when an unbalanced force acts on the boundary of a closed hole in the model. Even in this case the effect is not large, for the value of Poisson's ratio for the materials used in two-dimensional work does not differ much from that for most structural materials. Errors from this cause are not likely to exceed 7 per cent.

Under frozen-stress conditions, however, Poisson's ratio is very nearly 0·5. Exactly how this will affect the stress distribution it has been impossible, up to now, to estimate, for there are no theoretical solutions to compare with practical observations. With the development of the scattered-light method of observation, however, it will be possible to compare the results on a directly-loaded model made of the cold-loading type of material with those obtained from a similar frozen model. A cold-loading material with the requisite light-scattering properties is now being produced.

INFRA-RED OVEN FOR LOUDSPEAKER ASSEMBLY.

Accuracy of the Photo-Elastic Method.

The accuracy of the optical observations is generally high, and optical errors may be considered negligible. The main sources of error appear in the photo-elastic material itself, in the construction of the model, and in the reproduction of the loading conditions. The material may lack homogeneity and initial stresses may have been bound into it by chemical action during its manufacture. The models used for three-dimensional work are either machined from a solid block of material, or cast in a mould. The heat generated during polymerisation of the resins employed makes the casting of large blocks which are homogeneous and free from initial stresses a matter of some difficulty. The casting of a model in or near to its finished shape by reducing the mass of reacting material, helps to minimise the temperature effects. The technique of casting such models is still in the experimental stage, but in many cases it is quicker and more satisfactory than direct machining.

It is possible to apply corrections for initial stresses, but they cannot be relied on unless the initial stresses are small. It is accordingly frequently necessary to discard models and blocks of material. If, however, care is taken in selecting the materials, excellent agreement is obtained between measurements taken on several similar models.

The reproduction of loading conditions is, in many cases, the most serious source of error. The relatively large strains which occur in the model, especially in frozen-stress conditions, may in some cases tend to produce serious differences in the distribution of applied loads. No general rules for avoiding such errors can be laid down. In some cases, very small loads must be used for investigating stresses in the vicinity of load points, and larger loads for the more remote regions. In others it may be possible, by studying the effect of varying the loading on the model, to obtain a good estimate of the stress-distribution under the conditions existing in the prototype.

The peak stresses in a straight-forward two-dimensional model would be liable to an error of from 1 to 5 per cent., rising to a possible 10 or 12 per cent. where unbalanced forces act on the boundaries of holes. An error of from 5 to 30 per cent. might be expected in a three-dimensional model. Although the possible error in the last case may appear to be high, such errors will occur chiefly in problems for which no other method offers a solution. In such cases even a qualitative comparison of the stresses in two different designs may be of considerable value.

A technique is being investigated at the College of Aeronautics for applying photo-elastic methods to measuring strains in actual components. A layer of photo-elastic material is cast on to the surface of the component, and the optical effect in the layer when the component is loaded is observed by a reflection method. The photo-elastic material thus provides a continuous strain-gauge over the surface. A number of models have been tested satisfactorily, but the accuracy and reliability of the method have not yet been fully established.

INFRA-RED OVEN FOR LOUDSPEAKER ASSEMBLY.

An infra-red oven has been installed by Messrs. T. C. Spray Finishing Systems, 5, St. James's-place, London, S.W.1, in the factory of Messrs. Plessey, Limited, Ilford, for stoving the paint on loudspeaker assemblies. It is 48 ft. long and is visible in the illustration above as a kind of horizontal suspended duct. The loudspeaker assemblies, which vary in diameter from 5 in. to 10 in., are conveyed through the oven on special hangers at a speed of 10 ft. per minute and are there exposed to infra-red radiation. This radiation is generated in infra-red projectors which were made by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. They are fitted with tubular sheathed elements which operate at red heat and consist of a spiral of high-grade heat-resisting wire which is embedded in a mineral insulator, the combination being enclosed in a sheath of $\frac{1}{16}$-in. tube made of a non-scaling non-corrodible alloy. The process of embedding not only ensures that the spiral is held immovable in the centre of the bore of the mineral, but also that an even thickness of insulation separates it from the sheath. The projectors themselves are made of aluminium sheet which has been anodised to give maximum heat reflection and to provide protection from corrosion. They are carried in a light-weight frame.

Awards for Services to Rubber Industry.—The Colwyn Gold Medal for conspicuous scientific services to the rubber industry was presented by Sir Clive Baillieu, President of the Institution of the Rubber Industry, at the annual dinner of the Institution on December 11, to Dr. Geoffrey Gee, F.R.S., director of the British Rubber Producers' Association. Sir Clive also presented the Hancock Gold Medal, for services to the industry not necessarily of a scientific nature, to Dr. T. J. Drakeley, C.B.E., director of the National College of Rubber Technology.

DIESEL DUMPER.

CHASESIDE ENGINEERING COMPANY, LIMITED, HERTFORD.

3-CUB. YD. DIESEL DUMPER.

A NEW Diesel-engined dumper with a capacity of 3 cubic yards is being made by the Chaseside Engineering Company, Limited, Station Works, Hertford. A prototype of the vehicle was on show at the recent Public Works and Municipal Services Exhibition and Congress held at Olympia during early November. Two versions of the dumper are being built: one has a normal "dumper-drive" with the driver facing the load, the other has a "forward-drive," as shown in the illustration above, so that it may be licensed for the road. Overall dimensions are as follow: length, 13 ft.; width, 7 ft. $3\frac{1}{2}$ in.; height 6 ft.; and weight, 3·1 tons.

The dumper is driven by a six-cylinder Diesel engine, model P6, made by F. Perkins, Limited, Peterborough. This engine develops 52 brake horse-power at 1,500 r.p.m. and is fitted with fuel-injection equipment made by C.A.V., Limited, Acton, London, W.3. The fuel tank has a capacity of 10 gallons. The crankshaft ends at a hydraulically-controlled centrifugal-type clutch with a single dry plate mounted in a ball thrust bearing. The gearbox is a standard unit giving four forward speeds and one in reverse; from the gearbox, a universal coupling connects the drive to a differential axle which has two independent fully-floating half-shafts. Single-chain sprockets, 1·5-in. pitch, fitted to each half-shaft transmit the final drive to large sprockets on a tubular driving axle carried in adjustable mountings below the chassis. Hydraulic brake equipment, foot-operated and servo-assisted, is fitted to all four wheels; when the vehicle is brought to a standstill the brakes may be applied by a hand-brake. The steering axle, of a type not previously fitted to this class of vehicle, has been designed to eliminate radius rods and to give a better ground clearance. The stub axles are mounted in a diamond-shaped frame welded from pressed-steel sections; bearings, co-planar with the stub axles, carry a longitudinal shaft which secures the frame to the chassis, but which allows ample oscillatory movement of the frame. Steering is from a central point on a split track rod. The steering box is of a recirculatory-ball type with a reduction ratio of 24 to 1. All controls are built into a single unit carried above the chassis on a four-point flexible mounting. A "floating" seat is provided for the driver by the use of a shock-absorbing, toggle-link, suspension.

The chassis is constructed from 5-in. by 3-in. rolled-steel joists and from electrically-welded auxiliary members of pressed steel that have a box-section $5\frac{1}{2}$ in. deep by 3 in. wide. The hopper, which has a struck capacity of 3 cub. yd., is made from a single pressing from $\frac{3}{16}$-in. steel sheet; the bottom plate of the hopper is deeply ribbed, and welded gusset plates as well as edge pieces have been added to increase its robustness. When the holding device located at the rear of the hopper is released, the loaded hopper will tip forward under the weight of the contained material. The shock of unloading is taken by two helical springs which are attached to the chassis by chains. When freed from its load, the hopper swings back into the normal position under its own weight. Towing hitches are provided at both the front and rear of the vehicle. A draw-bar pull of 4,000 lb. can be developed in first gear. The recommended maximum operating speed of the dumper when loaded is 20 m.p.h. in top gear and 3 m.p.h. in reverse.

