THE FANNICH SCHEME: NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

THE Fannich project of the North of Scotland Hydro-Electric Board, in the County of Ross and Cromarty, represents the first stage of the development of the Conon Basin, the catchment area of which is 350 sq. miles with an average annual rainfall of 75 in. When completed, this development will include power stations at Grudie Bridge (24 MW), Glascarnoch (24 MW), Achanalt (2 MW), Luichart (24 MW), and Torr Achilty (15 MW), as well as a further 18-MW station, which will form part of the Orrin project. The eventual installed capacity will be about 107 MW, with an annual output of 442 million kWh.

Loch Fannich, which is about 20 miles from Dingwall, is $6\frac{1}{2}$ miles long. It has a water area of $3\frac{1}{2}$ square miles, the present level of which is + 822 ft. O.D. This level will, however, be raised some 20 ft. at a later date by building a dam 1,500 ft. long and 20 ft. high across the eastern end of the loch thus enabling water to be utilised not only in the Grudie Bridge station, as at present, but in the Luichart and Torr Achilty stations. The catchment area which is being utilised in the Fannich project extends to some 55 square miles, and the ultimate capacity of the reservoir will be about 7,200 million cub. ft. The consulting engineers for the civil engineering portion of the scheme are Sir Alexander Gibb and Partners, Queen Anne's Lodge, London, S.W.1.

Water is taken from the loch through a tunnel about $3\frac{3}{4}$ miles to a portal and then through a valve house to the top of a pipe-line, which leads down to the 24-MW power station at Grudie Bridge, as shown in the longitudinal section reproduced in Fig. 14, Plate IV. Near the entrance to the tunnel from the loch is a concrete-lined gate shaft, 125 ft. deep, the design of which will be clear from Figs. 9, and 10, Plate III, and the superstructure of which is shown in course of construction in Fig. 13, Plate IV. As will be seen from these illustrations, both emergency and control gates are provided, the primary function of the former, which is shown in the raised position in Fig. 9, being to shut off the water so that the well can be emptied and the control gate inspected and maintained. This gate can, however, also be used to cut off the flow if the valve at the top of the pipe-line fails. As such an occurrence would necessitate the closing of the gate through a rapid flow of water, it is made of heavy weldless steel tubes, which are 14 in. in external diameter and extend throughout its height. The ends of these tubes are closed by cast Meehanite bearings with lubricated bushes, which rotate on fixed axles. These axles, which are 4 in. in diameter, are turned down at the ends and fit into side frames faced with Muntz metal. The tubes, therefore, serve as rollers to facilitate movement and as beams to carry the water load across the span of the opening. The gaps between the tubes are closed by 4-in. diameter steel-tube staunching bars on the upstream side, which are held loosely in position at the side frames. They make watertight contact with the main tubes when pressure is exerted and also participate in the rolling motion as the gate travels down the face of the opening.

When the gate is down the lowest main tube rests on a metal sill, the face of which is of Muntz metal, while the uppermost tube bears against a similar face on the lintel. The gap between the side frame of the gate and the roller path is staunched by a strip of Muntz metal, which seals the angle between the frame and the joint as the gate closes. The gate opening is framed by ribbed Meehanite castings to which the Muntz-metal sealing faces are attached. The gate is hoisted by a 20-h.p. motor through gearing at a speed of 4 ft. to 5 ft. per minute, although this operation can also be effected manually. It is lowered by its own weight at a speed up to 15 ft. to 20 ft. per minute under the control of a hand brake. An automatic centrifugal brake is also provided.

As will be seen from Fig. 9, Plate III, there is a control gate of the counter-balanced type downstream of the emergency gate. This gate consists of a facing of $\frac{5}{8}$-in. steel plate, which is supported at $16\frac{1}{4}$-in. intervals by horizontal 16-in. by 8-in. steel beams. The beams carry the water pressure load across the opening and are extended beyond the plating at each end into 16-in. by 6-in. steel posts, which bear the whole of the load. A rocking path of nickel cast iron, $6\frac{1}{2}$ in. wide, is attached to the end post and bears against a train of nickel cast-iron rollers, $7\frac{1}{2}$ in. wide by $7\frac{1}{2}$ in. diameter, which transmit the load to the side walls of the well through a second fixed and renewable roller path of nickel cast-iron. This path is attached to a machined face on the Meehanite roller groove through which the load is transmitted to the concrete.

The plating at the bottom of the gate extends below the lowest beam and is reinforced and machined so that it makes close contact with a Muntz metal bearing plate on the sill casting. Sealing is effected at the sides by strips of rubber fabric, which extend the full height of the gate and are held in place and protected by metal keeps. These strips rub against machined strips of Muntz metal, which extend the whole height of the side and guide frames and are forced home by hydraulic pressure when the gate closes. Staunching across the lintel is effected by a brass tube, which is retained loosely in a recess and is forced into contact with the gate and the lintel when a difference in pressure develops. In addition, a rubber seal is fixed to the upper part of the lintel casting next to the gate.

To obviate the hydraulic and pneumatic disturbances which tend to occur when the gate is opened under the full head of 112 ft. to fill the tunnel, a limit switch is fitted. This prevents the gate from lifting more than 12 in. until the tunnel has been filled and the water has risen high enough in the shaft for No-flote electrodes to operate the switch.

The gate is opened and closed by an electric winch, which is installed in the house at the top of the tower illustrated in Fig. 13, Plate IV. Hoisting is effected by a Renold chain which is attached to a counterweight, as shown in Fig. 9, Plate III, and passes over a sprocket on the winch to suspension rods on the gate. The chain is sufficiently long to enable the gate to be raised or lowered through its own height. The gate can also be removed completely by raising it a rod length at a time and then securing it while another grip is taken. When it is being raised, the gate bears against the rollers, which move freely on their paths at half its speed. At the top of each roller train is a pulley which is supported in the bight of the chain. One end of this chain is attached to the top of the gate and the other to the top of the groove some 25 ft. above the sill. The resulting two-to-one purchase ensures that the pulley travels at half the speed of the gate, that is at rolling speed, so that the trains remain suspended. Both the emergency and control gates were designed and constructed by Messrs. Glenfield and Kennedy, Limited, Kilmarnock.

Downstream and closely adjacent to the gate shaft is a screen shaft containing coarse and fine screens for the interception and removal of debris. The position of this shaft is indicated in Fig. 14, Plate IV, while its construction will be clear from Figs. 11 and 12, Plate III. Views of the superstructure of this shaft in which the hoisting machinery is housed, and of its interior, also appear in Figs. 1 and 2, respectively. The coarse screen, which has a span of 12 ft. $10\frac{1}{2}$ in. by 7 ft., consists of 6-in. by $\frac{3}{4}$-in. bars spaced at 6-in. centres. It is supported on a steel structure, below which is a debris sump 5 ft. deep. The fine screen, which is downstream of the coarse screen, is made up of panels of 3-in. by $\frac{1}{2}$-in. round-ended steel bars spaced at $3\frac{1}{16}$-in. centres and covers an opening of 12 ft. $10\frac{1}{2}$ in. by 14 ft. These panels are furnished with trays to catch any debris which may fall while they are being lifted. The screen itself, which weighs eight tons, is suspended by wire ropes, so that it can be raised by a 10-hp. motor into the gate house for cleaning. During this operation it is steadied by skids which run in metal guides. The screens were also designed and constructed by Messrs. Glenfield and Kennedy, Limited.

The mouth of the tunnel through which the water is conveyed to Grudie Bridge power station will be about 104 ft. below the ultimate raised surface of the loch, as shown in Fig. 8. For 470 ft. from this opening the tunnel is of horseshoe section with an equivalent diameter of 11 ft., and then merges into a short section with an equivalent diameter of 10 ft., and 230 ft. long, between the bottoms of the gate and screen shafts, as indicated in Figs. 14, 15, 16 and 17, Plate IV. It next passes via a transition into the main tunnel, which is also of horseshoe section with an equivalent diameter of 10 ft., as shown in Fig. 17. This portion of the tunnel runs to a transition length at the bottom of the surge

FIG. 1. SCREEN-SHAFT SUPERSTRUCTURE.

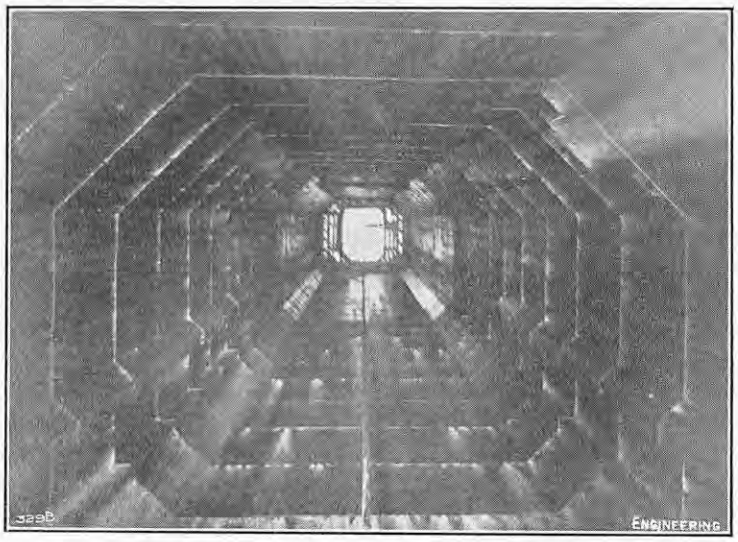


FIG. 2. INTERIOR OF SCREEN SHAFT.

THE FANNICH HYDRO-ELECTRIC SCHEME.

Fig. 3. SECTIONS OF TUNNEL AT ENDS AND THIRD POINTS OF TRANSITION

Fig. 4. SECTION ON C.L. OF TUNNEL

Fig. 5. SECTION EE

Fig. 6. SECTION FF

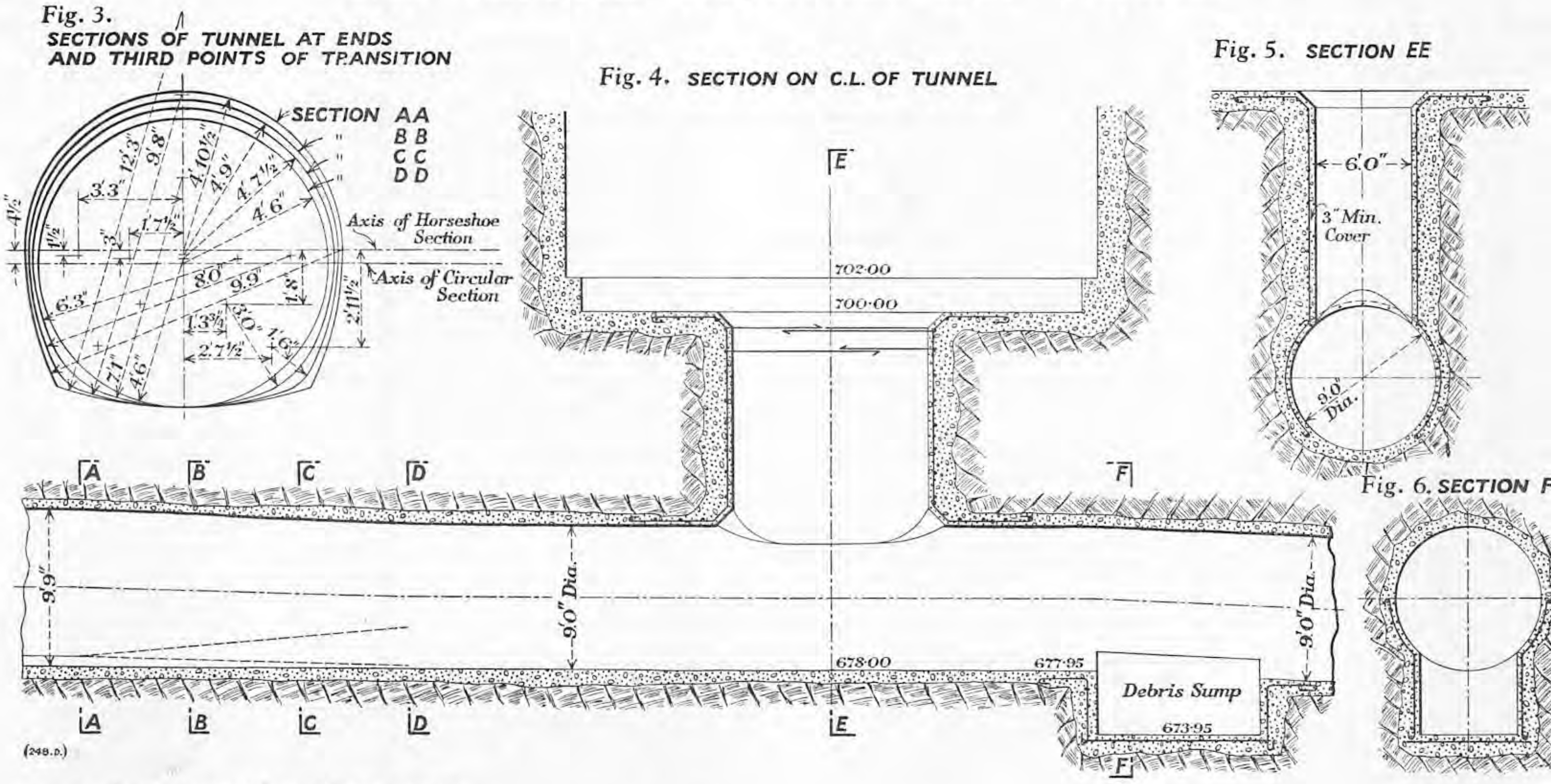


Fig. 7. SECTION THROUGH SURGE SHAFT

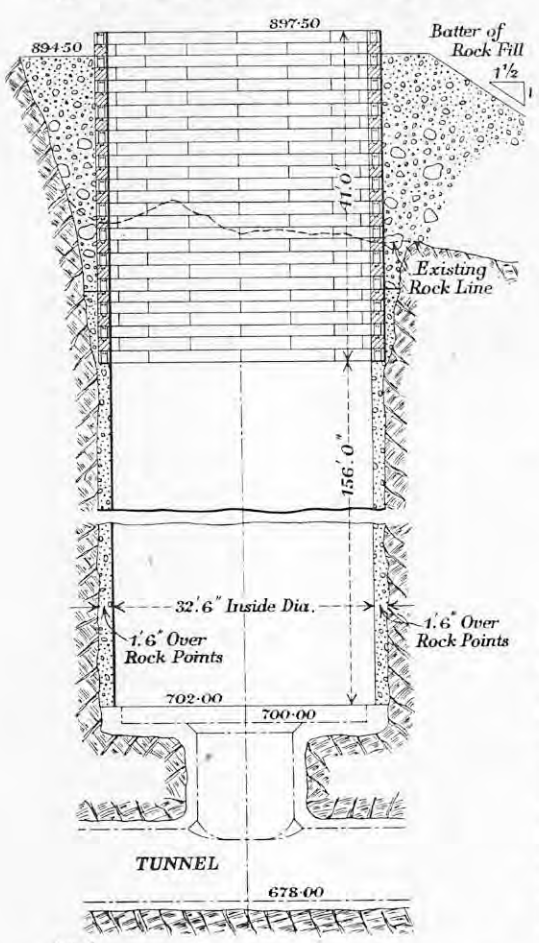
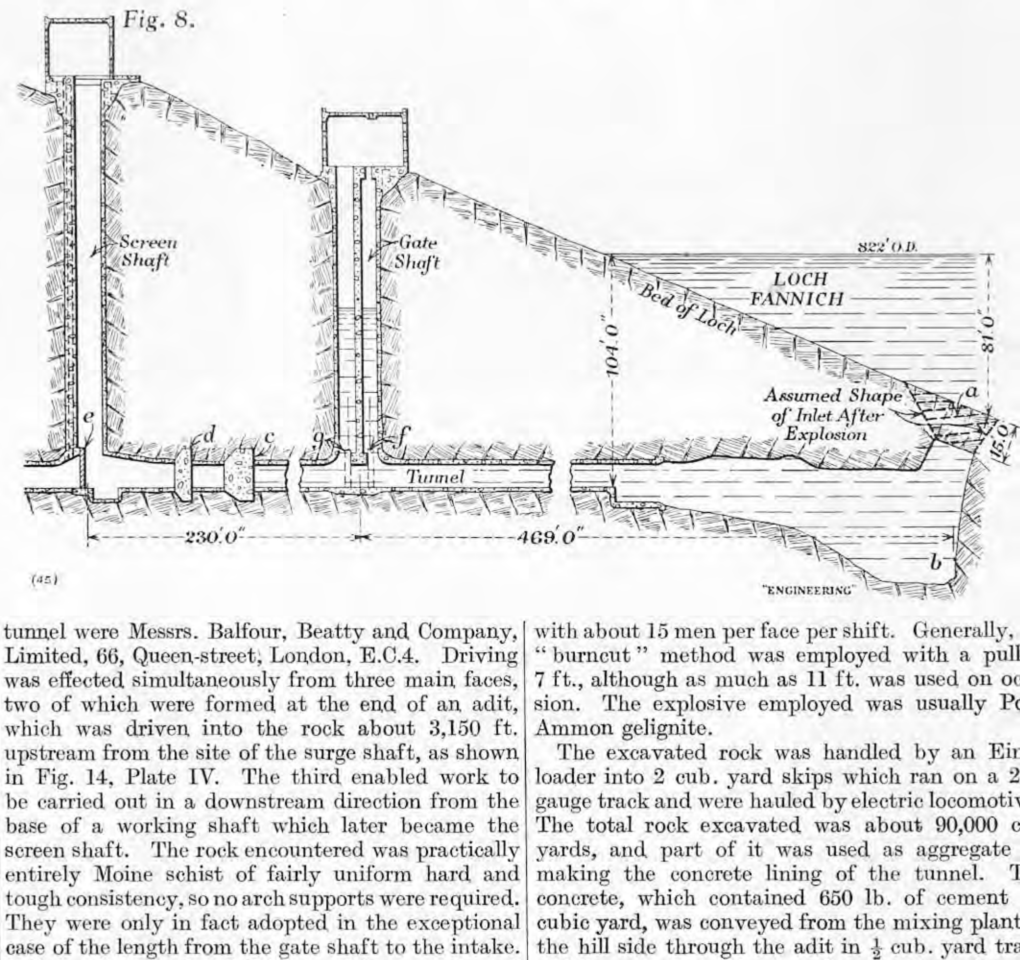


Fig. 8.



shaft, which is described later. From this point to the valve house at the top of the pipe-line, the tunnel, which is of circular section, is 9 ft. in diameter, as indicated in Fig. 18, Plate IV. The invert from the loch mouth to the bottom of the gate shaft lies on a rising gradient of 1 in 24, after which the tunnel falls on gradients between 1 in 355 and 1 in 311 to the base of the surge shaft. The short section of 9-ft. tunnel from the base of the surge shaft to the valve house is laid on a falling gradient of 1 in 21·7. The tunnel will take a flow of 760 cusecs.