THE AIR AND THE FUTURE.*

By AIR COMMODORE F. R. BANKS, C.B., O.B.E., M.I.Mech.E.

(*Concluded from page* 800.)

THE TREND OF ENGINE DESIGN.

In my earlier lectures, I explained the differences between the various types of aviation gas turbine: the jet-propulsion gas turbine, or turbo-jet; the propeller turbine, where the bulk of the available turbine power, in excess of that needed for the compressor, is used to drive a normal propeller; and, last, the ducted-fan or the by-pass engine which, in either form, has a multi-bladed fan placed in a duct surrounding the engine proper, driven by a free turbine located behind the main power turbine or by an extension of the compressor shaft at the front of the engine.

Since more effort has been put into the development of the turbo-jet, due to its military application, it is natural that this engine type is the more generally used; and with the success of the Comet in scheduled airline service, it would appear that the turbo-jet is also justifying itself as a prime mover of civil aviation. In my opinion, jet propulsion, which also includes the ducted fan and the by-pass varieties, is the ultimate; and while the propeller turbine also has a rightful place, it will not usurp that of the turbo-jet.

The propeller turbine has the potential advantages of improved take-off thrust and better fuel consumption, though the advances made in recent years in the higher thrust-weight ratio of the turbo-jet, together with the relatively large improvement (15 to 20 per cent.) in its fuel consumption, have closed the gap somewhat between the two engine types. If the promise of the ducted-fan or the by-pass engine is fulfilled, a further substantial improvement in fuel consumption can be expected; but there are still improvements to come from the propeller turbine.

The turbo-jet does, however, permit a very "clean" aircraft, aerodynamically, and a relatively simple engine installation of low weight. Since no allowance is necessary for propeller clearance, the undercarriage may be of the minimum height and, therefore, weight. Some make-up in weight will be necessary due to the greater fuel load to be carried for a given range by the jet aircraft; but extra fuel can also be carried in wing-tip or under-wing tanks without serious loss, if any, in operating efficiency. Further, the speed of the jet aircraft, compared with that of the propeller-turbine version, will probably be superior by 100 to 150 m.p.h.

While the propeller turbine offers more economical operation than any of the jet-propulsion varieties, particularly at sub-sonic flight speeds (and I do not envisage supersonic passenger aircraft for many years), there are considerable problems to be overcome in connection with the development of the propeller for engines of 4,000 to 5,000 s.h.p. and upwards. Propellers are not yet trouble-free, even on the large piston engine of 3,000 to 3,500 b.h.p.

It is not practically possible to construct a large propeller blade that will be completely immune from aerodynamic excitation. Therefore, attempts have been made by some American manufacturers to reduce propeller diameter (blade length) by the two-row arrangement, where the necessary blade area is obtained by putting two separate three-bladed or four-bladed propellers, of restricted diameter, together; as distinct from the contra-rotating propeller, which has two sets of blades rotating in opposite directions. The former is the lighter and less complex arrangement. More recent information suggests that it is considered possible to develop a four-bladed propeller capable of absorbing up to 10,000 s.h.p. Such a propeller would have very wide blades.

The propeller turbine is most suitable for aircraft of moderate size (40,000 to 50,000 lb. all-up weight) and speed, such as the Vickers Viscount, which has four Rolls-Royce Dart engines each of 1,400 s.h.p. Larger versions of such machines, of 80,000 to 90,000 lb. all-up weight, fitted with four propeller turbines of 2,500 to 3,000 s.h.p. each, or two of 5,000 to 6,000 s.h.p., should also have a ready market for Continental and medium-range operation, where the cruising speed could with benefit be raised to 350 m.p.h. and higher. For long distances, such as the North Atlantic route and the Far East routes to Australia and Japan, I consider the premium to be on still greater speed and comfort; and an aircraft of 150,000 lb. all-up weight, fitted with four turbo-jet engines each of 10,000 lb. (or somewhat more) static sea-level thrust, capable of cruising between 560 and 600 m.p.h. at 40,000 to 45,000 ft., should meet the case—followed in 15 or 20 years by larger and still faster machines.

Propeller-turbine aircraft may eventually be designed to fly as fast as their jet-propulsion equivalents, in the high sub-sonic speed range, but I have a "hunch"—if I may use the word—that the preference for the relatively simple and less complex turbo-jet will be so strong that the further development of the former might be somewhat restricted and most of the available effort concentrated upon the jet. A feature of the propeller turbine, which could well prove to be of decisive advantage in the field of civil aviation, is its comparative silence of operation. It has no great exhaust noise, since there is little jet energy left after translating most of that available to propeller horse-power; and the propeller can be designed for a reduction-gear ratio that will give it a reasonable tip speed and, therefore, low noise level.

A disadvantage of the gas turbine, regardless of type, is that it operates always as a "full-throttle" engine. By this I mean that it differs from the high-duty piston engine, the supercharger of which is of such capacity as to provide high take-off power and also reproduce a large percentage of the maximum power at a predetermined altitude. In other words, the latter is an "over-capacity" engine of relatively good operating flexibility, permitting it to cope with the take-off of a highly-loaded aircraft, in reasonable runway length, from high-altitude airfields, or to deal with a combination of high altitude and high ground temperature, as at Nairobi. The gas turbine, being a full-capacity engine at sea-level conditions, is sensitive to altitude

* Presidential address to the Junior Institution of Engineers, delivered in London on Friday, December 12, 1952. Abridged.

and also to temperature. Therefore, a jet aircraft, in particular, requires much increased runway length at high altitudes and high ground temperatures in order to take-off with the same load as it had, say, when leaving London Airport.

For military aircraft, this deficiency will be overcome by any one, or all, of the following three methods of thrust augmentation: (i) alcohol-water injection into the compressor or the combustion chamber; (ii) after-burning or reheat, i.e., burning additional fuel in the jet pipe, behind the turbine; and (iii) jet-assisted take-off by liquid or solid-fuel rockets. But for civil operation, methods (ii) and (iii) are, to say the least, excessively noisy and it would be asking a great deal of the passengers in civil aircraft and the residents local to the airport to tolerate them; although the development of a satisfactory "cold" rocket may later help to overcome these objections. Alcohol-water injection is not objectionable in this respect, but it does not give the same degree of thrust augmentation as either of the other two methods. The problem of take-off under such conditions will be solved, and the deficiencies of the gas turbine in this respect will not seriously restrict its use or retard its progress. The Comet is teaching us a great deal and the lessons learned from its operation will be invaluable to those designing for the future.

Competition for World Markets.

Our friends in the United States must not be underestimated in this gas-turbine age. They have been very impressed by the performance of the Comet and will not long delay building this type of aircraft for their own domestic requirements, and also to compete with us on the air routes of the world. We should be able to anticipate them by building still more advanced turbine-engined passenger aircraft, but these ought now to be in the advanced design stages.

The importance of timing in aviation cannot be overstressed. If one firm produces an aircraft of the right type and performance before another, that aircraft will have a ready market and long life or an extended period of obsolescence. A successful constructing company of energy and experience will then consider the next machine to follow while selling the former to the airline operating companies, so preventing anyone else from stepping in for some years. Correct timing is even more important in the case of the aviation engine, since the design and development of an entirely new engine absorbs a longer period than that of the prototype aircraft, and the engine must be ready before the aircraft.

It was, perhaps, more easy to ensure engine availability for civil transport aircraft in the period between the two wars, because the high-duty piston engine already existed in military form. In this role, its basic teething troubles were largely overcome before being adapted to airline use; although civil operation always brought out other weaknesses not apparent in military service, principally due to engine hours accumulating more rapidly and the demand, by the airline operators, for longer running time between maintenance periods. The Viscount and the Britannia are, in fact, two good examples of the point I am trying to make. Both are fitted with propeller turbines (the Rolls-Royce Dart and the Bristol Proteus III, respectively) which have not been ordered for any military aircraft. Therefore, these engines start from scratch in airline service; and, already, the Britannia has had to commence flight trials with an earlier type of engine (the Proteus II), to avoid the delays in awaiting the much-improved Proteus III.