The main contractors for the construction of the tunnel were Messrs. Balfour, Beatty and Company, Limited, 66, Queen-street, London, E.C.4. Driving was effected simultaneously from three main faces, two of which were formed at the end of an adit, which was driven into the rock about 3,150 ft. upstream from the site of the surge shaft, as shown in Fig. 14, Plate IV. The third enabled work to be carried out in a downstream direction from the base of a working shaft which later became the screen shaft. The rock encountered was practically entirely Moine schist of fairly uniform hard and tough consistency, so no arch supports were required. They were only in fact adopted in the exceptional case of the length from the gate shaft to the intake.

Generally speaking, full face working was adopted in the main tunnel to allow the concrete lining to be about half completed before the headings had been holed through. Drilling was effected from a jumbo by Ingersoll-Rand D.A. 35 drifters, using mainly forged carbide-steel bits. This jumbo, which was mounted on two bogies, and was made up of a tubular framework which also acted as an air receiver and distributor. It was fitted with side platforms, which were folded down for travelling and propped up when in use. It ran over a 2-ft. gauge track. Five drifters were used at each face, and the maximum footage excavated was 140 ft. a week, working 19 to 20 shifts with about 15 men per face per shift. Generally, the "burncut" method was employed with a pull of 7 ft., although as much as 11 ft. was used on occasion. The explosive employed was usually Polar Ammon gelignite.

The excavated rock was handled by an Eimco loader into 2 cub. yard skips which ran on a 2-ft. gauge track and were hauled by electric locomotives. The total rock excavated was about 90,000 cub. yards, and part of it was used as aggregate for making the concrete lining of the tunnel. This concrete, which contained 650 lb. of cement per cubic yard, was conveyed from the mixing plant on the hill side through the adit in ½ cub. yard trays, which were mounted on carriages so that when the train stopped opposite the shuttering there was one opposite each door. The sides of the trays were then lowered so that they rested horizontally on the platform, thus facilitating the shovelling of the concrete into the shutter. When the shutter had been filled to an intermediate level the doors were closed and the rest of the concrete was put in from the top. Immersion vibrators were used for consolidation. The concreting was carried out in four stages, two haunches first being cast along each side of the tunnel for carrying the shuttering. Next, the side walls and arch were completed with 70 ft. and 40 ft. shuttering, the trays during the

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(*For Description, see Page* 65.)

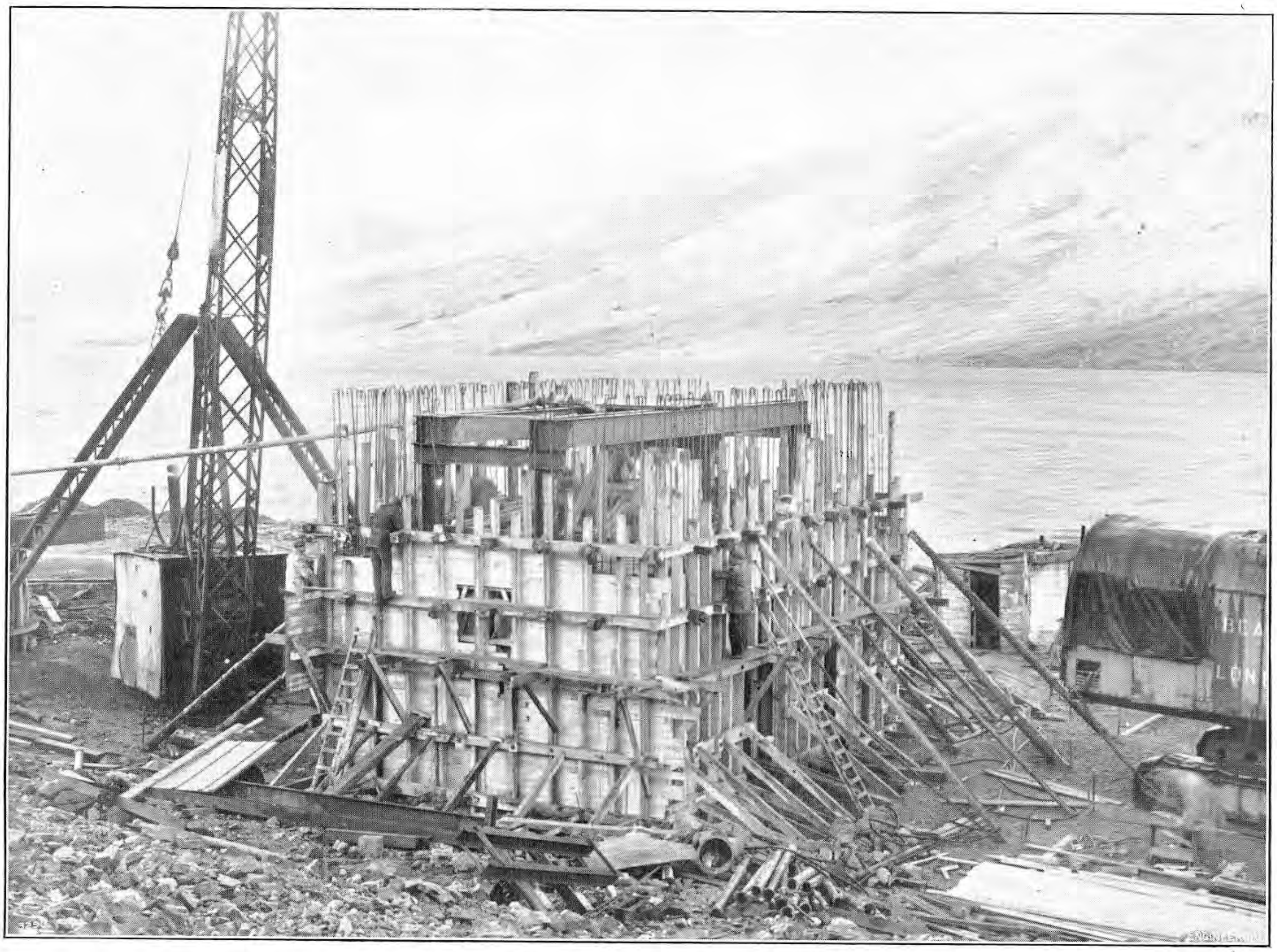


FIG. 13. GATE SHAFT SUPERSTRUCTURE UNDER CONSTRUCTION.

Fig. 14. **LONGITUDINAL SECTION THROUGH TUNNEL**

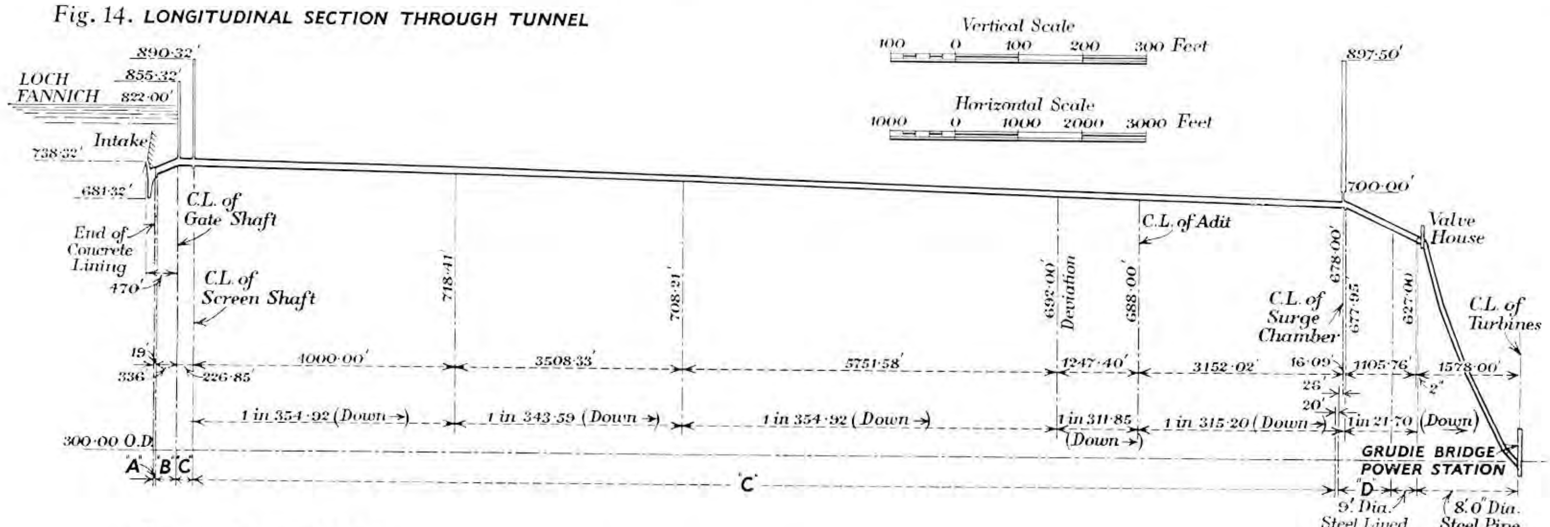


Fig. 15. **SECTION AT "A"**

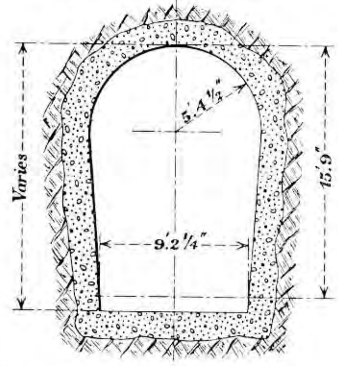


Fig. 16. **SECTION AT "B"**

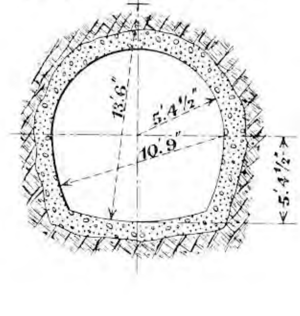


Fig. 17. **SECTION AT "C"**

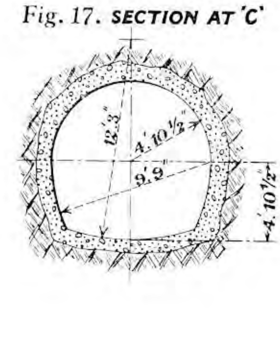
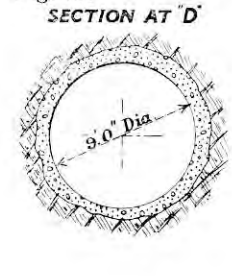


Fig. 18. **SECTION AT "D"**



(248.C.)

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(For Description, see Page 65.)

Fig. 9. VERTICAL SECTION THROUGH GATE SHAFT

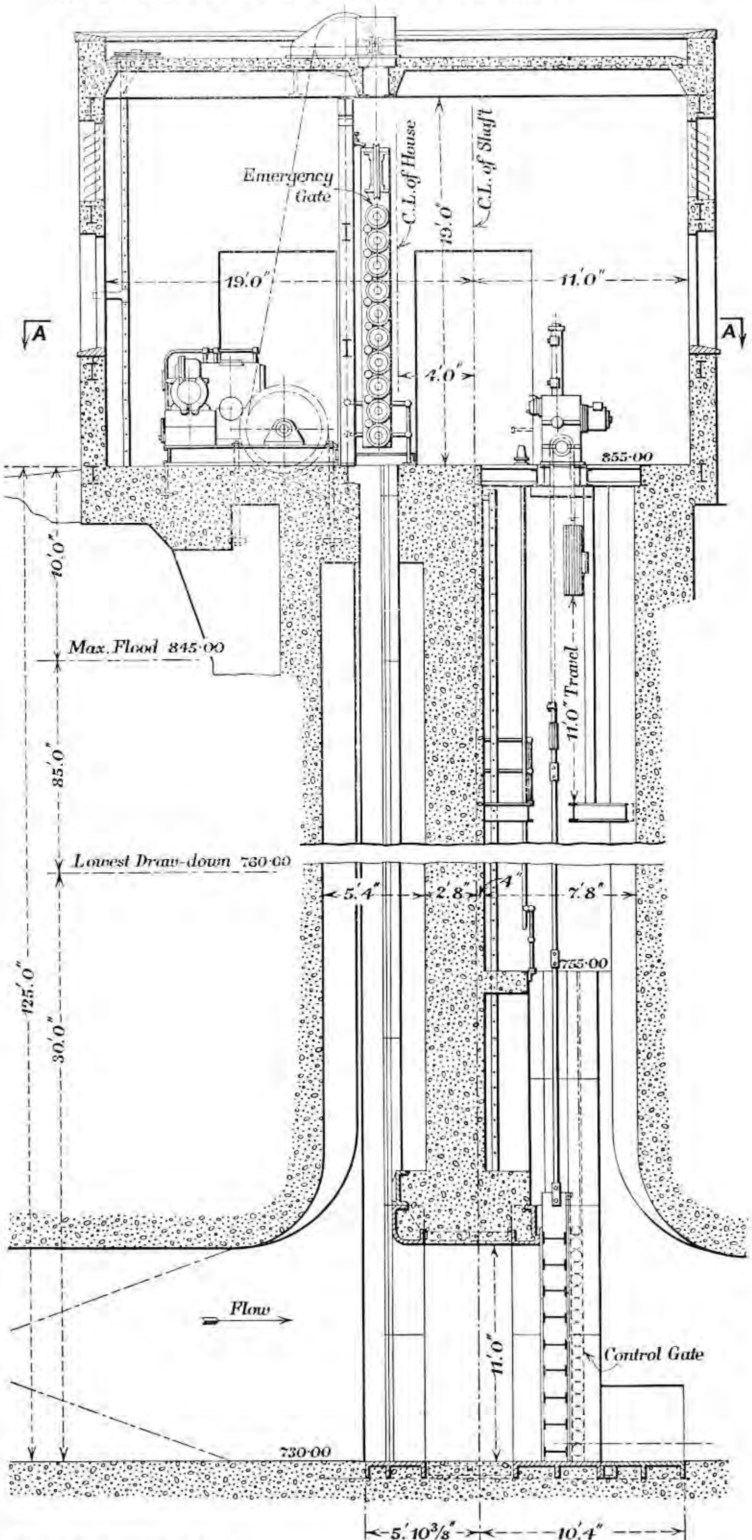


Fig. 11. VERTICAL SECTION THROUGH GEAR HOUSE AND SCREEN SHAFT

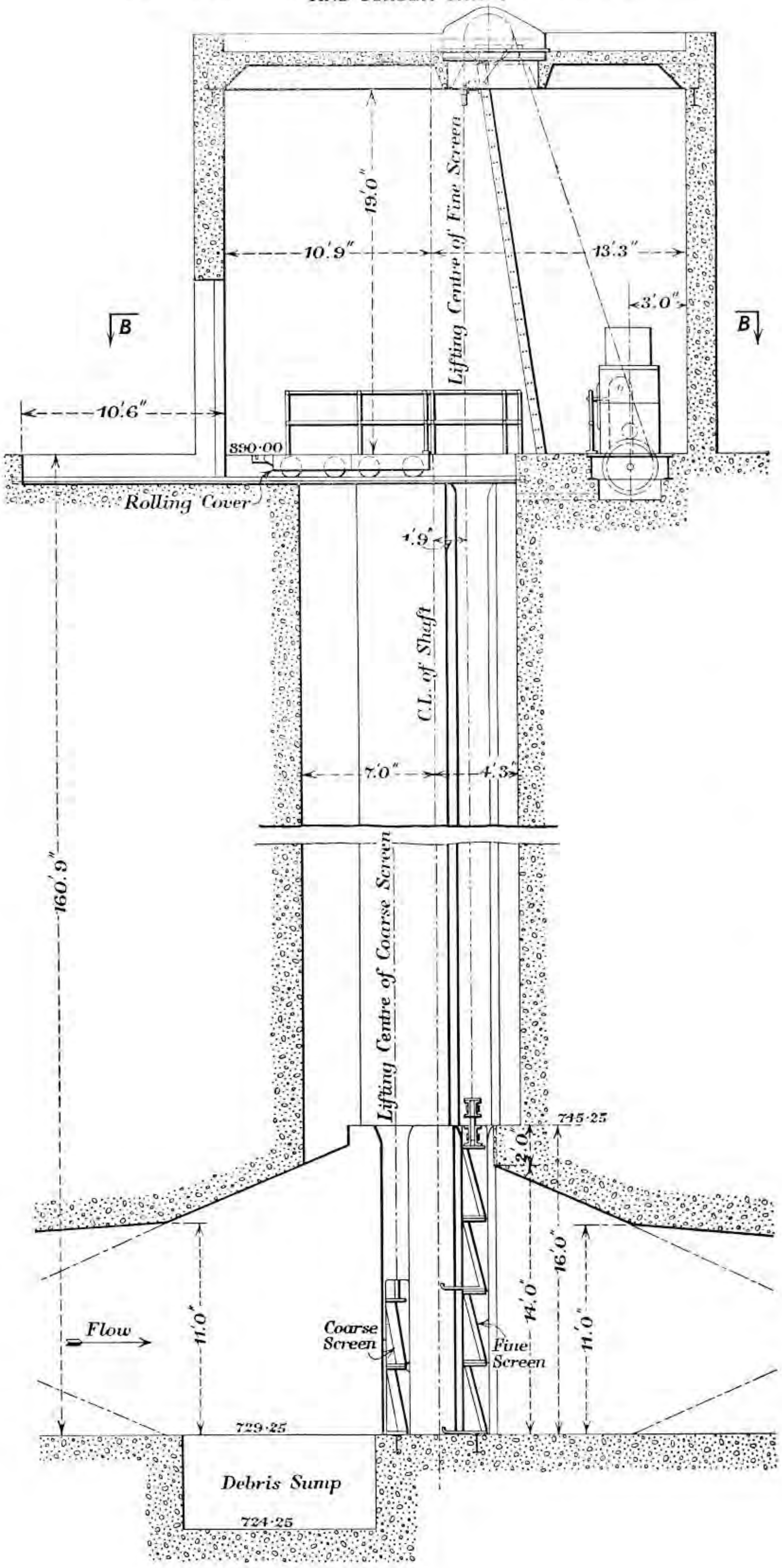


Fig. 10. SECTION AA

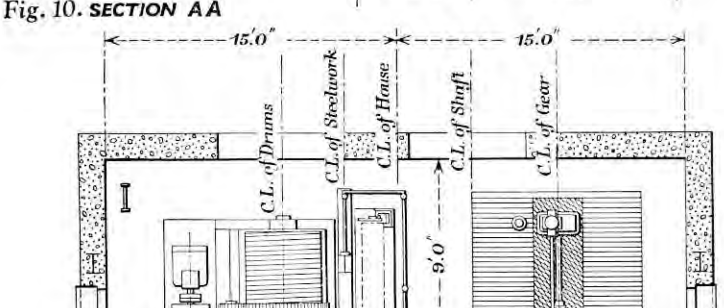
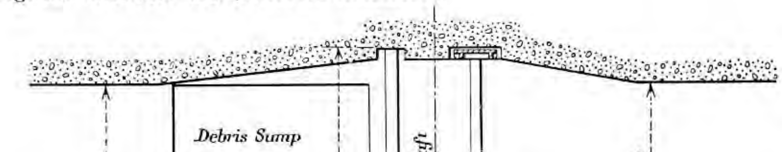


Fig. 12. SECTION BB (SCREENS REMOVED)



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THE FANNICH HYDRO-ELECTRIC SCHEME.

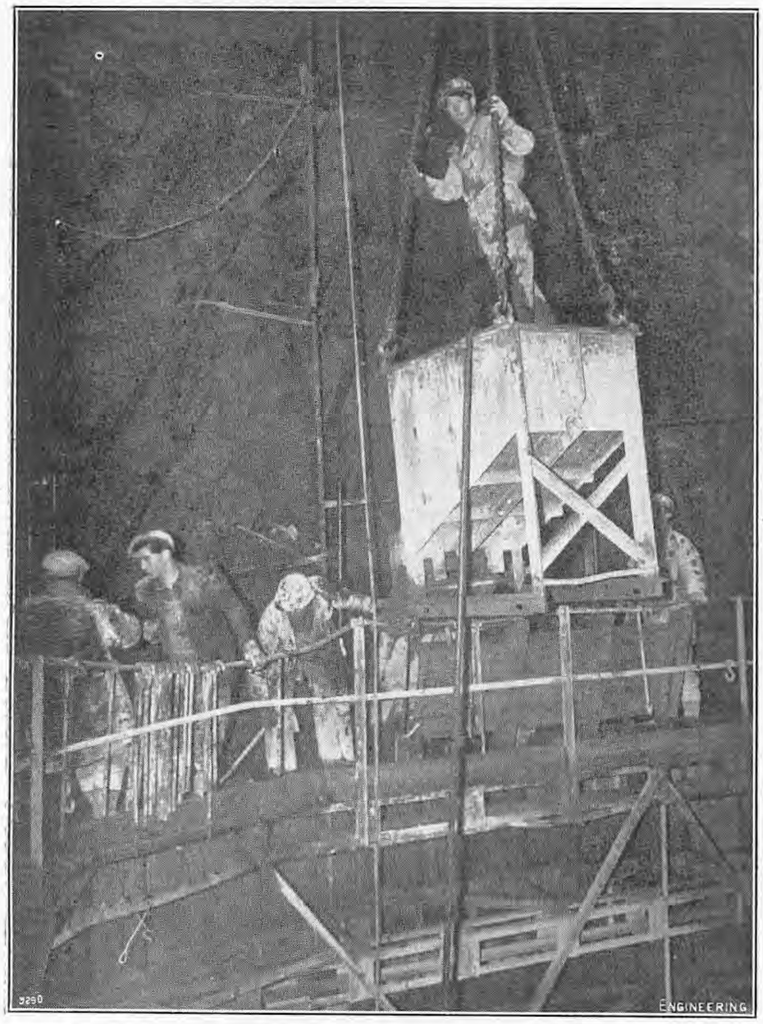


FIG. 19. CONCRETE SKIP AT SHUTTER IN SURGE SHAFT.

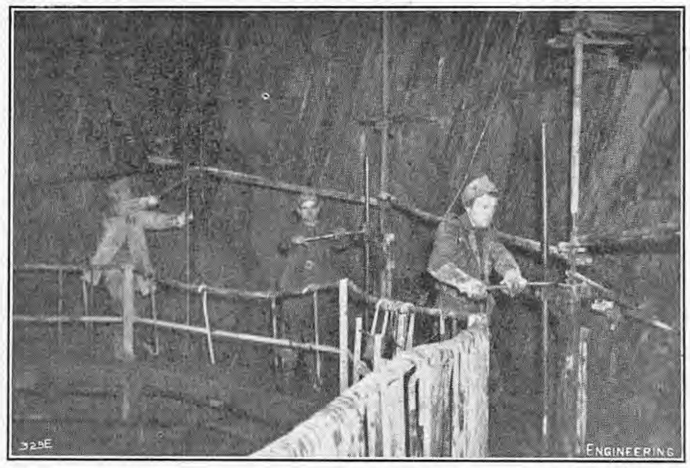


FIG. 20. JACKING-UP CONCRETE SHUTTER.

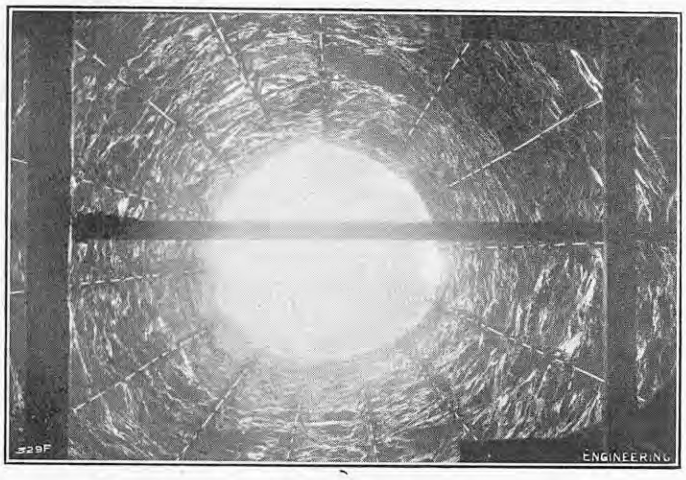


FIG. 21. SURGE-SHAFT SHUTTER JACKING RODS.

latter operation being mounted with their long axis perpendicular to the line of the tunnel. Finally, the invert concrete was placed. The 9-ft. circular tunnel and the steel-lined sections were concreted in 20-ft. lengths, the sides and arches being dealt with in one operation and a timber shutter being used.

The concrete for the section from the surge shaft to the exit portal was mixed in the tunnel and pumped into position, while at the end nearest the loch it was pumped down the gate shaft and then laid in place. After the concreting had been finished the tunnel lining was painted with bitumen, but this was not entirely successful, owing to the large amount of condensation preventing the bitumen from adhering. On the completion of the work the adit was sealed by a concrete plug in which access and drain pipes were inserted.

As the tunnel approaches the bottom of the surge shaft, the position of which is shown in Fig. 14, the 10-ft. equivalent horse-shoe section is reduced to a circular section of 9 ft. diameter. This reduction was effected in a series of four transitional profiles, which extend over a length of 20 ft., as shown in Fig. 3, opposite; the actual junction of the tunnel and surge shaft is shown in the sections reproduced in Figs. 4, 5 and 6. This shaft, which is 200 ft. deep and 32 ft. 6 in. in internal diameter is shown in Fig. 7. It was constructed by driving a 12-ft. by 6-ft. rectangular stope upwards from the tunnel for a distance of 154 ft. 6 in. A section of this stope, measuring 4 ft. by 4 ft., was then timbered out and provided with ladders; pipes for the water and compressed-air services were also laid. This vertical heading was excavated until it met a short shaft from the surface of the hill and was used for raising the tungsten-carbide drills, which were brought up by ponies, and the explosives from the tunnel floor. The remainder of the stope shaft was used as a muck hopper, the excavated material being released through a door at the bottom and taken away by tunnel skips. Subsequently, the stope itself was broken out and used to enlarge the surge shaft to its full diameter, the tunnellers retiring down the access compartment and closing a protective door before blasting took place. During this enlarging operation the rock excavated was also deposited down the stope shaft and conveyed through the adjacent adit to the spoil dump.

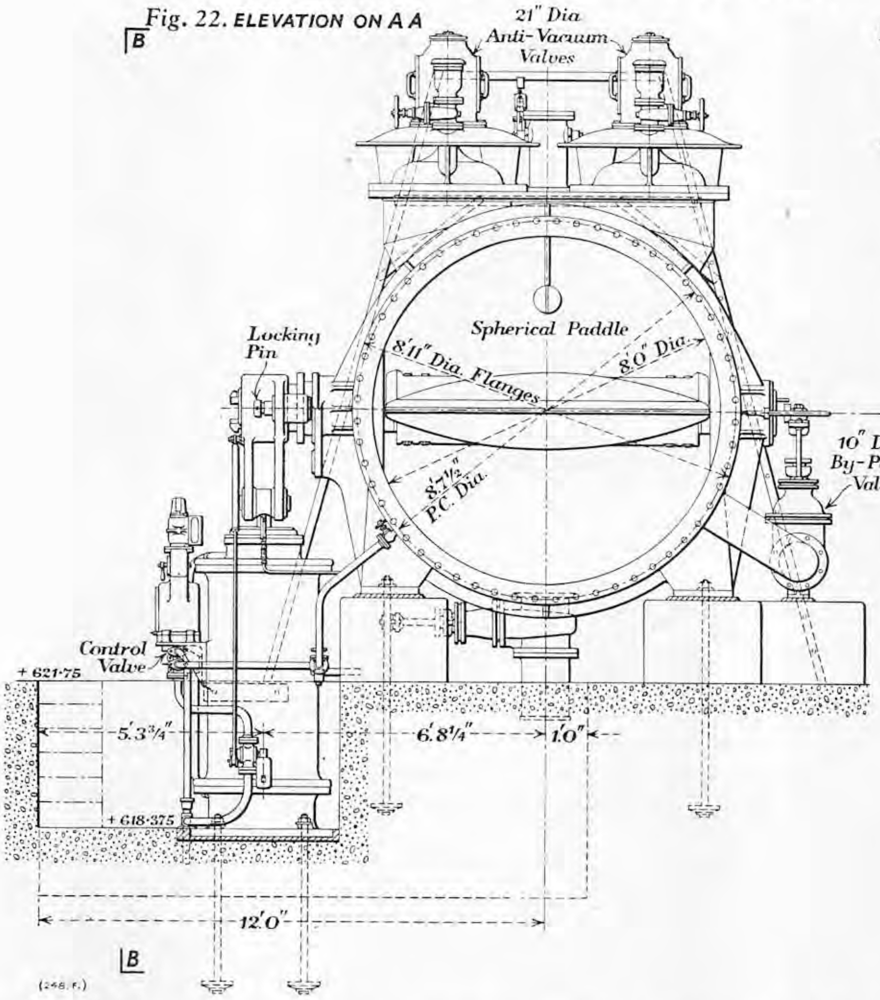
When the excavation had been finished the floor and throat of the surge chamber, a section through which is shown in Fig. 4, were completed and the shaft itself was lined with mass concrete to an average thickness of 2 ft. 6 in. up to 154 ft. above floor level, reinforcement only being used in places where loose rock was encountered. This work was carried out by erecting a climbing shutter, 6 ft. deep, which is illustrated in Fig. 19, on the step at the bottom of the shaft and supporting it by 14 $1\frac{1}{2}$-in. diameter rods placed at intervals of 5 ft. round the circumference of the shaft. Two dowels with fish-tailed ends were then driven into the rock and the fish-tail expanded to give a good grip. The rods were attached to the dowels by a collar and a strut inserted. As the concreting proceeded at a rate of about 8 ft. in 24 hours the collar was raised by 6 ft. long screw-jacks. A view of this shutter is given in Fig. 20, while the appearance of the jacking rods will be clear from Fig. 21. The concrete for lining the shaft was brought into the tunnel through the adit and hoisted through the throat at the bottom of the shaft by a small crane, which was erected on the step in the floor. From this point it was elevated in skips with a capacity of $\frac{3}{4}$ cub. yard. These skips were fitted with gates and chutes, so that the soft concrete could easily be delivered behind the shutter. This process was carried out continuously for 20 days, until the shaft widened out at 156 ft. above floor level and the shutters could be used no longer.

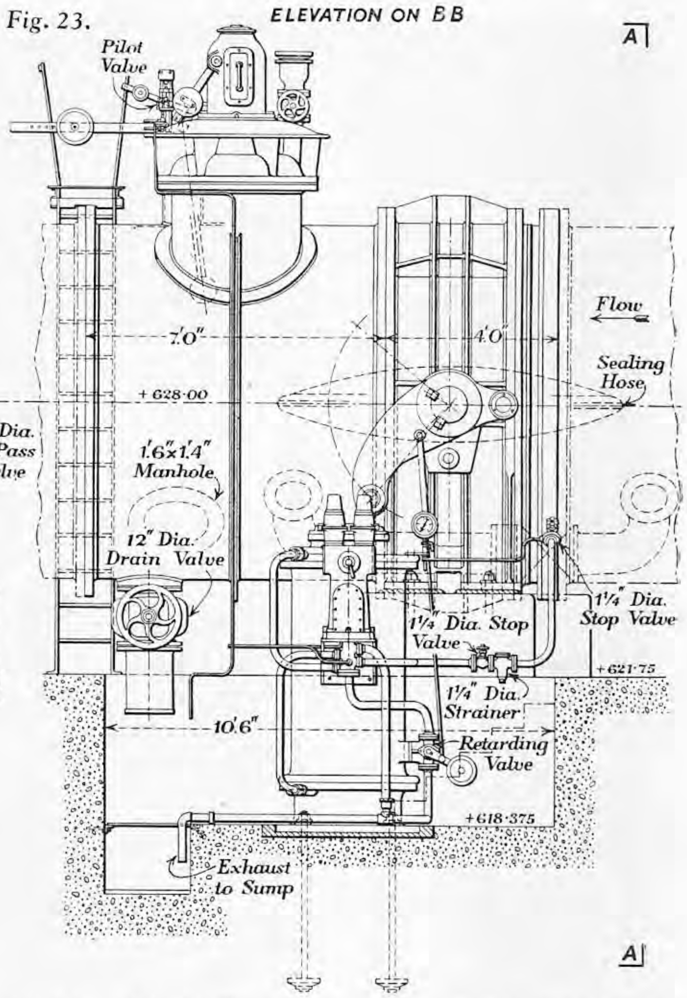
The lining above this level took the form of 27 rings of eight pre-cast concrete sections, each 18 in. deep, which were reinforced with rods in both directions and placed together to make a full circle, as indicated in Fig. 7. The voids were then filled in with concrete. This construction continued above the rock line into the open and was made up with rock on a batter of 1 in $1\frac{1}{2}$. The top of the shaft is open to the atmosphere and is sufficiently raised above the ground to act as a protective parapet.

The work of excavating the tunnel from the gate-shaft to the loch was continued until it had been completed with the exception of a rock plug 15 ft. thick which had been left between the roof of the tunnel and the loch. A detailed section of this portion of the work is given in Fig. 8, in which this plug is shown at *a* and a sump at *b*, which had been excavated to receive the 400 tons of debris which it was estimated would be loosened by the breaking-through explosion. At this place the tunnel (including the sump) is 45 ft. deep and 17 ft. wide and the sump capacity alone was sufficient for about twice the amount of material expected. The risk of any blockage was, therefore, small. While excavation was in progress loose material was scraped from the overlying bed of the loch, so as to expose the rock; and pilot holes were drilled which confirmed the survey that had previously been made. Over 100 holes, terminating 2 ft. from the bed, were drilled in the 15-ft. diameter plug and were loaded with a total of almost a ton of explosive. This work was carried out under the supervision of Imperial Chemical Industries, Limited, Buckingham Gate, London, S.W.1, special precautions being taken to ensure complete and instantaneous detonations of the charges.

In order to minimise the effect of the explosion on the tunnel structure and to prevent a dangerous in-rush of water, the length from the gate shaft to a position below the loch was filled with water. A negative head of 12 ft. was decided upon, based

THE FANNICH HYDRO-ELECTRIC SCHEME.





partly on previous model experiments and partly on judgment; and this assisted the fall of debris into the sump. The surge which followed the explosion confirmed that the 12-ft. negative head was about correct. Temporary concrete bulkheads, which are shown at *c* and *d* in Fig. 8, were also constructed to ensure that the water would not enter the main tunnel after the explosion. The first of these bulkheads was 13 ft. thick and contained 85 tons of concrete, while the second, which lay 36 ft. downstream, was 6½ ft. thick and was made of 40 tons of concrete. This arrangement was adopted to ensure that if the first bulkhead, which had to withstand an estimated pressure of 10,000 tons, was fractured, the second would prevent any flow of water into the main tunnel. As a further precaution, a third bulkhead, *e*, consisting of a gate of steel joists, was placed at the bottom of the screen shaft. After the explosion the control gate *f* and a temporary bulkhead were lowered to isolate the water of the loch from the tunnel and the water was pumped out of the downstream portion of the latter. Work was then begun on the demolition of the concrete bulkheads. Later, the main control gate *f* and the emergency gate *g* were installed, and the tunnel thus made ready for supplying water to the power station.