Centrifugal versus Axial Compressors.

You will have heard queried, and criticised, the effort which has been put into the development of the axial-compressor type turbo-jet, as distinct from the apparent lack of interest in the centrifugal compressor. The original Whittle engine had the latter type, and a very simple and attractive engine it was. But aviation engineering, above all other branches of engineering art and science, is never static; and it was inevitable that engines offering greater power and improved fuel economy would almost immediately be demanded. Since, by virtue of its working principle, the outside diameter of the centrifugal compressor is larger than its air inlet, and because it is not practicable to add more than one extra stage (making two stages in all) due to the serious loss in efficiency in the cramped bends between the stages, it will be apparent that the possibilities of developing farther the centrifugal-type turbo-jet had limitations.

The air inlet of the axial compressor, because the air is not turned radially in its course (as in the centrifugal type) largely determines the overall diameter of the engine. The axial is, however, somewhat longer than the centrifugal, because it has a greater number of work stages.

For a given engine diameter, the axial compressor takes in much more air than the centrifugal and, therefore, produces greater thrust per square foot of frontal area. Further, the efficiency of the axial is better than that of the centrifugal; and this contributes to improved fuel consumption, since less power is needed to drive the axial than the centrifugal for a given pressure ratio and air consumption. The higher pressure ratios practical with the axial also give superior specific thrust—up to a maximum ratio of about 8 : 1. In specific terms, the thrust per square foot of frontal area of a centrifugal engine is between 400 and 460 lb., whereas that of an axial is now better than 1,200 lb.

The specific weight (the weight per lb. of thrust) was, at first, lower for the centrifugal than for the axial, later becoming similar for both types; but the axial type now has the lower specific weight. The centrifugal is inherently more robust—the many blades of the axial rendering it more liable to damage by the entry of foreign bodies, which may either reduce compressor efficiency or be catastrophic to the whole blading. The cost of the two engine types, in terms of man-hours, is somewhat different and is much in favour of the centrifugal. The large number of blades in the average axial compressor (1,500 to 2,000) is the reason for this disparity. But there is hope that new methods of production will be evolved, to reduce considerably the present effort required for their manufacture to the close tolerances necessary for aerodynamic efficiency. Also, it is possible that further research and development may point the way to obtaining more work per stage, so that fewer stages and, therefore, less blades will be necessary for a given pressure ratio. Despite the greater production effort needed for the axial, its better performance fully justifies the extra cost.

Importance of Research Equipment.

An important matter is that of making available adequate testing equipment in order to calibrate the turbo-jet at simulated flight conditions. Since the turbo-jet is less flexible in its operation than the piston engine and depends so much upon forward speed for improving its propulsive efficiency and, therefore, fuel economy, the aircraft in which it is fitted must fly at considerable altitude in order to reduce aerodynamic "drag" to the minimum and so permit very high speed. But since an aircraft is not always available for engine flight-testing, an altitude chamber is necessary to operate the engine at simulated altitudes up to, say, 60,000 ft.

Such chambers are enormously expensive, because it is not only necessary to reduce the atmospheric pressure but also the temperature—to about − 75 deg. C. Further, the air must be dry, otherwise the whole tunnel and engine would be covered or filled with ice. It is doubtful whether an altitude chamber for engines having a maximum sea-level thrust of, say, 15,000 lb. could now be built for less than 3,000,000*l*., which is a very large sum for any individual firm to provide; and while we have, so far, done without this equipment, its need is becoming more and more urgent for our military requirements alone. The Americans already have such facilities—at some individual firms, but principally provided by the National Advisory Committee for Aeronautics (N.A.C.A.), at the Lewis Flight Propulsion Laboratory, Cleveland. It is only our native ingenuity and ability to improvise, and to develop engines more rapidly than any other country, that has kept us ahead in gas-turbine performance and technique; but this may not always hold, when a large and rich nation like America can put so much effort and expenditure into the provision of elaborate facilities.

THE DESIGN AND OPERATION OF DUNSTON "B" GENERATING STATION.*

By A. Howell and J. B. Jackson.

(*Concluded from page 804.*)

Slagging and Fouling.

Soon after the first boiler was brought up to full load, slagging occurred on the first row of generating tubes, starting at the rear furnace wall and gradually spreading forward along the under surface of the tubes. This tended to increase the superheated steam temperature, and on several occasions it was necessary to reduce load to bring this temperature down to the designed figure. The general slagging of these tubes was greatly reduced by attention to the correct setting of the Bailey air/fuel ratio controller and by adjustment of the rear tertiary air supply to keep the high-temperature combustion zone well down in the furnace. The modification of the superheater temperature control also allowed more excess air to be carried, so reducing the temperature of the furnace exit gas. Both units are now relatively free from this slagging trouble, although it is necessary to carry more excess air than the designed figure. A particular instance of slagging is of interest, since on one occasion this was attributed to false readings on the steam-flow/air-flow meter. A modification had been made to the reheater centre wall which resulted in increased air leakage into the reheater. As the air flow is measured by means of the gas pressure drop across the economiser, the air flow recorded at the economiser became disproportionally greater than that in the furnace. This resulted in a higher temperature of the furnace exit gas than was intended and led to slagging in the generating tubes. Any further occurrence of this trouble has been prevented by checking the steam-flow/air-flow meter against carbon dioxide readings taken on an Orsat apparatus twice a day. During the period when the slagging problem was most severe, attempts were made to clear the accumulations by means of water lancing. This proved to be a difficult operation due to the positioning of the galleries and inspection ports in relation to the slag accumulations. Nevertheless, it did meet with some success and this method of on-load cleaning has to be carried out occasionally up to the present time.

The automatic sequence-operated soot-blowers, consisting of eight furnace blowers and twelve superheater blowers, were at first operated completely once per shift, but signs of erosion were later discovered on the superheater tubes. The soot-blower nozzles were therefore changed to a modified type, giving a different angle of blow, and the soot-blowing routine was cut down to one complete sequence a day for all blowers, except the furnace blowers, which were operated once a shift. This is giving entirely satisfactory results. Choking of the rotary air-heaters occurred on both units shortly after they were commissioned, but this was cleared successfully by the application of a 10 per cent. solution of soda ash and subsequent water washing. The fouling was attributed to the initial operating conditions and the lack of soot-blowers. Soot-blowers have since been fitted to the gas-exit side of the heaters and, judging by subsequent inspections, are proving to be very effective. Although provision for air by-passing is provided on the rotary air-heaters, so far this has not been used because of the need for a hot-air supply to the mills during initial operation. Trouble was experienced from an accumulation of dust in the reheater-gas by-pass duct, which prevented satisfactory operation of the damper. This was overcome by fitting a hopper to the base of the duct and providing a chute with a damper to the main economiser hopper. The damper is operated once a day, which effectively clears away the dust.

* Paper entitled "The Design and Operation of Dunston 'B' Generating Station, with Particular Reference to 50-MW Turbo Alternators Unitised with Reheater Boilers," read before a joint meeting of the Institutions of Mechanical and Electrical Engineers on Friday, October 24, 1952. Abridged.

A serious position arose shortly after the boilers were commissioned, owing to repeated failures of hand-hole joints on the topping economiser outlet box. These hand-holes were originally fitted with stainless-steel sheathed asbestos joint rings, and the opinion was held that the failures were due to temperature changes brought about by the operation of the reheater-gas by-pass damper and defective joint seats. Because of the critical plant shortage at that time, it was felt that experiments with different types of joint ring could not be undertaken and therefore a new type of cap, designed for welding to the header box, was fitted to the hand-holes of both the main and topping economisers. To facilitate inspection, the penultimate hand-hole at each end of each header box was left as designed, but was fitted with a cupro-nickel serrated-ring joint. This modification overcame the trouble successfully and no further failures have occurred.