This method of connecting a tunnel to a reservoir has been little used, owing to the obvious risks involved, and it is a considerable engineering feat which is worthy of record. It may be recalled that a similar procedure was adopted at Loch Treig* in 1930, when the tunnel for supplying water to the power station of the British Aluminium Company at Fort William was being constructed. It is also a matter of interest that Messrs. Balfour, Beatty and Company were the contractors in both cases.

Returning to the main tunnel, it will be seen from Fig. 14, that the bottom of the surge shaft is connected to the downstream portal by a 9-ft. circular tunnel. This tunnel is of the same general construction as those of horse-shoe portion, except that the last 400 ft. are lined with ⅝-in. mild-steel plates. These plates are formed into 25 lengths, each of which is 16 ft. long, by bending two strakes to circular form and butt welding the circumferential and longitudinal joints. Each length was fitted with mild-steel rollers and this, together with welding the butt straps in the semi-circular halves to the adjacent pipe, facilitated the placing of the lining in position and the welding on site. During erection this steel lining was also fitted with internal "spiders" of mild steel placed 4 ft. apart, in order to keep it circular and to resist the forces exerted by the concrete which was packed between it and the rock.

At the tunnel portal the 9-ft. diameter lining is connected to the main pipe-line. This pipe is made of mild steel and extends for a distance of 67½ ft. in the course of which length a short taper reduces it to 8 ft. in diameter. It is then connected to a hydraulically-operated portal valve of the same diameter which, with its control and operating equipment, was supplied by Messrs. Glenfield and Kennedy, Limited, Kilmarnock. The valve assembly consists of a main valve of the butterfly type with which are associated a 10-in. hand-operated by-pass valve for filling the pipe-line preparatory to opening the main valve, and two 21-in. in diameter anti-vacuum valves, which allow air to enter or leave the pipe and thus provide for such contingencies as might necessitate an emergency closure of the portal valve. There is also a 12-in. drain sluice valve.

The arrangement of these valves will be clear from Figs. 22 and 23. The main valve is of welded steel construction and is designed with deep ribs to withstand a test pressure equivalent to a 470-ft. head. A gunmetal face is recessed into the valve body at the valve-door centre-line, and a reinforced rubber sealing hose is fitted to the periphery of the disc and makes contact with the gunmetal face when the valve is shut. The main shaft bearings are fitted with gunmetal bushes, the area of which is sufficient to give a low bearing pressure when the valve is operating against the maximum head. The bearings themselves are provided with Tecalemit pressure lubrication. The valve door is of high-tensile cast steel and is of double-convex streamline shape to minimise obstruction to the water flow and thus to reduce friction losses. The main shaft is of high-tensile nickel-chromium-molybdenum steel and is keyed to the door by taper pins. The control valve is of the balanced-piston type and is made of gunmetal. It is operated by a push-button in the turbine house which closes the circuit of a solenoid when it is desired to use it to close the main valve; local hand control is provided to open the main valve. A retarding valve, which is mechanically operated, slows down the rate at which the main valve closes and thus prevents dangerous surges in the pipe-line. There is also an over-velocity trip on top of the anti-vacuum valve pipe. This is operated by a spherical paddle in the main stream and in turn actuates a pilot valve which governs the main control valve. This mechanism is, therefore, independent of the electricity supply.

(*To be continued.*)

* See ENGINEERING, vol. 130, page 736 (1930).

NEW POWER STATIONS FOR THE B.E.A.: XV.—BLACKWALL POINT: ERRATUM.—We regret that, on page 692 of our issue of June 8, the address of Messrs. R. Dempster and Sons, Limited, who are supplying coal conveyors to the above power station, was incorrectly given; it should have been Rose Mount Iron Works, Elland, Yorkshire.

FORMATION OF COLEMAN WALLWORK CO., LTD.—Messrs. J. Stone and Company, Limited, Deptford, have purchased the Coleman Foundry Equipment Company, Limited, and have combined this business with their previously-owned subsidiary company, Stone-Wallwork, Limited, to form one organisation dealing with foundry equipment, namely, the Coleman Wallwork Company, Limited. The new company has the same management as was in charge of Stone-Wallwork, Limited, and the personnel and outside staffs will remain unchanged. The firm's offices, workshops, technical and research departments are centred at Windsor Works, Stotfold, Bedfordshire, and area offices will be opened at 157, Victoria-street, London, S.W.1, and 12, Bulldale-street, Glasgow, W.4.

THE JOINT ENGINEERING CONFERENCE, LONDON.

(*Continued from page 40.*)

THREE sessions of the Joint Engineering Conference, organised by the Institutions of Civil, Mechanical and Electrical Engineers, were held on Monday, June 11. The first of these was at the Institution of Civil Engineers, when a paper on "British Mechanical Road Transport Vehicles, 1851-1951" was read by Mr. J. Shearman. At the second, which was held at the Institution of Mechanical Engineers, Sir Arthur Whitaker presented a paper on "Aviation," while at the third, which took place at the Institution of Electrical Engineers, a paper on "Telecommunications" was presented by Colonel Sir Stanley Angwin.

ROAD TRANSPORT VEHICLES, 1851-1951.

ON Monday, June 11, Mr. John Shearman and Mr. B. B. Winter presented their paper on "British Mechanical Road Transport Vehicles, 1851-1951," Mr. E. A. Evans, M.I.Mech.E., occupying the chair. The first section of this paper was historical, and after having made brief reference to the exhibits at the 1851 Exhibition, traced the development of road vehicles up to 1925. In concluding this section, it was pointed out that in 1925 the British motor industry employed 200,000 persons, while there were 1½ million vehicles on our roads, whereas 30 years previously there were no British manufacturing facilities and only two or three cars on the road. The second part of the paper covered the period from 1925 to the present day, and, in reviewing the great progress made, the point was made that the industry has now become one of the principal factors in the nation's economy and has contributed more than any other single industry to our post-war recovery. It was considered that certain important factors had exerted a significant influence on the industry during the period under review; from 1925 to 1939, for example, efforts were directed towards the home market, whereas from 1945 onwards the national economy demanded a concentrated effort to meet world requirements, the incentive thus provided having resulted in a pronounced progressive move. Furthermore, the groupings of companies which took place during this period, with the resultant reduction of types and ensuing standardisation, unquestionably played an important part in the success achieved.

On the technical side, great advances had been made, the proper application of scientific methods having largely superseded the old doctrine of trial and error. An important step was the setting up in 1923 of a co-operative research station, subsequently expanded into the Motor Industries Research Association. After reference had been made to the valuable part played by the motor industry in the second world war, the paper reviewed in detail the progress made with the production of materials, and mentioned, among others, the introduction of powder metallurgy, low-expansion light alloys and zinc-base die castings. The following part of the paper was divided into sections dealing with private cars, commercial vehicles and motor cycles, respectively. In the section dealing with private cars, the many important developments that had taken place regarding engines, transmissions and chassis were dealt with in detail, due credit being paid to British inventiveness. Commercial vehicles, both for the transport of goods and passengers, were dealt with in a similar manner, but here it was considered that more virility had been shown in their development than with private cars. So far as motor cycles were concerned, it was thought that, in this field, Britain had for many years led the world, and would continue to do so. The developments that stood out from the many others were the introduction of the vertical-twin engine, the adoption of rear-wheel suspension, and the fitting of long-travel soft-action telescopic front forks.

The paper was concluded with an attempt to forecast future developments. Motor-car engines, it was thought, would be lighter and far more economical than at present. Probably this would be achieved with a short stroke and light reciprocating parts, and although the poppet valve had so far more than held its position, some other form of valve mill might be introduced. Transmission systems on medium and large cars would probably incorporate a hydraulic torque converter, but it was not thought that this would be applied to smaller cars. So far as commercial vehicles were concerned, it was felt that greater use of compression-ignition engines, particularly in the medium sizes, would be made. The synchromesh gearbox would probably become more popular, but for passenger vehicles an easy gear change would almost certainly be demanded, while for really heavy types of vehicle, power-assisted steering would be likely. The future trend in motor-cycle design was fairly clear, and efforts would probably be directed towards refined touring machines and lighter sporting machines. Perhaps the biggest question so far as the future was concerned was the multi-cylinder engine; the merit of four or more cylinders was still controversial, but it would appear that the bias was in favour of their development.

DISCUSSION.

In opening the discussion, Mr. E. S. Shrapnell-Smith, C.B.E., said that he desired to speak as a user with a background of some 56 years. He felt that a lot of benefit could be derived by comparing what could be done on a certain journey in the old days with that which could be done now. In 1901, for example, he took 15 hours to do 32 miles in a French car. Similarly, with heavy steam vehicles, they considered it lucky to complete a double journey between Liverpool and Blackburn in a week, whereas to-day this journey with a five-ton or a ten-ton lorry took only two hours.

Dr. E. A. Watson said he would like to supplement the paper by some references to the electrical system. Modern motor cars, in addition to ignition, demanded electric starting, reliable and adequate lighting, including fog lights, satisfactory windscreen wiping, interior lighting, heating and even wireless. As a consequence, the electrical installation had become a somewhat complicated and highly developed piece of equipment. Originally, little attention was paid to balancing dynamo outputs and system loads. The unsatisfactory service given by that system led to the introduction of voltage-control systems which aimed at automatic balancing of load and dynamo output. Now, both voltage and current regulators were employed, a system, it was claimed, that enabled better use of the dynamo characteristics to be made. Loads also had increased substantially; in the 1920's, for example, a dynamo load of some 150 watts was normal, whereas to-day loadings of the order of 300 to 400 watts on the same size machine were commonplace. Such increases had only been made possible by the adoption of ventilation and detailed improvements in design.

Dr. Watson then referred to the question of ignition. The magneto, although it had given excellent service, had its weaknesses, and was eventually replaced by the coil, a light, relatively inexpensive piece of equipment which could be driven at camshaft speed and be fitted easily with automatic control of the ignition point. Although the coil and associated distributor looked simple, a great deal of development had gone into them. Latterly, the trend towards increased compression ratios and a consequent requirement for higher sparking voltages had brought new problems and it almost looked as if they were in sight of the limiting voltage which could be dealt with by a high-tension ignition circuit of normal design. As a result, a certain amount of work was in progress which might involve fundamental changes in spark plugs and associated electrical systems. It was, however, too early yet to speak of that development with any certainty.

Mr. Maurice Platt said that, although he fully agreed with the statement that economic conditions justified a much smaller car, there seemed to remain in many countries a strong requirement for the middle size. In looking to the future, the authors had mentioned the big cost and complexity of modern productive equipment. He believed that that was setting a special stamp on the next period of development and they were, perhaps, coming to the time when the production engineers, the metallurgists and the chemists would constantly be providing the automobile engineer and designer with fresh possibilities. The initiative was passing to them and the development of vehicles was beginning to take its pattern from the development of the techniques by which it was made and the materials used to make it.

Mr. A. C. Kidner felt that sufficient credit had never been given to Dr. Lanchester for his work on the motor car. Credit was given rather to Daimler and Benz, and the British public did not realise sufficiently that in Dr. Lanchester they had had the pioneer of the real motor car. Mr. Kidner then referred to McCollums sleeve-valve engine; he still believed there was a great deal in the single-sleeve engine which, except for aeroplane engines, had never been properly developed. Much credit should also be given to Lord Austin for the design of the first truly light car; Lord Austin's idea was that the market for the cheapest possible car was the biggest in the world and he (Mr. Kidner) thought Lord Austin was right. So far as research was concerned, he thought that there still was not enough done in long-term research. As for racing, this country had fallen out of that, in the true sense, for many years, and as an old racing enthusiast he still held that even to-day more could be learned from a racing car than from any other method of testing.

Dr. C. G. Williams gave what he termed a five-minute history of the contribution made by fuels and lubricants in the period under review. The first important event came in 1859, with the drilling of the first oil-well, but at that time petrol was discarded as useless; in the 1890's, however, they had the Daimler car with its surface carburettor using volatile fuel. In 1910, the first thermal cracking plant was introduced, while ten years later there was the classic work of Ricardo on detonation, which showed the great importance of anti-knocking qualities of fuels. That was followed three years later by the discovery by Midgley in America of the anti-knock qualities of lead, while in 1930 a method was developed, again in America, of measuring the anti-knock rating of fuels. The middle 1930's saw the introduction of catalytic cracking, a notable advance that led to great improvements both in quantity and quality of petrol produced.

After showing slides dealing with various aspects of fuel, Dr. Williams turned to the subject of lubricants. During the era of the steam vehicle, vegetable oils were used, but mineral oils were introduced with the advent of the internal-combustion engine. About the middle 1920's, a good solvent-extraction process, in which certain undesirable constituents were removed from the oil, became widely adopted and much improved viscosity characteristics were obtained. Later, additives were introduced for various purposes, such as for overcoming bearing corrosion, ring sticking, etc., but he felt that the real value of additives was in regard to problems of wear and deposits. There was no doubt that they would be more widely adopted in this country.

Mr. D. Bastow was glad that the authors had stressed the important part played by the makers of quality cars; as Dr. Llewellyn Smith had once said, for equal quantities of steel given to the manufacturers of quantity and quality cars, as many dollars could be earned by the quality manufacturer exporting 15 per cent. of his output as by the quantity manufacturer exporting 75 per cent. of his output. The small producer and the quality producer, who were not the same, had important functions to perform in the British motor industry, and we were lucky in possessing not only the "Big Six" to make large numbers of motor cars, but also a sufficient number of small good-quality producers.

Mr. S. B. Bailey referred to that part of the paper concerned with the development of British motor-cycles since 1930. There were two main classes of rider, namely, those interested in sport and those concerned with comfortable economical transport. The sportsmen were, and always had been, adequately catered for, but the touring class seemed to get scant attention. A well-balanced multi-cylinder engine was essential, to give smooth performance, but although the popular vertical twin had improved silence and torque characteristics, it had much the same evil balance as the single cylinder which it had replaced, and it was time it was replaced, in turn, by the transverse horizontally-opposed flat twin.

The remarks in the paper to the effect that future efforts of the designers would be mainly concentrated on increased refinement for touring types and reduced weight for sporting machines were significant. He earnestly hoped that more stress would be placed on reducing the weight of touring machines which already were too heavy. Mr. Bailey then turned to the question of the number of cylinders and said that he did not agree with the authors that the bias was in favour of an increase in the number of cylinders to four or more. A 500-c.c. engine was large enough to meet most solo requirements and a large number of smaller cylinders could not compete in thermal efficiency with a small number of larger cylinders. Adequate balance, torque and silence characteristics could be obtained from the flat twin, and the increased capital cost, complication and fuel consumption of the four-cylinder engine would be undesirable for the transport machine.

The difficulties of operating transport overseas were mentioned by Mr. M. D. L. Rome, who said he was concerned with the maintenance of a large fleet of vehicles in South Africa. In his opinion, the chassis design of many smaller British vehicles was too light for the bad roads encountered. There was also the factor of altitude as in most parts of South Africa they were operating at heights of 5,000 ft. to 6,000 ft., which led to a large loss in power. American manufacturers provided services for coping with these conditions, but he had not noticed similar facilities being provided by British manufacturers.

Remarking that he spoke as a public-service vehicle operator, Mr. R. Le Fevre said that tribute ought to be paid to the tyre manufacturers, who had made remarkable improvements in their products. Although there had been great developments in public-service vehicles generally, he thought there was a case for simplification; at present there were too many frills. He would like to see more attention paid to standardisation of chassis so that one type of body could be fitted to different makes of chassis without having to carry out modifications. With regard to the introduction of under-floor engines, he did not think that this meant the end of the double-deck vehicle, particularly for heavy city work, as it would take three single-deck vehicles to replace two double-deck vehicles. Mr. Le Fevre then referred to drivers' comfort and remarked that there was room for improvement in this field.

Mr. C. V. Davies said that there were one or two points in which there had been a regression and quoted the provision of spares and accessibility as examples. Spare parts were not as easily obtained as they might be, while accessibility on some cars was bad indeed. As a motorist, he regretted the elimination of the sliding roof and the introduction of the fixed windscreen; he had yet to find better draught-proof ventilation than that provided by the sliding roof and one had only to drive in fog to appreciate the value of an opening windscreen.

The authors replied separately. Mr. Shearman said that he and his fellow author had been honoured by the presence of so many distinguished pioneers. He was glad that Mr. Kidner saw, as did the authors, the importance of the work of the early pioneers. Mr. Winter, in his reply, mentioned that from the point of view of automobile engineers and designers, British roads presented very little difficulty; it was the roads in other parts of the world that caused difficulties. The contributions of Dr. Williams and Dr. Watson had been excellent and he hoped that the time might arise when a more general paper would be read supported by other papers dealing with fuel, electrical matters, etc. With regard to the remarks by Mr. Rome and Mr. Davies, he believed that the industry was sensible enough to see what could be done about the points raised.

Aeroplane Structures.

At the meeting in the Institution of Mechanical Engineers, the chair was taken by Sir Arthur Whitaker, K.B.E., M.Eng. The first part of the paper on "The Development and Design of Aeroplane Structures," by Professor A. G. Pugsley, O.B.E., D.Sc., reviewed the history of the structural design of aircraft up to 1945. Surveying current developments, he said that the aircraft design changes most affecting the structure were the increased speeds and the adoption of pressure cabins. Many spar booms and extruded stringers were now made in zinc-aluminium alloy, with an ultimate tensile strength of 30 to 35 tons per square inch, in place of copper-aluminium alloys at 25 to 30 tons per square inch; sheeting had undergone comparable changes. In recent aircraft, skin buckling was commonly prevented by using thicker sheeting and more closely-spaced stringers, allowing the use of countersunk riveting and producing smoother surfaces. Spot-welding was frequently used in subsidiary structures, but not in the primary structure. Adhesive cements had been used by several firms for subsidiary components, but only by the de Havilland Aircraft Company, Limited, in a general way.

The main loads governing wing design arose from gusts, particularly on large wings, and during landing, primarily in bending rather than in torsion. Adequate bending strength was provided mainly by a heavy-gauge metal skin, reinforced with light closely-spaced stringers. The thicker skins also provided the higher torsional stiffness required at modern high speeds. Between the two wars, the structure-weight percentage of the all-up weight of most aeroplanes ranged from 25 to 35 per cent. Modern structure weights varied little from a value of about 30 per cent., achieved mainly by the development of stronger materials and by the use of higher wing loadings, and partly by improved techniques for determining the optimum design of structure.

Turning to research and future prospects, Dr. Pugsley said that much experimental work had been done recently on the fatigue properties of the newer materials in the presence of stress concentrations, and on testing the life of complete tailplanes and wings under a cycle of loading approximating to that experienced in service. Too little was known about the loading cycles that actually occurred; current British practice was to produce materials and structures able to withstand at least 2×10^6 cycles of loading fluctuating by $\pm$ 10 per cent. above the loads corresponding to level flight.

Laboratory experiments had been carried out on fillers for "sandwich" construction between sheets of plywood, including Formvar and paper honeycombs filled with resin. These sandwich structures had suitable strength-weight properties, but little was known about the practical aspects of their production and service qualities. Synthetic resins reinforced by asbestos fibres, which gave the required strength and weight characteristics, offered improved surface smoothness, and could be adapted for large-scale construction; it was hoped that pilot production of plastic wings and fuselages might start in the near future. Experiments were also being carried out on the structural use of magnesium plating of the order of $\frac{1}{4}$-in. thick; the problem of jointing might be solved by argon-arc welding, already developed for aluminium plating.

Swept-back and delta-wing shapes, which would be largely confined to military aircraft, introduced new structural problems; their modes of aero-elastic vibration would resemble those of a delta-shaped "jelly" rather than the bending and torsional modes of a conventional wing. The structural design of civil aircraft, which would probably develop along conventional lines, would be influenced by the need for economy as well as for minimum weight.

Airfields.

Mr. J. A. Dawson, C.B.E., B.Sc., M.I.C.E., read a paper on "Planning and Construction of Airfields." After reviewing the development of grass aerodromes, hard runways, and airfield lighting up to the present day, he outlined some of the considerations in selecting an airfield site, in layout, and in choosing the type of runway pavement. In this country it was normal practice to provide expansion joints in rigid pavements at distances not greater than 120 ft. apart. The correct spacing of contraction joints, which depended on the thickness of the slab, was essential to prevent cracking and to allow the full strength of the pavement to be developed when warped under temperature variations; a spacing of 20 ft. had been found suitable for 12-in. thick concrete.

The edges and corners of a uniform slab were its weakest points; to strengthen them, it was customary in the United States and some other countries to reinforce all joints with steel dowels. In Great Britain this practice had not been adopted; double-slab construction was used in airfields intended for heavy aircraft, the top slab of high-grade concrete being separated from the low-strength base slab by a bituminous film, with the joints of the upper slab arranged to lie some distance away from those of the lower slab. The size of the slab had to be limited to that at which the warping under temperature differences on the top and bottom surfaces was less than the safe deflection under load. The strength of the concrete must be combined with workability, so that the concrete could be fully compacted and the surface finish could be adequately smooth to ensure that the aircraft tyres were not cut by the contact with the hard pavement. Final smoothing by means of a belt was necessary to remove sharp edges in the slightly corrugated surface left by the screed.

Few flexible pavements had been built in this country. The preparation of the sub-grade was even more important than in rigid runways, and rollers up to 100 tons weight had been used in constructing the Changi airfield, Singapore; this technique reduced the depth of excavation and the thickness of the sub-base, and, thus, the costs.

It appeared to be probable that existing airfields of the highest class would be capable of carrying the largest aircraft which might be built in future. Present airfields in Great Britain had three runways forming a triangle. Large modern aircraft, capable of landing in a cross-wind component of 25 m.p.h., required only two runways. If undercarriages of the swivelling type became practicable on large aircraft, the number of runways could be still further reduced. The longest runways in this country were about 3,000 yards; improved landing and take-off characteristics might enable shorter runways than this to fulfil all requirements. A smaller number of shorter runways would greatly reduce the cost of airfield construction.

Discussion.

In opening the discussion on the two papers, the chairman, Sir Arthur Whitaker, suggested that the congestion which was arising in the air might lead to the use of very large aircraft. He also mentioned the possibility of bringing the airport into the centre of town with the development of hovering aircraft. The first speaker in the discussion, Mr. Cozens, said that flexibility in operation was the most important factor in airfield layout; and he thought that a large city requiring a rate of aircraft movements higher than 60 per hour should be provided with two smaller airports, with differing meteorological conditions, rather than one large one. If heavy earthwork plant were available, there were great advantages in building flexible pavements; less rigid control was required during construction, and they were easier to maintain and to alter in the case of modifications to the airfield lighting systems, ducts, etc. Mr. G. S. Cooper said that load-bearing tests on rigid pavements had revealed that under extreme temperature conditions, there might be a deflection of 0·06 in. before the top slab was in contact with the base; since slabs generally cracked at a deflection of 0·1 in. to 0·15 in., that meant the loss of almost half the available deflection range before a reasonable bearing value was obtained from the base. If it were possible to combine a high flexural strength with a low modulus of elasticity, the concrete could deflect further before breaking; but generally a low elastic modulus meant low-strength concrete. Moreover, other factors which had a marked effect only became noticeable after two or three years' service, as, for example, a clay sub-grade which would eventually sink under load, reducing still further the support to the corners of the slab.

Mr. G. H. Fretwell said that the natural load-bearing capacity of the site should be utilised, a waterproof pavement surface being provided for the constructed paving to maintain the best working conditions. The weather conditions in this country were not, however, entirely suitable for constructing mechanically stable flexible pavements. He thought that shorter runways would probably only be achieved with the development of assisted take-off and arrested landings; the essential paved area should be confined to the net take-off and landing runs, with safety margins provided by over-runs at the end of the paved runways. Airfield lighting and radio aids should not form obstructions at the end of the runway.

Mr. S. W. F. Morun, who was concerned with smaller private airfields, disagreed with Mr. Cozens that less supervision was required for flexible pavements. He regretted that little information was available on the moisture content of soils beneath runway pavements. In tests on silty soils, he had found bearing pressures ranging from ½ ton to 4 tons per square foot. It was unfortunate that various types of test all appeared to give varying results for the different soil samples tested. The soils capable of carrying 4 tons per square foot had been stabilised very satisfactorily; the ½-ton soil, with 4 in. of sand asphalt only, had also given successful results. From American road tests, it appeared that the intensity of traffic was a more powerful factor in the failure of pavements than the maximum load; he wondered if any similar researches had been carried out in this country.

Mr. C. S. Goode said that strengthening the earth underneath the runway was as important as the design of the pavement above it. It was essential to leave the compacted formation undisturbed for as long as possible, and he could not see the necessity for running longitudinal airfield lighting ducts beneath the paving. The advantages of both rigid and flexible pavements could be combined by constructing a concrete pavement at the bottom, and above it the flexible pavement. The slab would need no joints, with consequent reduction in costs, and there would be no temperature stresses; moreover, the airfield lighting ducts could be placed on it or in it without much trouble. Special provisions could be made at those spots where damage from jet exhausts might be expected.

Mr. K. C. Mann said that it was not yet certain that the equivalent single-wheel load value of multiple-wheel undercarriages could be determined with sufficient accuracy; further research was to be done on this aspect. The introduction of aircraft requiring stronger pavements increased the cost of construction and made it necessary to lengthen and strengthen pavements on existing airfields throughout the route over which the aircraft was to operate; in war, it added to the difficulties of choosing sites to give the required length of runway and of constructing temporary airfields rapidly to withstand the traffic. In attempts to improve take-off and landing characteristics, catapults and arrester gears were used for special purposes, but were not suitable for passenger-carrying aircraft. He looked forward to seeing aircraft without undercarriages, able to alight on a relatively small, possibly bogie-mounted platform, which could be towed away on tracks, and aircraft which could take-off without having to develop forward speed before becoming airborne.

Dr. P. B. Walker said that stressed-skin construction had been adopted, firstly, to ensure a reasonably robust material at the surface, and secondly, in order to have the main structural material as near the perimeter of the thin wing structure as possible, for torsional strength and stiffness. The risk of fatigue had increased as aircraft flew for longer periods; moreover, the metallurgists were now producing materials which were statically stronger, but no better in fatigue. There was a lack of data on the cumulative effect of loading cycles of varying intensity and varying speed. Nevertheless, nine-tenths of all fatigue troubles could be avoided by care in detail design.

Mr. J. A. Skinner thought that the selection of a rigid or flexible pavement would be largely affected by the availability of materials. Plate-bearing tests on a number of existing concrete pavements had shown that the economically-produced single slab would not stand up to the high loads of modern aircraft. The design of double slabs was difficult; the lower slab must be as strong as the top slab, which acted in effect as a protecting slab, to ensure that temperature and weather effects did not affect its strength. Plate-bearing tests on flexible pavements based on a good sub-grade had showed surprisingly high results; the available evidence showed that flexible pavements were desirable on good sites, whereas concrete was probably more economical on poor sites. He liked Mr. Goode's idea for buried concrete with an asphalt top, which made for better sealing, riding and maintenance.

Dr. O'Sullivan said that the forms adopted by aircraft constructors for the cross-sections of sheet-steel biplane spars (shown on slides by Professor Pugsley in the historical section of his paper) might have applications in the design of static suspended structures of long span. Referring to runway pavements, he said that prestressed concrete construction, which was flexible and highly elastic, offered possibilities intermediate between the rigid concrete pavement and the flexible bituminous or asphaltic construction. Much larger deflections could be tolerated by prestressed concrete. In general, the choice of pavement was affected by cost, availability of materials, and speed of construction.

Replying to the discussion, Professor Pugsley said that if aircraft designers succeeded in eliminating the undercarriage, the conventional type of aerodrome would also be eliminated. He thought that tyre pressures were likely to increase in order to reduce the weight of the undercarriage and to save space. An alternative approach would be to adopt many wheels spread along the frame, which would reduce considerably the stresses in aeroplane wings resulting from landing impact; certain experiments along these lines had been made but had not been followed up. The sheet-steel spars referred to by Dr. O'Sullivan were developed largely by test; remarkable results were achieved in postponing elastic buckling by curving their cross-section. Using flat steel strip with a proof strength of 60 to 70 tons per square inch, it was formed into spars which were again capable of withstanding 60 to 70 tons per square inch. The present aim in aircraft structures was towards increased stiffness; under laboratory conditions, certain light alloys had been produced with stiffness increases of 30 to 40 per cent.

Mr. Dawson, in reply, said that the composite pavement, with a rigid slab below, spreading the load, and a flexible pavement above, might be especially suitable for heavily-loaded military aircraft with very high tyre pressures. On flexible pavements, no great benefit was derived from the multiple-wheel assembly. Referring to prestressed concrete runways, he said that a section of track had been tested satisfactorily at London Airport, but it was very costly. Moreover, repairs could not always be carried out locally, which was a grave disadvantage from the military point of view.

TELECOMMUNICATIONS.

In a paper on "Telecommunications," which was presented at a meeting at the Institution of Electrical Engineers on Monday, June 11, with Sir Archibald Gill in the chair, Sir Stanley Angwin reviewed the progress that had been made in this branch of engineering during the last 100 years. In 1851, visual signalling and line telegraphy were, he said, the only applications covered, the Cooke and Wheatstone electrical telegraph having come into use in 1837. In 1851, some 48,600 messages were handled on the inland telegraph system, but by 1948, the number had grown to 47,440,000, to which must be added some 10,000,000 telegrams carried over 1,000 private wires. The first telephone exchange in London was opened in Coleman Street in 1879 with eight subscribers; and now there were nearly 5,200,000. Mechanisation of local services had steadily proceeded since the first automatic exchange was opened at Epsom in 1912, and at present, 70 per cent. of all telephone stations in the country were connected to such exchanges. The principles of automatic switching were fundamentally simple, but the complexity of the circuits, relays, contacts and switches was very great. Within a large multi-exchange area, such as London, the application of automatic switching was particularly complex and involved the use of registers or the director. During the first quarter of a century, developments in the switching techniques for the rapid setting up of long-distance communications had lagged behind new and economic methods of transmitting speech over long distances. Considerable advances were, however, now taking place, especially the use of voice-frequency pulses giving full signalling and dialling facilities.

The present trend was towards wholly electronic methods of switching, but the new system could only be justified if it offered outstanding advantages in efficiency and annual costs. Capital cost could not, however, be assessed until a workable system had been produced; and this also applied, to some extent, to maintenance. The components of an electronic system should require less maintenance than switches with mechanisms and metallic contacts subject to wear. In fact, electronic exchanges involved no fundamentally new conceptions of switching and transmission, and it could therefore be expected that workable systems would be produced before long.

Submarine cables hold a unique place in world telecommunication. The first transatlantic telegraph cable was laid in 1866, and by 1921 there were 21 such cables under the North Atlantic. Submarine cables for telephony were a logical development, the first being laid across the English Channel in 1891. Improved transmission followed the introduction of loading coils in 1910 and the employment of continuous loading in 1924, while submerged amplifiers had first been used in 1943. The Lowestoft-Borkum cable, which was laid in 1946, and was nearly 200 nautical miles long, embodied a single amplifier and consisted of five telephone circuits, any of which could be used for 18-channel voice-frequency telegraphy. As a result, a standardised system providing 60 circuits per cable had been developed. The possibilities of laying a cable with amplifiers capable of withstanding the pressure at depths of 2,000 fathoms was now in sight, and it was intended, in 1952, to equip a new cable about 650 nautical miles long with five amplifiers operating at this depth. The system would provide one telephone circuit to C.C.I.F. standards (which could be used alternatively for 24 voice-frequency telegraph circuits operating at 50 bauds) and two 100-baud telegraph circuits. The amplifier housing would consist of high-tensile steel forgings, 9in. in diameter, and some 7ft. long, the cable entering at the two ends through glands of ceramic and nylon and moulded polythene.

DISCUSSION.

Dr. W. G. Radley said that it would be appreciated that the capital cost of providing a communication circuit by a coaxial cable was only a small fraction of what it used to be with an open wire line. In spite of the complicated terminal equipment the maintenance effort, too, was less, being 320 man-hours per year for a 100-mile open wire circuit, 65 man-hours for an audio-cable circuit of the same length with two intermediate repeater stations and only 33·4 man-hours for a similar circuit in a coaxial cable. For a 200-mile circuit the coaxial cable required 39 man-hours, while the open-wire figure was about 640 man-hours and the audio-cable figure 130 man-hours. A possible weakness of the present coaxial system was the concentration of equipment at the terminals with the result that 70 per cent. of the capital cost was due to the latter, a figure which could be further broken down into 42 per cent. for transmission equipment and 28 per cent. for signalling equipment. This result was due to the belief that frequency bandwidth on the line was expensive and must be conserved at all costs. While this was true for lines 1,000 miles and longer, it was becoming less true now higher frequencies were used. In this country, where the bulk of circuits were 200 miles or less, it was satisfactory therefore to know that a simpler system was being developed. He did not think enough had been said about the lead we had in this country in our methods of dialling and signalling over long-distance circuits. To-day, over 4,000 of our circuits were being operated by voice-frequency circuits, so that a London operator could dial a subscriber in, say, the Manchester area directly. This was only the first step towards the complete mechanisation of the British trunk service.

Professor Willis Jackson pointed out that the progress of telecommunication afforded an outstanding example of the intimate relationship between science and engineering, and of the essential dependence of one upon the other. This progress had been assisted by the intensive studies which had been carried out all over the world into such questions as the characteristics of the ionosphere and the interactions of electrons and electromagnetic waves. Similarly, science had gained very considerably from telecommunications. Means for assessing quantitatively the information content of the message had been obtained recently by the foundation of what was called "information theory." This theory had been found to have a wide scientific significance in making quantitative comparisons between the information-handling mechanisms of the brain and of electronic computing machines. A further step had led to a consideration of the reaction of the receiver on the source of information, so that it seemed that the work of the telecommunication engineer had initiated a new branch of science, which revealed and promised to clarify the different processes by which living organisms received, analysed, used and transmitted information.

Mr. A. H. Mumford thought that a great need at the present time was to utilise all means of reducing interference between transmissions. Mr. A. W. Montgomery deprecated the use where mechanical methods could be employed.

Dr. A. Smith was fascinated by the author's statement that the Atlantic telephone cable was in sight. This result was primarily due to the advent of submerged repeaters, although the new insulator, polythene, had played a not inconsiderable part. He would like to say a word for the rigid form of repeater housing containing a two-way amplifier, as he thought that the Post Office practice (which had been well established in European waters) of having one self-contained cable would be the best for the Atlantic cable. He wondered whether the conclusion reached by Dr. Buckley some years ago that the scheme was economic, and that even if it were not it had strategic advantages, still held good. He thought that the cable must provide the highest quality results, but that all the circuits need not be of the highest quality.

Mr. T. H. Flowers pointed out that the issue between manual and automatic exchanges had been decided not by the relative complications of the two systems, but by the fact that it had been impossible to find sufficient skilled operators to work the former. He thought that the issue between electronic and mechanical exchanges might be settled by a similar consideration, for it was doubtful whether enough men could be found to service the present exchanges, so that with the growth of telephony it would be necessary to employ a system which required less maintenance.

Sir Stanley Angwin, in reply, said that he had not much doubt that the Post Office had been right in using the rigid type of repeater, but whether it was the best for very deep water cable was an open question. As regards the use of thermionic switching, the increase in the number of valves had to be faced. He thought that Dr. Buckley's remarks about the Atlantic cable were still true, although it was necessary that cable and radio should be co-ordinated for long-distance transmission. One of the factors in the success of the cable would undoubtedly be the use of polythene, while another would be the feed-back repeater.

(To be continued.)