The pipes conveying the steam to and from the reheater are 22 in. and 30 in. in diameter respectively. The reheater outlet-pipe divides into two pipes of 22 in. diameter at a point before the intermediate-pressure cylinder, and carries steam at a pressure of 135 lb. per square inch and a temperature of 865 deg. F. All joints are of the fixed flange and bolt type with $\frac{1}{32}$ in. "Klingerit" between the faces. All the joint failures to date have been on the reheater outlet-pipes, and the rate of failure has been unduly severe. Since the units were commissioned, nine joints on one unit and twenty on the other unit have failed; of these, three have been second failures. If this present trouble persists, a system of tightening the bolts to micrometer gauge will be introduced, followed by further tightening after a period of steaming. It was apparent after some months of operation that the performance of the electrostatic precipitators was below expectation. This was borne out by the fact that it became necessary to fit new wearing plates to both induced-draught fans after 7,500 hours' running in the case of one unit and 4,400 hours for the other unit. Considerable modification was carried out on one unit to improve the gas-flow distribution through the precipitator, and an improved type of discharge electrode was fitted to ensure a more uniform electrostatic field. The effect of these modifications remains to be determined.

TABLE I.—*Tests on Unit 5 and Unit 6 Boilers.*

—	Unit 5.	Unit 6.
Duration, hr.	6	2
Coal. Proximate analysis, per cent.—		
Moisture	3·71	8·88
Volatile matter	29·11	28·29
Fixed carbon	53·56	44·94
Ash	13·62	17·89
	100·00	100·00
Gross calorific value (as received), B.Th.U. per lb.	12,335	10,980
Gross calorific value (ash and moisture free), B.Th.U. per lb.	14,920	14,990
Net calorific value, B.Th.U. per lb.	11,865	10,487
Coal fired, lb. per hr.	43,860	50,174
Evaporation, lb. per hr.	381,850	380,020
Evaporation per lb. of coal, lb.	8·706	7·554
Superheater outlet pressure, lb. per sq. in. gauge	624	620·5
Superheater outlet temperature, deg. F.	858	856·8
Economiser inlet pressure, lb. per sq. in. gauge	744	696·5
Feed-water temperature at economiser inlet, deg. F.	351	347·7
Reheater inlet pressure, lb. per sq. in. gauge	149	159·0
Reheater inlet temperature, deg. F.	562	555·5
Reheater outlet temperature, deg. F.	871	861·2
Total heat in superheated steam above feed-water, B.Th.U. per lb.	1,114·9	1,119·7
Heat realised per lb. of steam in reheater, B.Th.U. per lb.	157·5	156·4
Heat realised in reheater per lb. of stop-valve steam, B.Th.U. per lb.	144·4	145·5
Total heat realised in boiler and reheater per lb. of stop-valve steam, B.Th.U. per lb.	1,259·3	1,265·2
Total heat realised per lb. of coal, B.Th.U.	10,960	9,557
Net calorific value of coal, B.Th.U. per lb.	11,865	10,487
Thermal efficiency of boiler and reheater (based on net calorific value), per cent.	92·4	91·1
Gases at air-heater outlet—		
Mean temperature, deg. F.	279	301
Carbon dioxide, per cent.	11·3	9·6
Overall thermal efficiency of unit 6 at 50 megawatts (on gross calorific value)—		
Overall thermal efficiency of unit based on *net* generated output (test conditions), per cent.		31·40
Overall thermal efficiency of unit based on electricity generated (for direct comparison with station returns), per cent.		31·46
Overall thermal efficiency based on electricity sent out (for direct comparison with station returns), per cent.		29·61

TABLE II.—*Unit 6 Turbine Tests at 40 MW and 50 MW.*

Test number	1	2
Power factor at alternator terminals, lag	0·79	0·82
Alternator output by standard meters at 66 kV, kW	40,318	50,352
Losses in step-up transformer (makers' curve), kW	330	430
Alternator terminal output, kW	40,648	50,782
Power input to exciter and alternator fan (metered), kW	488	512
Power input to oil pump (metered), kW	20	20
Alternator net output for purpose of test, kW	40,140	50,250
Alternator net output at 66 kV, kW	39,810	49,820
Turbine condensate weighed in weigh-tank, lb. per hr.	302,857	378,140
Steam used by one air ejector (makers' figure), lb. per hr.	1,150	1,150
Leakage of river water into condensate, lb. per hr.	Nil	Nil
Turbine stop-valve steam rate for purpose of test, lb. per hr.	301,707	376,990
Turbine steam consumption rate for purpose of test, lb. per hr.	7·516	7·502
Pressure before combined stop-valve emergency valve, lb. per sq. in. gauge	636	630
Temperature before combined stop-valve emergency valve, deg. F.	854	846
Pressure at high-pressure turbine outlet (high-pressure heater No. 3 tapping), lb. per sq. in. gauge	127·0	161·2
Temperature at high-pressure turbine outlet, deg. F.	563	563
Pressure at intermediate-pressure turbine inlet, lb. per sq. in. gauge	117·2	148·0
Temperature at intermediate-pressure turbine inlet, deg. F.	857	853
Pressure drop between high-pressure turbine outlet and intermediate-pressure turbine inlet, lb. per sq. in.	9·8	13·2
Temperature of feed-water leaving high-pressure heater No. 3, deg. F.	333·5	345·7
Absolute pressure at low-pressure turbine exhaust, in. of mercury	0·93	1·01
Total heat of stop-valve steam, B.Th.U. per lb.	1,435·7	1,431·5
Heat of feed-water, B.Th.U. per lb.	305·8	318·4
Total heat of steam above feed-water, B.Th.U. per lb.	1,129·9	1,113·1
Total heat of steam at high-pressure turbine outlet, B.Th.U. per lb.	1,307·0	1,304·2
Total heat of steam at intermediate-pressure turbine inlet, B.Th.U. per lb.	1,456·1	1,452·9
Reheat of steam passing through reheater, B.Th.U. per lb.	149·1	148·7
High-pressure No. 3 heater bled steam as percentage of stop-valve steam, per cent.	6·88	7·31
Reheat referred to stop-valve steam rate, B.Th.U. per lb.	138·9	137·8
Total heat of stop-valve steam plus reheat, B.Th.U. per lb.	1,268·8	1,250·9
Turbine heat consumption "as run," B.Th.U. per kWh	9,536	9,384
Correction for:—		
Stop-valve pressure, per cent.	Nil	Nil
Stop-valve temperature, per cent.	+0·06	—0·06
Reheat temperature, per cent.	+0·13	+0·06
Pressure drop through reheater circuit, per cent.	+0·29	+0·20
Low-pressure turbine exhaust, per cent.	+0·28	+0·60
Correction for variations in feed-water rate and temperature in condensate and feed-water circuit, due to limited capacity of test return pump, etc., per cent.	—0·19	—0·03
Total correction, per cent.	+0·57	+0·77
Turbine heat consumption as corrected, B.Th.U. per kWh	9,590	9,456

TABLE III.—*Unit 6 Condenser, Air Ejector and Pump Readings.*

—	Unit 5.	Unit 6.
Test number	1	2
Alternator terminal load, kW	40,140	50,250
Condenser.		
Absolute pressure, at top of condenser by barometer and mean of two columns, in. of mercury	0·93	1·01
Corresponding temperature, deg. F.	76·7	79·3
Temperature in top of condenser (four thermometers), deg. F.	77·0	79·5
Air and vapour temperature leaving condenser East, deg. F.	61·0	64·9
Air and vapour temperature leaving condenser West, deg. F.	73·7	72·9
Condensate temperature leaving condenser, deg. F.	76·1	78·4
Circulating water inlet temperature, deg. F.	51·5	50·8
Circulating water outlet temperature, deg. F.	65·9	68·9
Circulating water rise temperature, deg. F.	14·4	18·1
Circulating water rate (calculated), gal. per min.	27,700	27,050
Circulating water outlet, in. of mercury vacuum	19·44	11·14
Air Ejector (B).		
Steam pressure—		
Stage 1, lb. per sq. in. gauge	599	592
Stage 2, lb. per sq. in. gauge	595	587
Stage 3, lb. per sq. in. gauge	595	598
Vacuum in Stage 1, in. of mercury	28·45	29·00
Stage, 2, in. of mercury	24·50	26·70
Steam used (makers' figure), lb. per hr.	1,150	1,150
Extraction Pump (West).		
Water delivered, lb. per hr.	302,857	378,140
Suction, in. of mercury	26·0	25·2
Discharge pressure, lb. per sq. in. gauge	29·0	30·2
Current input, amp.	48	59
Boiler Feed-Pump.		
Water delivered, lb. per hr.	306,677	380,000
Suction	—	—
Discharge pressure, lb. per sq. in. gauge	894	860
Current input, amp.	99	109

OPERATIONAL EXPERIENCE.