Committee on Uses of Fuels.—The Minister of Fuel and Power, Mr. P. J. Noel-Baker, stated at the conference of the National Union of Mineworkers at Blackpool on July 3, that a special committee is to be appointed to investigate the wider aspects of national fuel policy. Such a committee has been urged by the Federation of British Industries and the Trades Union Congress. It will inquire into the questions whether the various forms of fuel and power are being used to the best advantage; whether electricity should be used for domestic, office and factory heating; whether gas should be used for public lighting; and what are the true costs, including capital costs, of the fuels in use for various purposes.

AERONAUTICAL RESEARCH IN AUSTRALIA.

Through the courtesy of the Chief Superintendent of the Aeronautical Research Laboratories of the Department of Supply, Australia, we have received a copy of the departmental report of the Laboratories for the year 1949-50. As in the 1948-49 report, which was reviewed on page 468 of our 169th volume (1950), it is divided into six main sections covering structures, engineering materials, aerodynamics, power plants, electronics and instrumentation, and applied research.

The work on structures falls into two main subdivisions—the life-testing of aircraft structures, and investigations on structural analysis and efficiency. Work on repeated-load tests has been mainly concerned with modifying the test rig, by adding a "reaction neutraliser," i.e., a sympathetic vibrating system, to overcome large fluctuating reactions set up in the supporting structure during resonant-vibration tests on wings, in which it was found to be necessary to support the wings at the fuselage-attachment points, which were not nodal points, in order to simulate the air-load shear and bending-moment distribution over the critical part of the wing. Several mathematical investigations have been carried out on the dynamic behaviour of aircraft structures, and on static stressing analyses including studies undertaken at Sydney University on thin stiffened shell structures, with and without cut-outs, and on the behaviour of swept-back tubes under bending and torsion.

Studies of fatigue, slow deformation, high-temperature metals, the properties of alloys, corrosion, and the furnace-brazing of steel formed the main activities of the engineering-materials section. In tests on the effect of surface-finish on the fatigue resistance of aluminium-alloy 24S-T rotating-cantilever specimens, it was found that longitudinal hand-polishing gave the highest strength for a life of 100×10^6 cycles; specimens with an ordinary turned finish had a strength of only 80 per cent. of that of the hand-polished test pieces. At high stresses, however (corresponding to a life of about 10^5 cycles), the highest fatigue strength was shown by the rough-turned specimens. The effect of various normal heat-treatments for steel on the profile and the chemical composition of the surface layers has been studied by the taper-sectioning method; it is concluded that the neutral salt-bath method is satisfactory for normal use, and that the method of surface coating adopted by the Laboratories for fatigue specimens (described in the last report) is considerably superior, from the point of view of decarburisation, to normal heat treatment, although cracks developed in the coating when used on fatigue specimens. In a long-term fatigue investigation on aluminium-alloy specimens under repeated direct stress, it has been observed that, for a constant life, when the mean stress is compressive or only slightly tensile, the stress range is approximately proportional to the compressive mean stress. Slow-speed repeated direct-stress tests on annealed commercially-pure copper have shown that structure breakdown was accelerated by high stresses and low frequencies, and that there was a marked change in the degree of breakdown at a given stress when the stress cycles were changed from 300 to 400 a minute; under alternating direct-stress tests at $\pm$ 7 tons per square inch, similar specimens run at 300 cycles a minute failed at about 50,000 cycles, whereas a life of more than 100,000 cycles was obtained at a stressing rate of 400 cycles per minute.

The slow deformation of fine-grain aluminium has been studied at various temperatures between 20 deg. and 350 deg. C., at a straining rate of about 0·02-per cent. elongation per hour; the crystal grains showed no internal derangement, even for large strains, and it was concluded that, under such conditions, plastic flow could be attributed entirely to the viscous nature of the grain boundary region. The work on chromium-base alloys with beryllium, with manganese, with titanium, and with tungsten, for high-temperature applications, has continued. An argon-arc furnace has been used for melting the alloys and a high-frequency induction heater for thermal analyses. Alumina and beryllia refractories have been produced to withstand the extreme temperatures, but attempts to produce magnesia crucibles and sheaths to replace the toxic beryllia refractories have so far been unsuccessful. The chromium-beryllium and chromium-tungsten equilibrium diagrams have been almost completed; a preliminary survey of the chromium-manganese system below 1,050 deg. C. has been made, and the liquidus and solidus curves up to 60-per cent. manganese have been established. The general nature of the whole chromium-titanium system has been determined; there are promising high-temperature alloys in both the chromium-rich and titanium-rich regions.

The mechanism of the hardening action in the precipitation process is being studied by work on zinc single crystals, high-purity aluminium-copper alloys, and relatively pure iron. It has been found that when zinc is deformed at high temperatures, some grains show a sub-structure which becomes increasingly perfect as the temperature of deformation is raised; it is considered that this is related to the "cell" structure formed during the creep of aluminium alloys. For investigating the effects of stress on the corrosion of aluminium and its alloys, two more tensile-testing machines are being built. Tests on Duralumin have shown, so far, that, as in aluminium, the electrode potential is affected, not by the actual stress, but by plastic strain in the metal causing the oxide film to break.

The corrosion of buried iron and steel pipes and piles has been shown to be influenced chiefly by the differential aeration of the water in the soil, and not by bacteria; in certain soils, it has been found that dissolved oxygen does not penetrate below a depth of about 5 ft.; corrosion of a buried steel pile in such soil can, therefore, be largely suppressed by a protective coating to this depth. The danger of potassium-dichromate corrosion inhibitors, in setting up intensified corrosion at surface defects where the dichromate could not form its passivating film, has been demonstrated. Corrosion pustules thus produced on steel and stainless steel were in an unusual form of long thin tubes originating from the small unprotected anodic areas. A fundamental investigation on the growth of films on metals, in electrolytic polishing, has been initiated. Studies on the copper-brazing of steel have shown that the shear strength varies inversely with the size of the gap; the high shear strength associated with small gaps is due to the dissolution of iron in the molten copper and to the inter-crystalline loosening of ferritic grains which subsequently bridge the gap.

Aerodynamic investigations have covered high-speed aerodynamics, research on boundary layers, turbulence, and stability and control. For the high-speed work, new wind tunnels are urgently needed. The power of the variable-pressure tunnel is being increased by replacing the existing electrically-driven contra-rotating fan with a two-stage fan driven by a Merlin engine; at the time of compiling the report, the new drive was not in operation. A new type of interferometer has been designed for visualising flow in the high-speed tunnel, and three portable small-source high-intensity flash units have been made for use with the interferometer, when it is completed. The preliminary experiments on phase-contrast method show promise of producing quantitative results on air flow. Ground-launched rocket tests for exploring flight characteristics in the trans-sonic range were initiated in September, 1949; the drag is determined by measuring, from the ground, the deceleration of the model after burning is complete. For more detailed tests, telemetering or airborne instruments recovered by parachute are used; this work is carried out at the Rocket Range, Woomera. In collaboration with the Aircraft Research and Development Unit of the Royal Australian Air Force, a high-speed aircraft is being fitted with instruments for investigating compressibility effects on performance; an irreversible elevator control is also being fitted in this aircraft.

Further tests have been carried out on the glider fitted with a suction wing; although the performance of the suction system has not attained the values predicted in the wind tunnel, it has been established that the overall drag of the suction

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

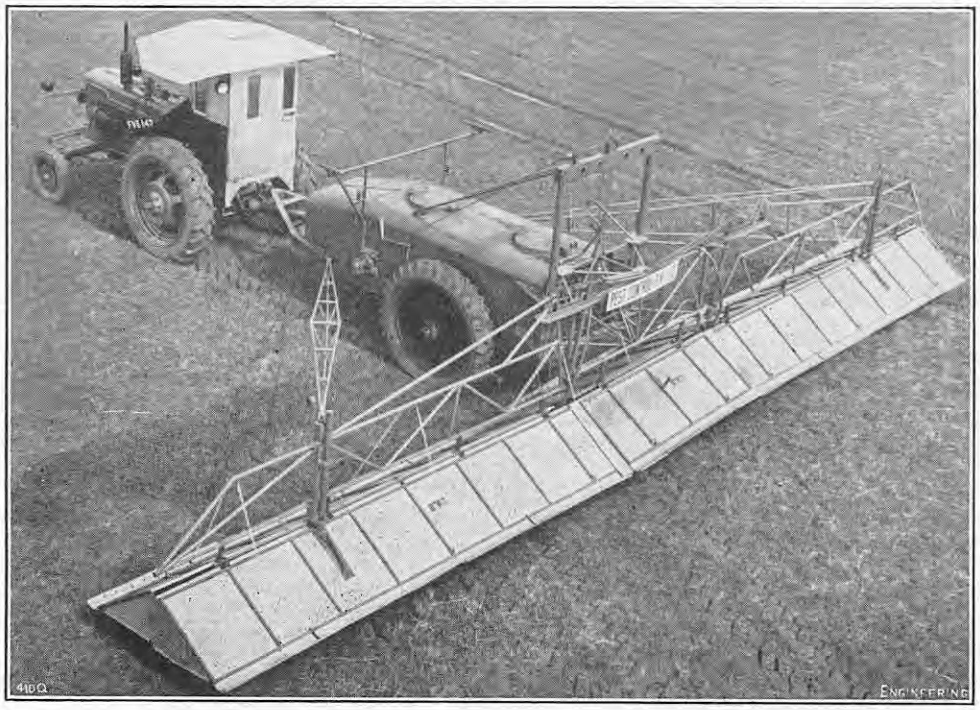


FIG. 16. "NODRIF" SPRAY BOOM; PEST CONTROL, LIMITED.

wing is about the same as that of a moderately thick wing section. If the losses in the suction system could be reduced to the wind-tunnel values, the overall drag would approach that of a thin laminar-flow aerofoil. It is proposed to build a glider with swept-back suction wings, to provide data for a possible transport aircraft; auxiliary slots would be fitted to maintain laminar flow over most of the top surface, in the event of leading edge "contamination"—as for instance, with insects—which in the present wing causes appreciable disturbance of the flow. At Sydney University, experimental work has been carried out on turbulent boundary-layer separation, using special equipment and techniques; a large-amplitude square-wave generator has been developed for setting the compensating circuit of a hot-wire anemometer; and a single slanting wire has been calibrated for the measurement of turbulent shearing stresses. Measurements of the intensity of turbulence close to square-mesh wire grids have been made in connection with an investigation on the propagation of the flame front in the combustion of gaseous or vaporised liquid fuels. The twin jet engines of the radio-controlled Stork model aircraft have been replaced by piston engines; yaw measurements in the wind tunnel have been made on a tailless model aircraft. New equipment has been designed and tried out on the Stork for determining the moment of inertia; the design of a pneumatic launcher has been completed, but construction is still in an early stage.

Studies of combustion in turbine engines have been continued; it has been found that large-scale mixing effects have a much greater influence on combustion than small-scale turbulence. Early results on the survey of air flow, pressure and temperature, over a range of fuel-air ratios in a Lucas combustion chamber, have suggested that there is a fairly wide range of burning-zone fuel-air ratios which give a constant high combustion efficiency. The effects of nitrogen-oxygen additives, carbon monoxide and methyl-ethyl ketone on flame speed have been studied.

Further work has been done on the combustion of pulverised brown coal for gas turbines. The effect of airflow on combustion intensity and stability is being studied in a refractory-lined straight-through chamber; the pulverised coal is metered from a hopper, by a screw feeder, into an airstream which feeds into the combustion chamber. Pneumatic pulverising equipment is under test, and the possibility of "flash" pulverising wet coal is under consideration. For studying the erosion of turbine blades by brown-coal ash, a furnace is being built.

Low-speed cascade tests have been carried out on several blade sections; laminar sections, it is concluded, should not be used for high deflections where the pressure gradient must be kept low. A high-speed cascade tunnel supplied by a 3,500-h.p. compressor was under construction at the time the report was compiled, and was expected to be operating this year. A vortex tunnel was also being designed. The turbine-engine test plant, for jet engines up to 10,000 lb. thrust, is in operation; the engine is mounted in a large steel box fed with air, at atmospheric pressure in the test cell, by a 550-h.p. fan. The thrust, speed and fuel consumption can be measured to within an accuracy of $\pm \frac{1}{4}$ per cent. Experiments are being carried out on the behaviour of resonant pulse jets.

In the work on piston engines, the final part of the investigation on piston-ring lubrication has been completed; it was found that the taper on the running face, chamfered corners, and "torsion rings" had marked effects on the stability of the oil film. Development work on a two-cylinder rotary-valve engine is still in hand. Two types of engine have been constructed for the radio-controlled model aircraft; one is a two-cylinder two-stroke aircooled V-engine, designed for an output of 3·5 h.p. at sea level; the other, developing 24 h.p. at 20,000 ft., is an unorthodox supercharged two-stroke engine with a single horizontal cylinder and opposed pistons driving contra-rotating crankshafts and propellers. A third engine, similar to the 3·5-h.p. engine, has been designed to develop 5·5 h.p.

The section on electronics and instrumentation has been concerned with developing control equipment for flying models and instruments for flight research. For use as servo-motors in the automatic aileron-control instruments which have been constructed, small direct-current motors are being developed. Many parts of the multi-channel optical recorder for flight research, mentioned in the previous report, have been assembled; a feed-back type transmitting accelerometer has undergone promising preliminary tests; and the development of an eight-channel pressure recorder for use in rocket models, for investigating the flow past aerofoils at high speed, has been initiated. Other developments include a recording electrometer with improved stability and high input impedance, and a recording dilatometer with a resolution of the order of 10^{-5} cm.

The applied research section has completed an orchard sprayer, which breaks up the liquid spray into a fine mist and conveys it to the trees by an air stream produced by a double-sided centrifugal fan driven by a 70-h.p. engine; the spray mist is injected into the airstream from nozzles fed by an engine-driven pump. A vertical fan for protecting fruit crops against frost has been built for the Commonwealth Scientific and Industrial Research Organisation, consisting of a 30-ft. steel tower carrying a turntable on which are mounted two 50-h.p. electric motors driving 12-ft. diameter propellers, the shafts of which are slightly offset to give a turning moment which rotates the turntable and, with it, the jets of air.

THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

(*Continued from page* 54.) 632·5

A DIFFICULTY in spraying fields, and one which has caused most vexation between farmers and their neighbours, is the damage caused by the drift of weed killers on to neighbouring susceptible crops. Sugar-beet fields have suffered most in this country but various brassica crops have also been extensively damaged; hops, too, are particularly susceptible to very small quantities of the hormone type of weed-killer. Overseas, considerable damage to grape crops has been caused by the wind-drift of plant hormones and in California legislation has been introduced to prevent the spraying of hormones in certain areas. Pest Control, Limited, Harston, Cambridge, have carried out much research to overcome this problem and at this year's Show they were exhibiting a spraying boom which is fitted with cowling to prevent the drift of spray. Known as the Nodrif spray boom, it comprises a cover which encloses the area of ground to be sprayed in such a way that interference from wind is largely prevented. It is illustrated in Fig. 16, on this page, and Fig. 17, on page 74, the former showing the machine arranged for working and the latter folded for transport. The spray bar is in three sections, each with its individual cowl. Both side booms are supported by caster wheels which maintain the spray bar at a constant height above the ground and thereby prevent the wind shields from digging into the ground. Each wind shield forms an obtuse angle with the ground so that the wind is easily deflected. To guard against side winds, folding triangular-shaped deflectors are provided; and, to prevent wind from getting underneath the shield, there are serrated rubber curtains along the lower edges of the deflectors.

Apart from safeguarding adjacent crops, the use of the Nodrif boom ensures that the operators are not covered by toxic chemicals when working in windy conditions. To give added safety for the operator, however, Pest Control, Limited, have also introduced a gas-proof air-conditioned tractor cab. This consists of an almost airtight cabin into which air is fed by a compressor driven from the tractor power take-off. A pressure somewhat higher than atmospheric is maintained inside the cab and the air escapes through the apertures for the various controls. A large charcoal filter is fitted to the intake side of the compressor for the absorption of gases and, in addition, there is a special filter to prevent the passing of fine smokes and dusts. The cab also incorporates means of keeping the temperature below 75 deg. F., as it is dangerous to work in temperatures above this value. Temperature control is achieved by trickling water over the cab, a method often adopted for greenhouses in tropical climates. Further protection against a rise of temperature inside the cabin is given by a large screen arranged over the roof.

Some of the exhibits on the stand of Messrs. Harry Ferguson, Limited, Coventry, were described in the first part of our report on the Show, which appeared on page 20, *ante*. Other exhibits on their stand included the disc harrow and the three-furrow plough illustrated, respectively, in Figs. 19 and 20, on page 75. The disc harrow is a mounted implement and has been developed for use in orchards, vineyards and other places where manœuvrability is of prime importance. It consists of 14 discs, 20 in. in diameter, arranged in two separate gangs, and is believed to be the first mounted offset disc harrow to be made in the United Kingdom. The disc angle is fixed, depth being controlled solely by means of the tractor's hydraulic-lift assembly. Offset is obtained by slackening simple clamps and sliding either one or both gangs to the right or left, the total offset available being 6 ft. from the centre of the tractor; this gives a maximum width of working of 7 ft. 3 in., whereas the minimum width is 5 ft. 3 in. Adjustable scrapers are provided so that the discs can be kept clean, whether clogging occurs at the peripheries or at the centres. Without offset, the discs form an efficient heavy-duty cultivator, and with offset they can be used to throw the soil either towards or away from the trees. The harrow can be fitted behind any standard Ferguson tractor.

The three-furrow plough has been developed for use in shallow soils and other conditions where a well set-up furrow slice is needed. It is of strong construction and, like most Ferguson implements, is designed so that it is used in conjunction with the rear implement linkage of the tractor. Lea-type bodies are fitted and these, with the undercut coulters and narrower furrow width, make it possible to turn crested furrows even at shallow depths.

A novel form of manure spreader was being shown by Messrs. Atkinsons Agricultural Appliances, Limited, Enterprise Works, Clitheroe, Lancashire. The outstanding feature of this machine is the method by which the manure is ejected, a simple hydraulic-ram mechanism being employed for this purpose. A photograph of the spreader is reproduced in Fig. 18, on this page, from which it will be seen that the general design follows standard practice, comprising a two-wheel trailer which is hitched to the rear of a tractor in the normal manner. The distributor mechanism is located at the rear and consists of two tine shafts arranged to rotate in opposite directions to ensure proper disintegration of the manure, and an impeller shaft to give even distribution and width of spread. Unlike most machines of this class, the spreader-beater mechanism is driven from the tractor rear power take-off, the drive being transmitted first to a bevel gearbox, the moving parts of which are immersed in oil, and then by Renold chains to the distributor.

As previously mentioned, the manure is ejected hydraulically, the mechanism consisting of a double-extension hydraulic ram fitted at the forward end of the chassis. This is connected to the front board of the body, which is free to move within guides towards the beater-spreader unit situated at the rear of the body. To commence spreading, a hydraulic pump, also driven from the tractor rear power take-off, is put into operation and the ram moves the front board, or barrier plate, as it is termed by the manufacturers, towards the disintegrating tines. The pump is driven constantly and control of the ram is effected by opening and closing a relief valve incorporated in the hydraulic circuit. A variable-stroke pump is used and the rate of delivery of the manure is adjusted by setting the actuating arm at different centres. After the barrier plate has travelled its full distance of 7 ft. 6 in., and all manure has been ejected, it is returned to the forward position by means of a simple winch mechanism, driven through a clutch from the main drive shaft.

It will be appreciated that the use of a travelling head board for ejection of the manure entirely eliminates the slatted conveyor usually employed on this class of machine. As a consequence, it is only necessary to remove the disintegrating and spreading mechanism from the rear to convert the machine into a two-wheel trailer, in which role the ejecting gear can be employed for such jobs as discharging root crops into clamps, etc. The complete unit is of strong construction, the chassis frame being constructed from heavy channel-section structural members and the body from steel sheet, reinforced by angle sections. The depth of the body is 1 ft. 6 in. and its length 8 ft., the stroke of the ram, as previously indicated, being 7 ft. 6 in. Including the tow bar, the overall length of the machine is 14 ft. 6 in. and the width over the tyres, 6 ft. 6 in. The capacity is 2 tons and the weight of the complete equipment is about 15 cwt.

(*To be continued.*)

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

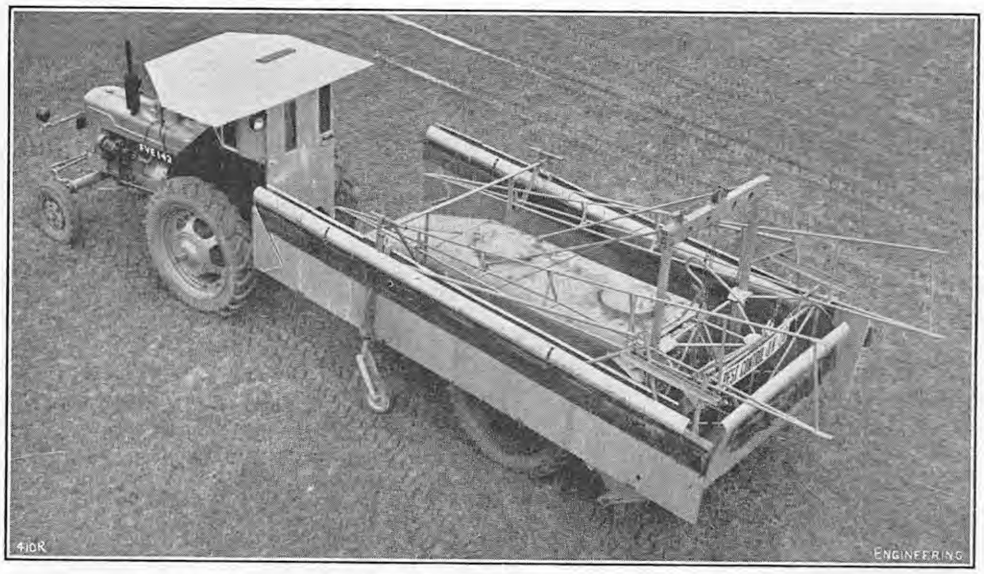


FIG. 17. "NODRIF" SPRAY BOOM; PEST CONTROL, LIMITED.

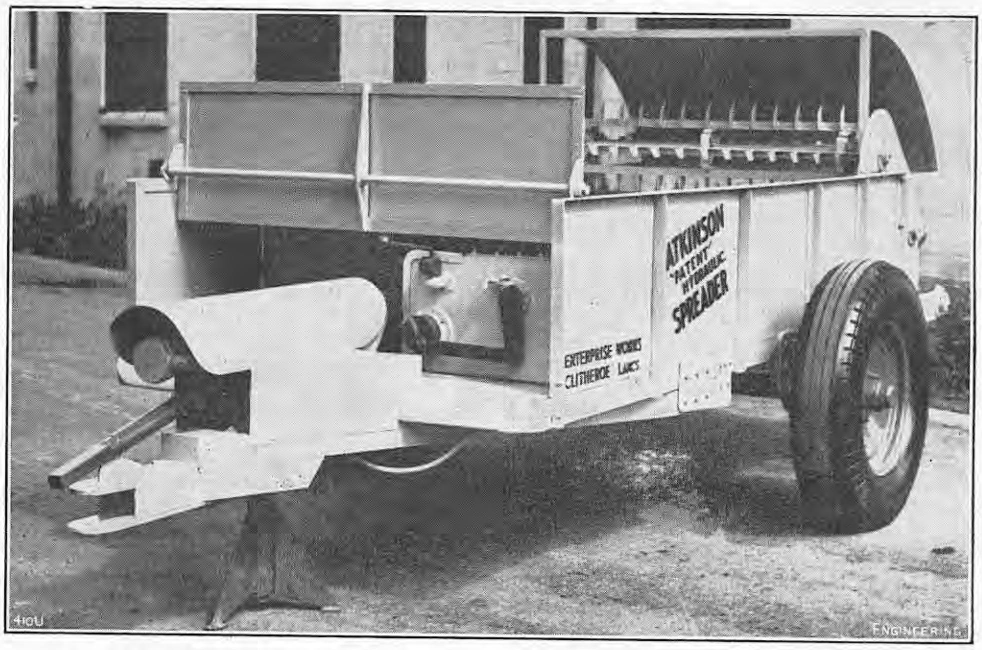


FIG. 18. MANURE SPREADER; ATKINSON'S AGRICULTURAL APPLIANCES, LIMITED.

EUROPEAN NEEDS FOR SCRAP.

To a large extent, Europe can satisfy, its present demands for scrap for maximum iron and steel production if all countries concerned will increase their scrap collection and apply the available scrap for its most effective immediate use, according to the United Nations Economic Commission for Europe. A panel of experts who have been investigating the subject recommend that countries should adopt price policies which would encourage the maximum collection and marketing of all available supplies of both high-quality and low-quality scrap, and should seek to draw out more scrap by means of intensive organised collection. The panel met in Geneva on June 27 and 28, after having visited the Benelux countries, France, the United Kingdom and Western Germany.

Although scrap by itself cannot continue to provide a solution to the raw-material problem of the steel industry, at the present time steelmakers in some countries cannot work to maximum capacity unless they can obtain increased supplies of scrap without delay. For this reason, the E.C.E. experts maintain, it is essential to intensify scrap collection and to ensure the rapid flow of the collected and processed supplies to the consuming works now. In the not too distant future, the demand for steel might decrease and pig-iron supplies improve considerably. There would then be a reduction in scrap requirements.

If Europe is to improve its scrap position, the price policy adopted in each country must be such as to encourage the collection of all available supplies, including those marginal tonnages which are difficult and expensive to collect and which might not normally be recovered. This policy may, in certain cases include special subsidy arrangements. All countries, it is urged, should also take appropriate measures to recover light scrap for pressing, despite its inferior quality and high cost of transport. Interested countries should study jointly the possibility of providing support for schemes to recover scrap from other than normal sources, such as the deserts of North Africa, abandoned wrecks, and sunken ships. Substantial quantities of scrap might be recovered from such sources during the next few years if adequate financial help and equipment could be provided.

Even where high prices constitute an incentive for maximum collection, some scrap does not reach the market because owners of even small quantities of scrap are not aware of the immediate benefits which they can derive from selling their scrap, or because those who are in immediate control of the scrap are not personally interested in the price factor. This can arise in the case of Governments, military establishments, public authorities, and even private enterprises where, in the absence of proper direction from the highest level, it is unlikely that steps will be taken to dispose of obsolete equipment. Similarly, many small farms or households can only be reached by intensive and well-organised collection. In spite of the results already achieved in scrap drives, further efforts to promote collection are needed. The panel emphasises that no country should suspend or abandon its efforts for intensifying scrap collection as soon as its own industrial requirements are satisfied, because the need to obtain extra tonnages for export continues; and no measures should be taken to prevent the export of such surplus tonnages to countries suffering from scrap shortage.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, CAMBRIDGE.

(*For Description, see Opposite Page.*)

FIG. 19. DISC HARROWS; MESSRS. HARRY FERGUSON, LIMITED.

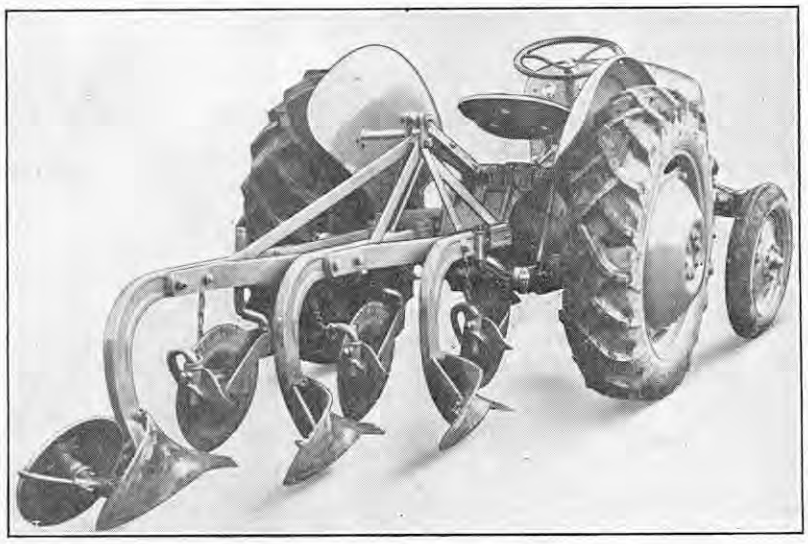


FIG. 20. THREE-FURROW PLOUGH; MESSRS. HARRY FERGUSON, LIMITED.

RESEARCH AND DEVELOPMENT CENTRE OF THE SIMON ENGINEERING GROUP

ON page 19, *ante*, we referred to the opening by Sir Henry Tizard of new buildings for research and development, erected at Cheadle Heath, Stockport, for the Simon Engineering Group. The principal members of this group are the firm of Henry Simon, Limited—founded in 1879 by the late Henry Simon, father of the present Lord Simon of Wythenshawe—which specialises in the design and erection of flour and provender mills and milling plants for cereals; Messrs. Simon-Carves, Limited, specialists in coal, coke and gas plant, water-tube boilers, steam power-plants, and sulphuric-acid and other chemical plants; Simon Handling Engineers, Limited, concerned mainly with pneumatic and mechanical handling, granaries and their equipment, and storage, weighing, screening and blending plants; and Turbine Gears, Limited, manufacturers of industrial gears and gear units. In addition to these main members there are numerous subsidiary companies. It will be evident, therefore, that the Simon group has many ramifications and covers a wide field in engineering. Although the constituent companies have engaged in research and development related to their activities for many years, their experimental work at Cheadle Heath, although it would be incorrect to say that it was not co-ordinated, has been organised departmentally and carried on in a number of separate laboratories and experimental plants scattered over the 80 acres of the site. The various research groups therefore, have not enjoyed the advantages of working intimately together under one roof. The new research centre, which has cost some 250,000*l.* to build and equip, remedies the situation and provides the research staffs with more and better accommodation than hitherto.

The new buildings, illustrated in Fig. 1, on page 76, include the laboratory block, seen on the left, for Messrs. Simon-Carves, Limited, and the experimental flour mill of Henry Simon, Limited, which is housed in the tower on the right. Behind the laboratory building, but not visible in the illustration, there is a further building for development work, which is shared by Messrs. Simon-Carves and Simon Handling Engineers, Limited. The executive and drawing offices are housed in a wing of the building which lies to the right of the tower, as illustrated, and which forms a continuation of the laboratory block.

The new research department will act as a central organisation serving all the Simon-Carves contracting departments and its work will fall into three main categories, namely, mechanical and chemicals testing, pure and applied research, and the provision of a technical information service. The first of these will be a continuation and expansion of investigations that have been in progress for the past 50 years. The design of coal preparation and utilisation plant, in which the company specialises, demands extensive preliminary investigations of the coals to be used, in order that the plant shall function as efficiently as possible. No fewer than nine laboratories, therefore, have been provided for the preparation and analysis of samples, for assessing the "washability" and coking qualities of coals, and for determining their calorific values, ash-fusion characteristics and grindability. The laboratory illustrated in Fig. 2, on page 76, is for the chemical analysis of coal, by-products, ores, metallic residues, water, acid-resisting materials, etc. A float-and-sink laboratory contains equipment for separating shale and dirt from samples of graded coal in prepared solutions of known specific gravity. Another laboratory, illustrated in Fig. 5, on Plate V, is equipped for coal carbonisation and coke reactivity tests, and a third contains a series of muffle furnaces, employed to determine the ash and volatile contents and the agglutination characteristics of coals.

Facilities have been provided also for testing the refractory materials used in coke ovens and in boiler combustion chambers, and for metallurgical work, which includes the heat-treatment and microscopic examination of metals used in the construction of plant. Building materials, also, will be tested. A furnace room contains equipment for heating refractory materials to temperatures up to 1,750 deg. C., the furnaces using gas, compressed air and oxygen. A room has been provided with equipment for crushing refractories, for preparing samples suitable for specific-gravity determinations and for examining test pieces under load after they have been subjected to expansion and refractoriness tests. A metals-testing laboratory contains equipment for the mechanical and physical testing of metals and for heat-treatment. The apparatus includes a 300-ton compression tester, a 50-ton Denison Universal testing machine and a Vickers projection microscope.

A large and varied programme of research will engage the attention of the research groups. A subject of considerable interest and importance is the behaviour of aggregates of small particles such as are encountered in sedimentation, in the collection, extraction and disposal of industrial mists and dusts, in the pulverisation of coal, and in the combustion of pulverised fuel and sulphur-bearing ores. The fact that the particles forming these aggregates are seldom of uniform density adds to the difficulty of precipitating them by electrostatic means and complicates such problems as the assessment of boiler flue-dusts and the determination of the stability of dense media in coal-washing baths. Research on dense-medium coal-washing requires a study of the magnetic properties of such particles, and methods of identifying and analysing magnetic constituents of ores require development.

A major problem, at present, is the supply of sulphur for the production of sulphuric acid. The sources of sulphur under examination by the company include waste gases and flue gases. Sulphur is also present as hydrogen sulphide in town's gas and can be obtained by flash-roasting iron pyrites. Recently, interest has been aroused in the possibility of obtaining sulphur from micro-biological processes. The company is also studying problems relating to effluents from gasworks and coke ovens and is investigating the corrosion-resistance of metals used in plant construction. Fundamental or long-range research is in progress to determine heat- and mass-transfer coefficients which will provide data on absorption required in the commercial production of sulphuric acid. Electrostatic precipitation is also being studied, with special reference to migration velocities, the wave-form of applied potentials, and corona discharge.

The work of the development department falls into two categories. The first involves the study of new principles and processes developed in the laboratories with a view to their commercial application. This generally involves the construction of a number of pilot plants of increasing scale. In the early stages, individual units of such plants are tested and, later, the units are integrated to form a complete plant. The other main branch of the department's work does not involve new principles but calls for a study of the operating characteristics of existing commercial plants. The results of these investigations are taken account of in the design of subsequent installations or in the modification of existing ones. The erection of pilot plants is delegated to the development building section, and the plants are designed so that they can be modified or replaced readily, although some of them become permanent installations and serve as large-size test equipment once their performance and operating characteristics have been established.

The development building at present houses three pilot plants in various stages of development. The largest is a coal-washing plant illustrated in Fig. 3, on Plate V, which is capable of treating 20 tons of raw coal an hour. It incorporates several novel features which improve the efficiency of the washing process, simplify the design, and result in lower capital and operating costs. A dense medium, prepared from blast-furnace flue dust and containing a high percentage of magnetic material, is employed for separating the coal from the dirt by what is known as the "float and sink" method, in a bath of controlled specific gravity. The magnetic properties of the medium are used subsequently to effect its recovery and cleansing. Similar methods have been used for many years in ore dressing, but they have been applied to coal washing only recently on any large scale, largely as a result of the growing use of coal-cutting machinery and the opening up of inferior seams, which have made coal washing increasingly difficult and necessary.

The washing process, when a dense medium is employed, is comparatively simple. If a bath of liquid of suitable specific gravity is employed, the coal floats to the surface and the dirt sinks to the bottom. In the scheme developed by Messrs. Simon-Carves, Limited, and incorporated in the pilot plant mentioned above, the bath is comparatively small and is located beneath two rotating conveyor wheels which dip into it. These wheels are mounted vertically in planes at right angles and are so arranged that they interlace like the links of a chain. The higher wheel of the two, which passes through the upper half of the liquid, conveys the uncleaned coal to the bath and the cleaned coal away from it. The lower wheel, passing through the lower half of the liquid, collects the sludge and removes it from the bath.

The cleansing of the contaminated medium is more complicated, but is essential if running costs are to be kept low and if troublesome increases in viscosity which would affect the efficiency of separation are to be avoided. Magnetic cleaning offers what is possibly the simplest solution to the problem, and Messrs. Simon-Carves, Limited, have devoted considerable attention to it. The mixture of the solid material of the medium with the coal and clay slimes is collected and pumped to a magnetic desliming cone. In this, the medium is magnetised and, in consequence, flocculates. In this condition, it settles rapidly to the base of the cone, while the coal and clay slimes, which are unaffected by the magnets, overflow from the rim. The process is highly efficient and normally suffices to clean the medium to the required degree. If this is so, the specific gravity of the outflow at the base of the cone is maintained at a value between 1·8 and 2·0 and the effluent gravitates to a de-magnetiser in which the medium is deflocculated and pumped to a storage tank. When additional cleaning is necessary, the underflow from the magnetic cone is fed to a separator employing a magnetic belt, from which an almost completely clean product is obtained. The latter is then de-magnetised and pumped to storage.