During a week-end shut-down in the initial stages of operation a slight fouling was heard in the intermediate-pressure cylinder while one of the machines was on the barring gear, owing to part of the shrouding on the fifth and sixth rows of the spindle having become detached and damaging rows 4, 5, and 6 on the intermediate-pressure cylinder. This shrouding had been fixed by light riveting on to the blade-tip tenons and subsequent brazing. A final machining operation to provide a smooth exterior had, however, unduly weakened the attachment. At the first opportunity, the first six rows of both intermediate-pressure turbines were renewed with shrouding having more generous riveting and brazing, and with the final machining operation omitted.

During the first annual overhaul of one unit, modifications were carried out to reduce wear on a labyrinth-gland strip due to the vertical expansion of the feet of the high-pressure cylinder being greater than that of the bearing pedestal. This

TABLE IV.—MONTHLY PERFORMANCE—JANUARY-DECEMBER, 1951.

—	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Unit 5.													
Kilowatt-hours generated, millions	33·887	23·609	31·997	1·251	4·051	19·617	35·105	37·625	34·428	31·781	37·444	33·817	324·6
Kilowatt-hours sent out, millions	32·488	22·371	29·991	1·185	3·964	18·672	32·992	35·024	32·161	29·916	35·179	31·771	305·7
Coal per kWh sent out, lb.	1·01	1·01	1·02	1·00	1·10	1·04	1·03	1·06	1·05	1·03	1·04	1·05	1·04
Gross calorific value, B.Th.U. per lb.	11,603	11,678	11,908	11,975	11,187	11,180	11,233	10,715	10,978	11,174	11,180	11,026	11,245
Heat rate, B.Th.U. per kWh sent out	11,697	11,769	12,109	11,998	12,327	11,675	11,528	11,362	11,575	11,556	11,632	11,540	11,644
Thermal efficiency, per cent.	29·2	29·0	28·4	28·5	27·7	29·2	29·6	30·0	29·5	29·5	29·3	29·6	29·3
Unit availability, per cent.	91·1	69·0	84·7	3·3	18·7	59·4	93·2	99·2	92·5	83·2	99·2	88·2	73·7
Unit 6.													
Kilowatt-hours generated, millions	31·140	33·685	24·792	36·758	23·917	33·115	28·333	—	35·061	38·322	33·871	35·370	354·4
Kilowatt-hours sent out, millions	29·366	31·745	23·297	34·685	22·569	30·931	26·489	—	32·854	36·004	32·001	33·250	333·2
Coal per kWh sent out, lb.	1·02	1·03	1·00	1·00	1·02	1·02	1·06	—	1·04	1·02	1·02	1·04	1·02
Gross calorific value, B.Th.U. per lb.	11,671	11,878	11,861	11,476	11,104	11,023	11,413	—	10,889	11,083	10,992	10,919	11,282
Heat rate, B.Th.U. per kWh sent out	11,929	12,199	11,888	11,413	11,341	11,252	12,127	—	11,347	11,271	11,179	11,307	11,549
Thermal efficiency, per cent.	28·6	28·0	28·7	29·9	30·1	30·3	28·1	—	30·1	30·3	30·5	30·2	29·5
Unit availability, per cent.	85·9	98·2	67·5	99·1	64·5	90·2	79·6	—	96·1	99·5	91·7	93·6	80·2

involved the lowering of the feet at the high-pressure exhaust end and the raising of the shaft at No. 1 bearing. After the unit was put back into commission and full load on the machine had been reached, further trouble was encountered in the form of a failure of the high-pressure front-thrust pads. Examination showed that the intermediate-pressure back-thrust pads and the low-pressure front pads were also "wiped." The failure of the high-pressure front-thrust pads was eventually overcome by increasing the oil supply to the thrust block and reducing the clearance between the steady bearing and the shaft, to prevent by-passing of the oil from the thrust block. A contributory cause for the failure of the high-pressure front-thrust pads was the drooping of the steam end pedestal due to temperature differences between the front and back of the pedestal. To counteract this the pedestal was lagged with asbestos board, and a tapered liner was temporarily fitted in the high-pressure thrust-block. The wiping of the intermediate-pressure back-thrust pads and the low-pressure front-thrust pads was explained by the locking of the semi-flexible coupling between the intermediate- and low-pressure thrust pads. To prevent a recurrence of this trouble, an increased clearance was given between the tooth faces of the coupling, and the oil float in the low-pressure thrust block was increased.

Tests on the system showed that the time lag between failure of the main oil pump and the steam-driven standby oil pump picking up was excessive, and resulted in the oil pressure at No. 8 bearing falling nearly to zero and the power oil-pressure being reduced to such a low value that the emergency stop-valve closed. This time lag was decreased by re-positioning the orifice in the steam-supply line and increasing its diameter, while to ensure sufficient oil supply to the bearings a head tank was fitted to the main bus delivery line. Subsequent stationary tests have shown that this head tank will maintain a satisfactory pressure at all bearings for a period of approximately 2 minutes. Satisfactory operation of the pump has been attained when the pump and pipe-lines are thoroughly warmed through, but tests made when the pump and pipe-lines are cold resulted on one occasion in complete failure and, in all other tests, relatively slow pump acceleration. For this reason it has been decided to install a small direct-current motor-driven emergency lubricating-oil pump and, in the meantime, the stand-by pump is run continuously on the regulator by-pass to keep it turning round slowly and in a warm condition. To overcome the difficulty that the coarse ash fines and dust, when mixed with water, take up a concrete consistency and will not flow by gravity, further water drainage units have been installed at the bottom of the bunker. This corrects the previous tendency for the contents when discharging to be too wet at the bottom and too dry at the top.

During 1951 the availability of one unit was 73·8 per cent. and of the other 80·2 per cent. On the first unit the greatest outage apart from the annual overhaul was due to turbine thrust trouble and amounted to 9·5 per cent. On the second, it was caused by pipework joint failures and amounted to 6·1 per cent. The annual overhaul of each unit took about five weeks, during which period the modifications to the boilers for superheat temperature control were carried out. It is expected that this can be reduced to three weeks.

PERFORMANCE TESTS.

Numerous tests, which have been conducted over periods up to two weeks, show that the plant will operate consistently with an overall efficiency of at least 29·5 per cent. based upon the kilowatt-hours sent out. Tables I to III show the results of a test during which as much simultaneous information as possible was obtained on the boiler, turbine and condensing plant of Unit 6. During this test a bad bout of slagging occurred owing to the nature of the fuel and the boiler had to be operated with 60 per cent. excess air. Even under these conditions the efficiency of the whole unit was 29·61 per cent. Since these figures are not typical of the boiler's performance under test conditions, figures obtained on Unit 5 boiler have also been included in Table I.

The monthly performance figures for both units are shown in Table IV. The total electricity generated on one occasion exceeded the product of the maximum continuous rating and hours generating. This is the result of the high rate at which the machines may be loaded and unloaded, and of the fact that they are capable of running for extended periods at loads above the maximum continuous rating.

It is not uncommon for the ash content of the day's coal sample to vary within the range of 11·8 to 21 per cent. from day to day, and operating experience suggests that similar wide changes occur in the fusion properties of the ash. The variations in furnace conditions are shown by the fact that the carbon dioxide had to be reduced to 9·6 per cent. during the tests shown in the tables, whereas the average for the month was 10·9 per cent.

CONCLUSIONS.

The authors consider that during the second half of 1951 Dunston "B" station was operated at or near its optimum efficiency of 29·7 per cent. One of the most successful features of the plant has been its flexibility in operation. Running up a machine and loading it has proved no more difficult than with a straight cycle and, if necessary, full load can be attained in a little over 1½ hours after a shut down of about five hours. Operating experience has shown that further economies in capital and operating expenditure could be obtained by omitting the partition wall between the boiler and turbine, and by bringing the boiler and turbine control points closer together. Where, however, wide variations in the properties of the fuel are to be expected, the boiler furnace demands closer attention than can be given from a remote operating room. Most of the shorter outages—which aggregated an appreciable amount—occurred because the detail design or workmanship of pipe joints was not up to the required standard. For instance, owing to the manufacturing situation flanged valves had to be accepted instead of those with welded ends. There is also a pressing need for more attention to detail in making the joints and in pulling up the bolts of such high-pressure bolted joints as have to be used.

The owners considered high availability to be so vital to success that they began to brief the engineers who were to operate and maintain the plant almost as soon as the orders were placed. Unitisation cannot, in fact, be fully successful unless all parties, including the manufacturers, realise that they have undertaken and make the necessary changes in their established practice. The conclusions to be drawn from the performance figures are that unitised generating plant can be controlled so closely that test conditions and test performance can be realised in commercial practice.

SIZE DISTRIBUTION AS A QUALITY FACTOR OF BLAST-FURNACE COKE.*

By J. TAYLOR and J. D. GILCHRIST.

(Concluded from page 807.)

ATTEMPTED CORRELATION WITH FURNACE PERFORMANCE.

FROM the point of view of furnace performance it is more desirable to be able to characterise the size distribution in the simplest way than to attempt to isolate the factors which contribute to that distribution. Since the size distributions are all of the same type, any method of determining mean size may be used for comparison purposes. The simplest empirical method of characterising the spread is to give the ratio of screen sizes between which say 5 per cent. and 95 per cent. of the material is retained. A slight modification of the latter which seemed to offer certain advantages was to adopt a certain standard size ratio and record the percentage of undersize material outside this ratio as "fines." For the majority of cokes in this country the problem is one of excess fines rather than excess of large coke and the method proposed has the advantage of expressing spread in terms of that excess.

The method then was to plot the screen analysis on the special Rosin-Rammler graph paper, read off from the straight-line portion the screen size at which 5 per cent. is retained and divide this by the chosen size ratio. This gives the lower screen size and the percentage passing this screen size is expressed as fines. A standard ratio of 4·0 was chosen as representing a quality which was approached but not surpassed within our experience. In this case the Rosin-Rammler relation is used purely and simply as a tool, a convenient means of arriving at the 5 per cent. retained screen size by extrapolation. The lower screen size was often off the linear portion of the graph but that was of little consequence since close screening at the small sizes is easy and there is therefore no difficulty in interpolation. It will be observed that this method of characterising spread is similar to that commonly used in which the percentage of material below an arbitrary-chosen screen size, usually 1 in., is described as fines or breeze. Here the screen size is related to the size distribution of the coke. Because so many cokes are similar in size, the practical difference is usually small but the method does allow for the occasional coke which differs rather markedly from the normal in size. The data given in Table I, page 806, *ante*, are repeated in Table III on the new basis.

TABLE III.

Coke.	Sampling Position.	Mean Size, in.	"Fines,"* per cent.	Lower Screen Size of S.S.R.*
A_1	Grizzly ..	2·95	5·0	1·1
	B.F. bin ..	2·35	7·6	0·85
	Drum test..	2·30	8·5	0·9
A_2	Grizzly ..	2·75	11·0	1·1
	Drum test..	2·25	17·5	0·95
A_3	Grizzly ..	2·4	6·5	0·92
	Drum test..	1·9	11·5	0·75
B	Grizzly ..	2·9	4·0	1·05
	B.F. bin ..	2·35	9·5	0·9
	Drum test..	2·35	8·0	0·85
C	Grizzly ..	2·55	2·0	0·85
	B.F. bin ..	2·3	—	—
	Drum test..	2·3	6·0	0·8
D	Grizzly ..	3·1	2·0	1·0
	B.F. bin ..	2·6	8·0	1·0
	Drum test..	2·6	7·5	0·9
E	Grizzly ..	3·35	9·0	1·2
	B.F. bin ..	2·9	9·5	1·0
	Drum test..	2·9	10·5	1·05
F	Grizzly ..	3·05	3·3	0·5
	B.F. bin ..	2·75	3·1	3·1

* Fines are as defined in the paper, i.e., the percentage of undersize material outside the sizes included in the standard size ratio (S.S.R.).

The hope was entertained for a time that the correlation could be attempted through controlled experiments. A modern blast furnace, however, consumes an enormous tonnage of coke and the hope was not realised. Failing this, the normal fluctuations of furnace performance had to be accepted. There was also the comparison of the results of different furnaces but the variables introduced by different furnaces, raw materials, etc., were so complex as almost to rule out this line of approach. Two furnaces of identical dimensions and virtually identical operating conditions, however, were available, and it was considered that comparative data on these might yield useful information. Tests were run over a period of from four to five weeks on two separate occasions at these two plants. The periods may seem short but, even so, the work involved made a severe call on the sampling and testing facilities of the plants concerned. Great stress was laid on the sampling procedure as inadequate samples could vitiate the whole test. Also since regularity of quality could be an important factor, frequent samples were desired. The procedure followed was to take shift samples, each sample consisting of six increments each of about 50 lb. The sampling point was on the belt immediately after the grizzly, this being considered the most convenient and reliable position. Full screening analyses, down to ¼ in. size, were carried out and then the appropriate drum test performed on charges made up in aliquot propor-

* Read before the West of Scotland Iron and Steel Institute on Friday, October 24, 1952. Abridged.

SIZE DISTRIBUTION OF BLAST-FURNACE COKE.

Fig. 3. VALUE OF FINES ON COKE "A_1" ON SUCCESSIVE SHIFT SAMPLES.

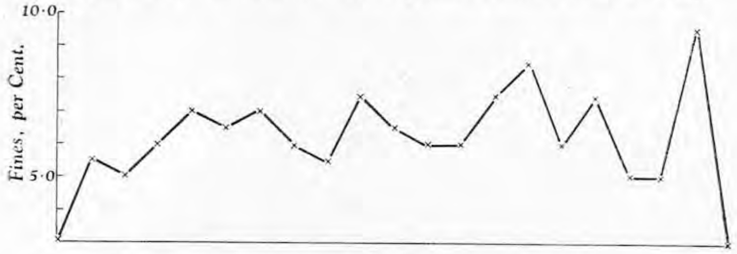


Fig. 5. VALUE OF FINES ON COKE "D" ON SUCCESSIVE SHIFT SAMPLES.

Fig. 4. VALUE OF MEAN SIZE ON COKE "A_1" ON SUCCESSIVE SHIFT SAMPLES.

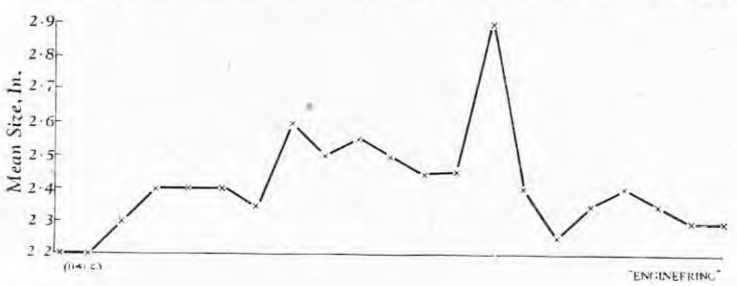


Fig. 6. VALUE OF MEAN SIZE ON COKE "D" ON SUCCESSIVE SHIFT SAMPLES.

Fig. 7. FREQUENCY DISTRIBUTION OF MEAN SIZE ON SHIFT SAMPLES AT OVENS.

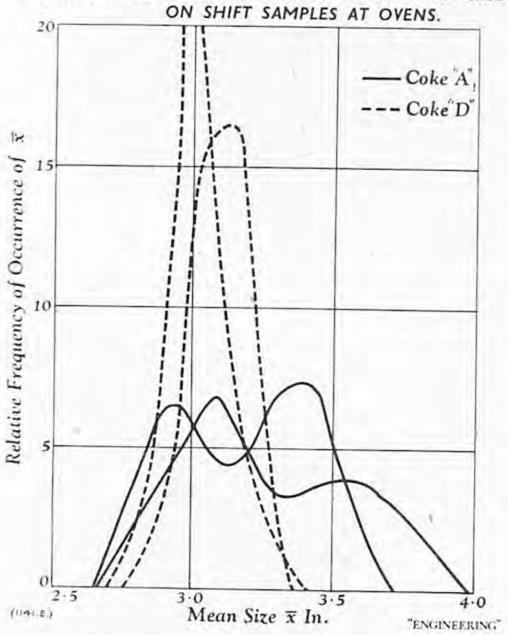
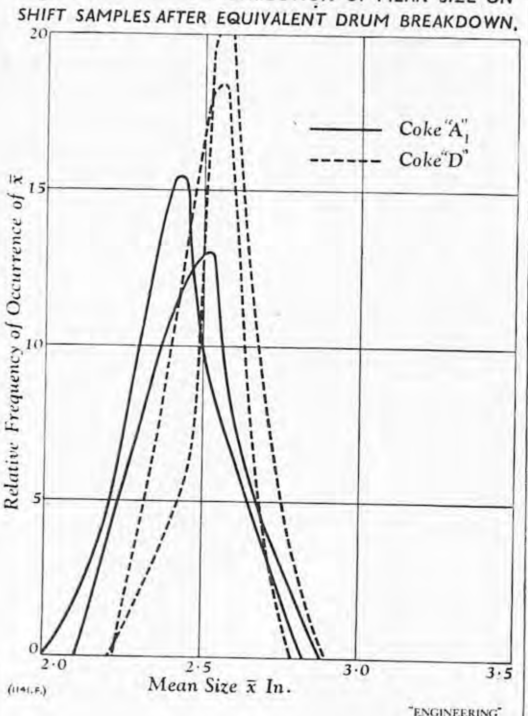


Fig. 8. FREQUENCY DISTRIBUTION OF MEAN SIZE ON SHIFT SAMPLES AFTER EQUIVALENT DRUM BREAKDOWN.



tions of the various sizes. The size grading of the product was that to be expected after the blast-furnace bin. Direct sampling at the bin was ruled out on account of the physical difficulties of sampling there and the care necessary to ensure reliable samples. At each plant, however, it was possible on a separate occasion to have bin samples taken over a period of one week and these results confirmed those obtained above.

The ore : coke ratio was chosen as the measure of furnace efficiency. A period of one week was considered the minimum for which figures were reliable. These are given in Table IV together with the average weekly values for the coke tests. Both furnaces operated most consistently during the test periods except during part of the first test at plant A when other factors caused a change. Under these circumstances no positive correlation with furnace performance was possible: only the negative conclusion could be drawn, that the observed variations in coke quality were insufficient to affect furnace operation. This does not preclude the possibility that a wider range of variation might have an effect. Although the range of the average values shown in Table IV is small, the shift values are, of course, much more variable. These are illustrated in Figs. 3 to 6, on this page, for a short period at each plant. Figs. 3 and 4 show the values of mean size and fines for coke A_1, after equivalent drum breakdown on successive shift samples. Figs. 5 and 6 show these values for coke D. The values are a measure of the regularity of coke quality which itself could possibly be a factor in furnace performance. The graphs showed, however, that the consistency of the size characteristics varied little from week to week.

Turning now to a comparison of the two furnaces referred to in Table IV. There arises the question of the assessment of performance, which is a vexed one, even for conditions so nearly identical as those represented here. Since operation was so very regular in each case, it sufficed to obtain a valid basis of comparison for any typical operating period. Fortunately, complete thermal and materials balances have been carried out in each for the one-week periods indicated in Table IV, so that comprehensive data were available on which to base a comparison. Consideration of these data showed that, because of the similarity in conditions, the performance could be fairly compared on the basis of the carbon rates and top-gas $CO:CO_2$ ratios. These are shown in Table V. Again we are faced with a difference so small as to be of uncertain significance. If the coke-quality factors given in Table IV are considered, there is nothing to choose between the two cokes. At plant A the mean size was greater over the greater part of the test period, but this dropped to the same value as for coke D after a change in the handling system without any apparent effect on furnace operation. The only factor which might possibly correlate with the slight but probably significant difference in operation is the regularity factor. This is best illustrated by mean size/frequency curves. These are shown in Figs. 7 and 8, on this page, for the shift samples of the two main test periods. Fig. 7 shows the frequency distribution of mean size on shift samples at the coke ovens and Fig. 8 the frequency distribution of mean size on shift samples after equivalent drum breakdown. From these it can be seen that, at the coke-oven de-breezing screen, the mean size of coke D is much more consistent than coke A_1 but much of this difference is eliminated after breakdown in the handling system. This leaves no more than the possibility that consistency of size grading is a factor in coke quality. Typical shatter indices for the two cokes have been given in Table II, on page 807, *ante*. Here again

TABLE IV.

Period, Week Ending	Coke After Drum Test.		Furnace Performance, Ore/Coke Ratio.
	Mean Size, in.	Fines, per cent.	
Plant A.			
8.1.49	2·42	8·8	1·74
15.1.49	2·34	8·6	1·79
5.2.49	2·50	9·6	1·86
19.4.49	2·42	6·4	1·87
26.4.49	2·39	7·2	1·91
3.4.49	2·59	6·6	1·88
10.4.49	2·46	7·4	1·94
Plant D.			
29.1.49	2·47	8·7	2·36
5.2.49	2·47	8·1	2·43
12.2.49	2·60	8·1	2·42
19.2.49	2·57	7·3	2·41
26.2.49	2·55	7·3	2·42
21.8.49	2·67	7·8	2·48
28.8.49	2·58	7·5	2·45
4.9.49	2·70	6·2	2·45
11.9.49	2·70	5·7	2·44
18.9.49	2·66	5·9	2·48
B.F. Bin Sample. Plant A.			
2.4.48	2·45	6·5	1·94
Plant D.			
20.6.50	2·4	5·7	2·44

Note.—The amount of breeze screened out after the blast-furnace bin was about the same at each plant, namely, from 3·5 to 4·0 per cent.

TABLE V.

Coke.	Carbon Rate.	$CO:CO_2$ Ratio.
	Cwt. per ton of Pig.	
A_1	12·5	2·34
D	12·8	2·45

there is nothing to indicate any marked difference between the two cokes.

The lack of positive conclusions was disappointing, not least by reason of the work involved even in such limited trials. Nevertheless, the investigation appeared worth recording for two reasons, namely, the data accumulated on a wide slection of cokes and a fuller appreciation of the problem of the correlation of coke quality and furnace efficiency. The cokes examined were from every major coking area in the country and while the mean size varied considerably there was less variation in the dispersion factor than had been anticipated. If small changes in the dispersion factor are not reflected in blast-furnace performance it follows that, for a large number of cokes, it is not an important variable, i.e., for comparative purposes. If small changes are important, large samples are absolutely essential in order to obtain accurate values. On the whole, the data relating to furnaces A and D tend to support the former view. This must not be taken to imply that close sizing is not important; that is accepted. Nor is the fact overlooked that there are cokes with dispersion values much worse than that of the major group which would certainly be expected to give poor results in the blast furnace. It is only suggested that for many British cokes the values are so similar that it is not an important factor in comparing those cokes for blast-furnace use.

ANNUALS AND REFERENCE BOOKS.

Mechanical World Year Book, 1953.

Emmott and Company, Limited, 31 King-street West, Manchester 3. [Price 3*s*. 6*d*. net.]

A NEW chapter on spring design, contributed by Dr. W. R. Berry, M.Sc., M.I.Mech.E., is the chief feature of the latest edition of this hand-book. It deals almost wholly with statically-loaded springs, for the design of which Dr. Berry gives a number of charts and—in a book of this size—comparatively full information. He covers ferrous and non-ferrous materials suitable for springs, and the design of tension and compression springs made of round wire, rectangular-section compression springs, helical torsion springs and flat springs. The rest of the book contains the customary sections on, for example, inventions and patents, gas-turbines, machine tools, mechanical press work, plastics, gears, and light alloys. There is also a number of useful tables of weights and measures, screw threads, tolerances and fits, physical properties of materials, etc.

Who's Who in the Motor Industry.

Compiled by ROLAND C. BELLAMY, A.M.I.Mech.E. and CYRUS ANDREWS. Roland C. Bellamy Publications, Saint Mary's Gate, Grimsby, Lincolnshire. [Price 27*s*. 6*d*.]

To embark upon the production of what is, in effect, a directory of the motor-car industry is an undertaking requiring courage as well as a capacity for close application. It may be that others have felt the desirability of such a compilation, but have shrunk from the task of making and publishing it; but now that it is available, assuredly the industry should be grateful and should see to it that the venture does not languish for want of support. The main sections are those containing particulars of firms, with the names of their principal executives; individual biographies, to the number of well over 2,500; associations and professional institutions; and the Press, both national and specialised, dealing with the motor-car industry and its associated industries. Other sections, possibly interesting rather than positively significant, are those listing the "biographies" according to the schools from which they emerged, and biographical details about "motor journalists, editors, etc." The book is a valuable addition to the ranks of current reference works.

Fire Protection Year Book, 1953.

Compiled by GEOFFREY F. D. PRATT. Thirteenth edition. Benn Brothers, Limited, Bouverie House, Fleet-street, London, E.C.4. [Price 12*s*. 6*d*., post free].

As was the case with previous editions, the subject matter in this now well-known *Year Book* is divided into a number of comprehensive sections, each dealing with a particular phase of fire fighting or fire protection. The present, 13th edition, contains eight such sections, the first constituting a directory of all the public fire services in the British Isles, and the second a directory of salvage corps and industrial and private fire brigades in the United Kingdom. The third section relates to fire services of the Commonwealth and Empire, and the fourth deals with Government departments concerned with fire protection and fire engineering. Section V contains particulars of associations, institutions and societies interested in, or actively connected with, fire fighting and fire prevention, while the last three sections are encyclopædic in nature. Section VI deals with "Fire Brigades, Fire Protection and the Law," and Section VII with "Civil Defence," and both are by Mr. Peter Pain, M.A., barrister-at-law. Section VIII which is concerned with fire-engineering data, has been revised by Mr. Wallace E. Whitehouse, M.B.E., M.Sc., Hon.M.I.Fire. E. The *Year Book* ends with a desk diary and includes also lists of suppliers of fire service and safety equipment, a classified directory of such equipment, and one of trade names.

F.B.I Register of British Manufacturers, 1952-53.

Published for the FEDERATION OF BRITISH INDUSTRIES, 21, Tothill-street, London, S.W.1, by Kelly's Directories, Limited, 186, Strand, London, W.C.2, and Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42*s*. including postage.]

THIS is the 25th edition of the *F.B.I. Register*, though, as it was not published during the war, its usefulness to British industry and commerce, and to those of overseas countries also, extends over a longer period than the quarter-century. The format that has proved so satisfactory in the past is retained, as is the arrangement of the contents. The principal feature is a classified Buyers' Guide in which over 6,000 member firms of the Federation are listed under more than 5,000 alphabetical trade headings. The introductory information, and instructions on how to use the *Register*, are given in French and Spanish as well as English. The addresses, telephone numbers, etc., of the member firms are given in full in the Addresses Section, together with a brief indication of their more important manufactures. Another section of the *Register* gives particulars of trade associations, and others deal with brand and trade names and with trade marks. Each section is provided with a projecting guide tab, to facilitate quick reference.

COURSES IN HIGHER TECHNOLOGY.—The London and Home Counties Regional Advisory Council for Higher Technological Education have issued Part II of their *Bulletin of Special Courses in Higher Technology*, 1952-53, giving particulars of advanced courses available in the spring and summer of 1953 at technical colleges in London and the Home Counties, and schools of the University of London. Copies may be obtained from the secretary, Regional Advisory Council, Tavistock House South, Tavistock-square, London, W.C.1, price 1*s*. 6*d*., post free.

TRADE PUBLICATIONS.

Heavy-Duty Fans.—Keith Blackman, Ltd., Mill Mead-road, Tottenham, London, N.17, have sent us a copy of publication No. 25, illustrating their Tornado fans. More than 40 fans and installations are described.

Lubricating and Cutting Oils.—We have received from Marine and Industrial Lubricants, Ltd., Algeria House, Bury-street, London, E.C.3, an illustrated brochure describing the production and application of Morola lubricating and cutting oils, and containing tables of data on oils and greases and recommended grades for particular engines.

Flight-Refuelling Equipment.—We have received from Flight Refuelling Ltd., Tarrant Rushton Airfield, Blandford, Dorset, a brochure describing their flight-refuelling equipment and giving details of the components used, some of which are applicable also to other purposes.

Metal Fixings for Insulating Boards.—The Metal Fixing Association, 32, Queen Anne-street, Cavendish-square, W.1, have issued a code of practice and manual for lightweight metal fixing systems for building linings and ceilings.

Builders' Plant.—George Pike, Limited, Equipment Works, Alma-street, Birmingham, 6, have sent us a catalogue, No. 52, of road signs, lighting sets, roadmen's huts, barrows, pumps, pulley blocks, shovels, rakes, etc.

Winding Wires.—British Insulated Callender's Cables Ltd., Norfolk-street, London, W.C.2, have sent us a publication dealing with the manufacture and properties of their "Bicalex" winding wires, which are insulated with a synthetic enamel of the vinyl acetal base type.

Electric Cables.—A pamphlet received from British Insulated Callender's Cables Ltd., Norfolk-street, London, W.C.2, deals with their "Bestos" A.V.C. (asbestos varnished cambric) cables, which permit conductor temperatures up to 85 deg. C. to be sustained.

Thread-Rolling Machine.—The Adam Machine Tool Co., Acme Works, Waverley-road, St. Albans, Herts, have published an illustrated booklet describing a hydraulic thread-rolling machine manufactured by Thommens Watch Company, Waldenburg, Switzerland, for whom they are sole distributors in the United Kingdom. The machine, for production work, will handle pieces up to 48 mm. in diameter.

Motor-Control Equipment.—A booklet giving particulars of the standard contactor-type starters and special assemblies which they manufacture for the control of machine tools has been published by Allen West & Co., Ltd., Brighton, 7.

Street-Lighting Control Switch.—A pamphlet describing the "Rhythmatic" control switch which they manufacture for the control of street lighting has been received from the Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7.

Machine Tools.—H.E.B. Machine Tools, Ltd., 5-17, Haverstock-hill, Chalk Farm, London, N.W.3, have published a number of illustrated catalogues and instruction manuals in respect of their production, tool-room and hydraulic copying lathes, as well as other machine tools. The company are the sole distributors in the United Kingdom and Commonwealth for machine tools constructed by H. Ernault-Batignolles, France.

Lighting Fittings.—We have received four illustrated broadsheets from Courtney, Pope (Electrical) Ltd., Amhurst Park Works, Tottenham, London, N.15, describing the lighting equipment they manufacture for commercial and industrial use. In particular, they describe fittings made for use in conjunction with Frenger ceiling panels.

Aluminium Casting Alloy.—Alar Ltd., a technical association of light-alloy refiners, 3, Albemarle-street, London, W.1, have sent us a data sheet describing the properties and characteristics of the low-expansion casting alloy for pistons to specification B.S. No. 1490 : LM-13.

END OF THE ONE HUNDRED AND SEVENTY-FOURTH VOLUME.