The development building also contains a coke-oven plant completed some years ago and now used for test purposes. This equipment is illustrated in Fig. 4, on Plate V. The oven of this plant can carbonise 10 cwt. of coal at a time. There are also coal-crushing and blending plants and means for examining the coke which is produced. An integrating radio-meter is employed to investigate the combustion qualities of samples of domestic coke. The third of the pilot plants which were mentioned above is for distillation and is being used to try out a new process. The design of the fractionating column represents a departure from earlier practice and promises well. Work, which includes guarantee and performance tests of coke ovens and coal-washing plants, investigations of pressures within coke ovens, determinations of the shrinkage characteristics of coking coals and the establishment of heat and material balances in by-product plant, is also done on full-size installations.

Short-term investigations are frequently required at the site of some particular plant. When bench experiments suffice, these are carried out by the chemical plant department in collaboration with the research department. The mobile laboratory, illustrated in Fig. 6, on Plate V, is frequently employed for this purpose. Long term work, which includes the development of equipment for producing sulphuric acid, for sulphur recovery, and for electrostatic precipitation, is also undertaken by the chemical-plant department. The power-plant department's investigations include studies of the behaviour and characteristics of fuels, the treatment of feed water, and heat transmission and water-circulation in boilers. A combustion pot is to be installed in the development building to determine the behaviour of solid fuels on travelling-grate and spreader stokers, and a new type of pulveriser will be used for an investigation of the pulverisation characteristics of coals. Another test rig will be used to determine the best type of expanded joint for high-pressure pipelines.

Messrs. Simon Handling Engineers, Limited, who also make use of the development building, have installed there a pneumatic and mechanical handling plant which is being used to determine whether certain materials which, hitherto, have been considered unsuitable for pneumatic handling, can, in fact, be transported by this means. The main problems are first, to move the material and, secondly, to separate it from the air stream. It is important, also, to examine its behaviour in storage bins. The test plant comprises a full-size pneumatic intake and handling system fitted with various types of air filter. It operates in conjunction with mechanical handling equipment, and includes automatic weighers, small storage bins and a spout for sack-filling. The plant is also used to test newly-developed equipment.

As was mentioned previously, the tower which is a conspicuous feature of the new buildings, contains full-size plant for grain cleaning and flour-milling. The equipment is arranged on six floors, as in a commercial mill, and includes a low-pressure pneumatic conveying system. New processes and the performance of new equipment can be studied in the mill on a practical scale. Messrs. Henry Simon, Limited, who operate the plant, also have laboratories equipped for research on flour milling and for studying the fundamentals of grinding, separating and conveying mill stocks. A flour-treatment laboratory contains apparatus for determining the ash and moisture contents, the particle size and the colour of flour, and for assessing the special properties of self-raising flour and the strength and gluten content of dough. The laboratory's main function is to assess the performance of new machines.

Although much of the work of research and development has, of necessity, been passed over, it will be evident that a wide field is covered. The firm founded by Henry Simon is now a large undertaking with important connections overseas and a large share in the export market. In the fierce competition which characterises modern commerce, established positions can be maintained only by continually improving the design and quality of commercial products. The new research and development buildings of the Simon Engineering Group testify to a recognition of this fact by the constituent companies and to their determination to maintain their world-wide prestige.

RESEARCH OF THE SIMON GROUP CENTRE.

FIG. 1. LABORATORY BUILDINGS.

FIG. 2. ANALYTICAL LABORATORY.

WEST HAM "B" POWER STATION.

THE West Ham "B" power station of the British Electricity Authority, which was formally opened by the Mayor of West Ham (Councillor W. W. Paton) on Wednesday, July 18, is the fourth of its line. The first, which was started up in 1895, was situated in Canning Town and contained two 15-kW sets driven by horizontal gas engines. Shortly afterwards, a second station was opened at Abbey Mills, in which four Ferranti sets with a total capacity of 675 kW and operating with steam at 120 lb. per square inch, were installed. In 1899, two further Ferranti sets, each with a capacity of 1,200 kW, were brought into use at this station, while in 1904 a station on Bow Creek was inaugurated with a capacity of 5,700 kW, some of which was provided by machines transferred from Abbey Mills. This station was extended at various times until, before the war, its capacity had been increased to 76·5 MW, of which 66·5 MW is still in commission.

This station, which is now known as the "A" station, however, is being gradually replaced by the "B" station on a site which has good cooling-water facilities. Coal can be brought in by barge and railway, and the station is well placed with regard to the load, the surrounding district having been scheduled for industrial development under the Town and Country Planning Act. The new station is designed for an ultimate capacity of 180 MW, made up of six 30-MW sets, and will be completed in three stages. The first of these is now in operation and is described below. The second is in course of construction, while the third will follow later. Its design is due to Mr. J. W. J. Townley, who, when the plans were made, was engineer and manager of the West Ham Electricity Department. Associated with him were Messrs. Merz and McLellan and Mr. G. D. Bendix.

In the paper which he read before the recent Joint Engineering Conference, Mr. V. F. Bartlett pointed out that the extension of a station while the plant was kept in operation gave the civil engineer some difficult and interesting problems. This is well illustrated at West Ham, where the site has been extended from 9 acres to 21 acres. The site was covered by a layer of ballast from 6 ft. to 10 ft. thick, about 15 ft. below ground level, and the standing-water level was only a few feet below ground. It was therefore necessary to enclose the area in a steel sheet-pile cofferdam.

In the boiler house, owing to the limited area available, special arrangements had to be made for the chimneys, fans and dust-extraction plant at suitable levels. The 280-ft. chimneys, of which there will be one to every four boilers, have been built above the coal bunker bay on a group of four main columns on the portal system. The framework of the boiler house consists of box-type plated columns, resting on grillages. The walls are of dull red facing brick. The boiler-house roof and the forced-draught fan floor are of concrete. The turbine-house operating floor is of concrete with a tiled finish and is laid upon curved corrugated sheet centring with large well openings between the sets. The switchhouse is a separate reinforced-concrete building 80 ft. square with an adjacent open-type structure for the main transformers. The

RESEARCH AND DEVELOPMENT CENTRE OF THE SIMON ENGINEERING GROUP, STOCKPORT.

(*For Description, see Page* 75.)

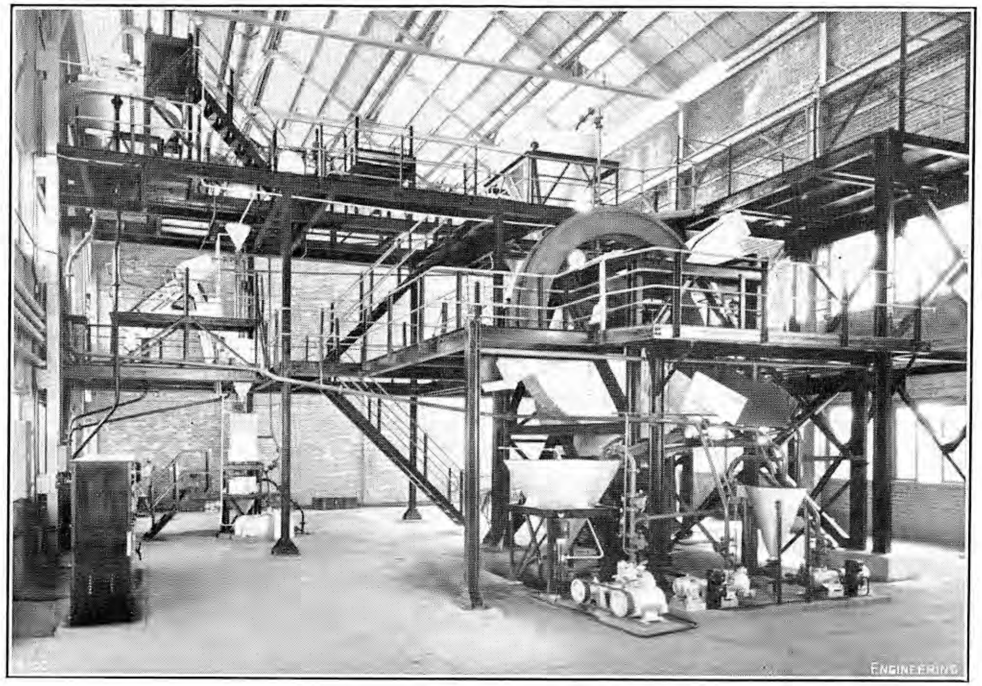


FIG. 3. DENSE-MEDIUM COAL-WASHING PLANT.

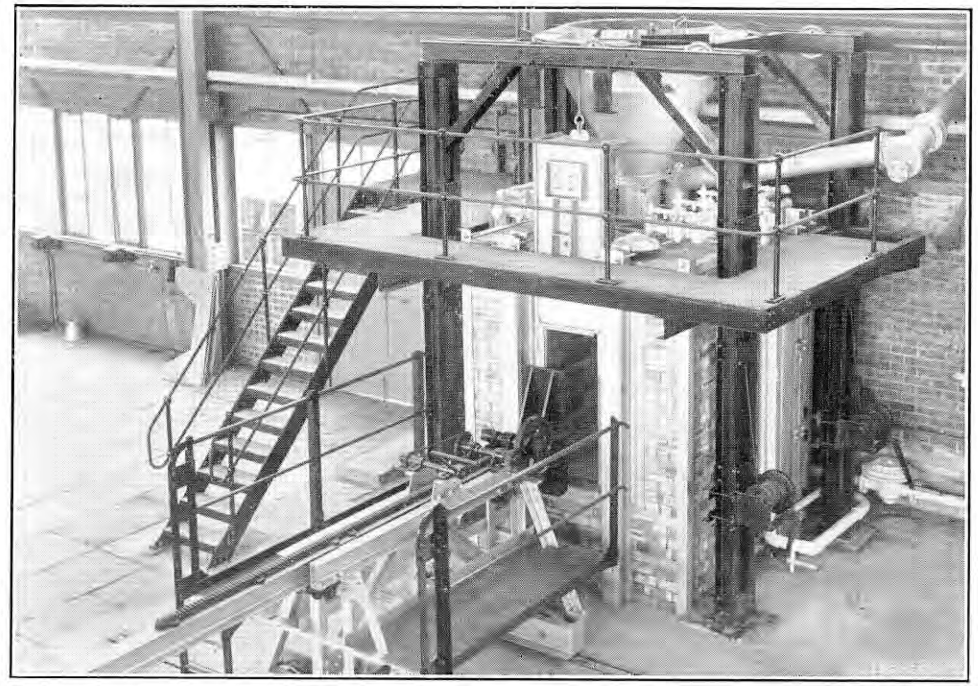


FIG. 4. EXPERIMENTAL COKE OVEN.

FIG. 5. LABORATORY FOR TESTING FUELS.

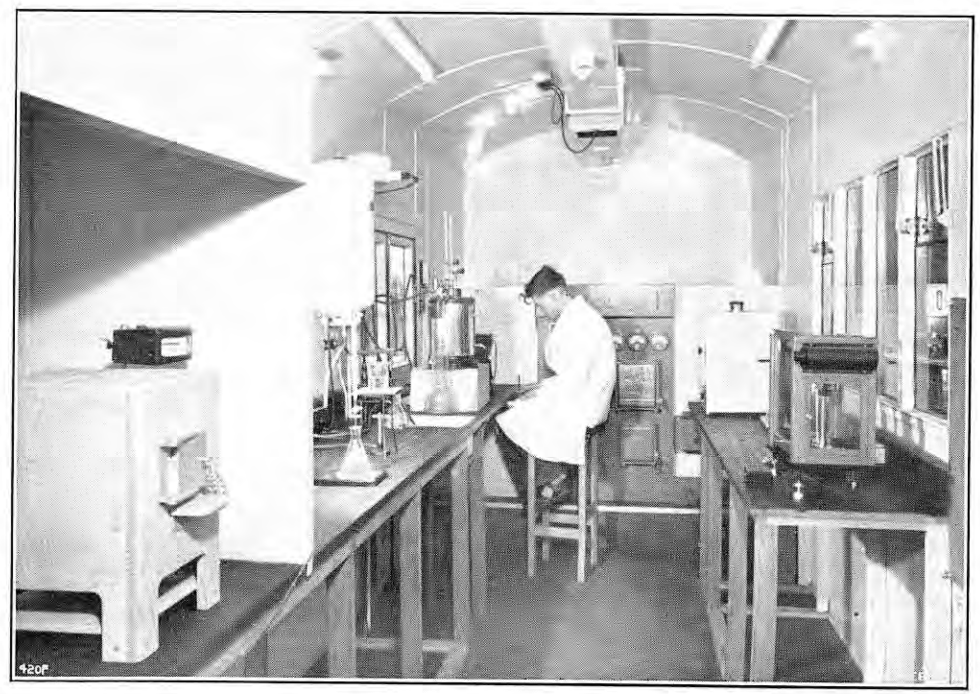


FIG. 6. SIMON-CARVES MOBILE LABORATORY.

THE 180-MW WEST HAM "B" POWER STATION OF THE BRITISH ELECTRICITY AUTHORITY.

(*For Description, see Page 76.*)

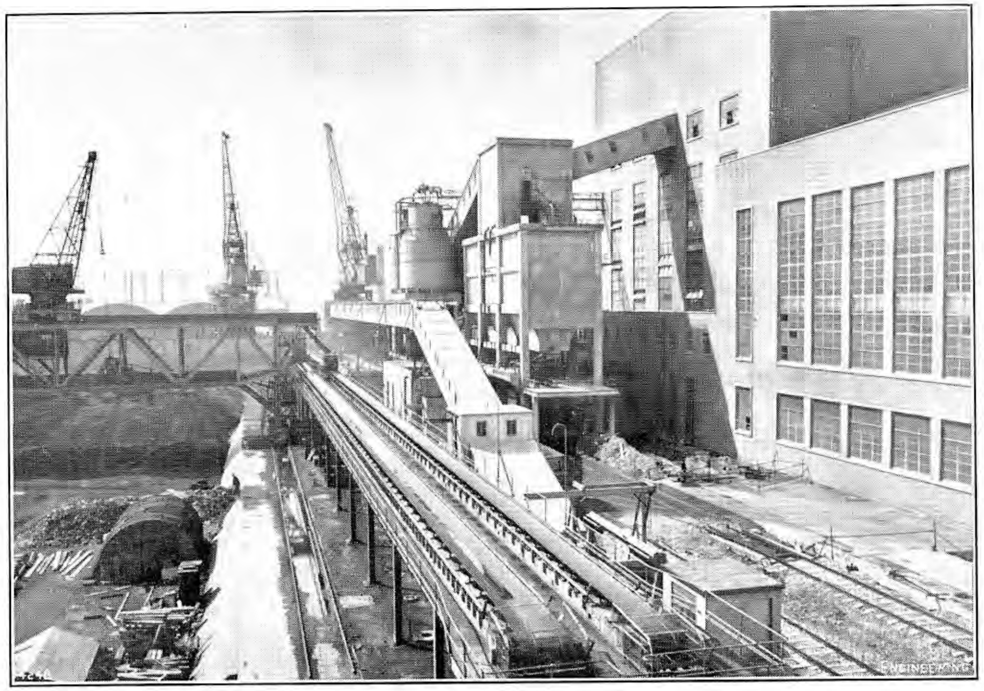


FIG. 2. CONVEYORS AND COAL-HANDLING PLANT.

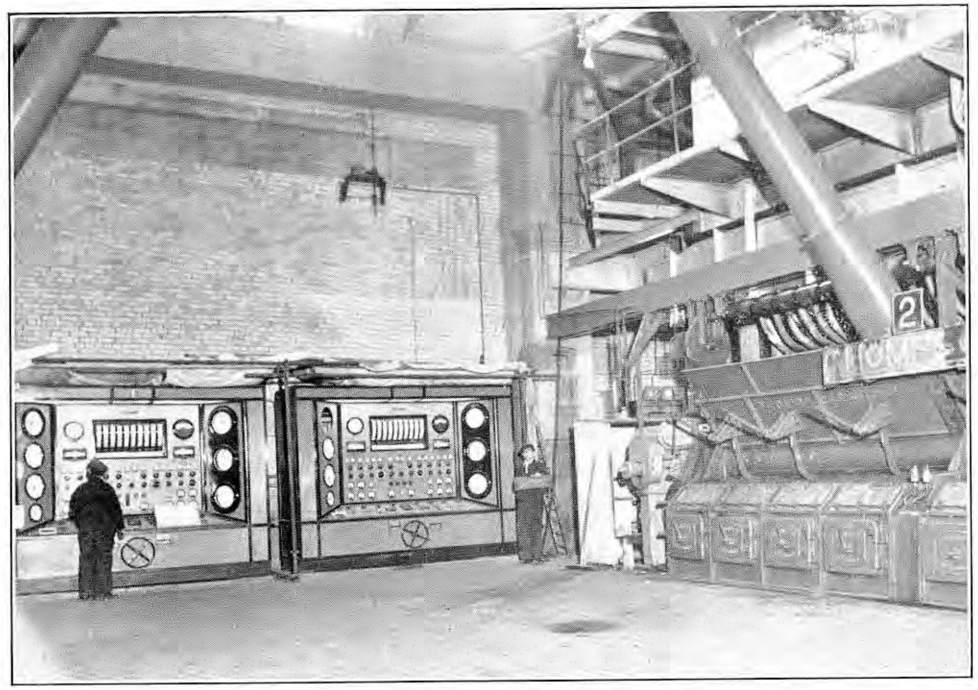


FIG. 3. FIRING FLOOR OF BOILER HOUSE.

FIG. 4. GENERAL VIEW IN TURBINE ROOM.

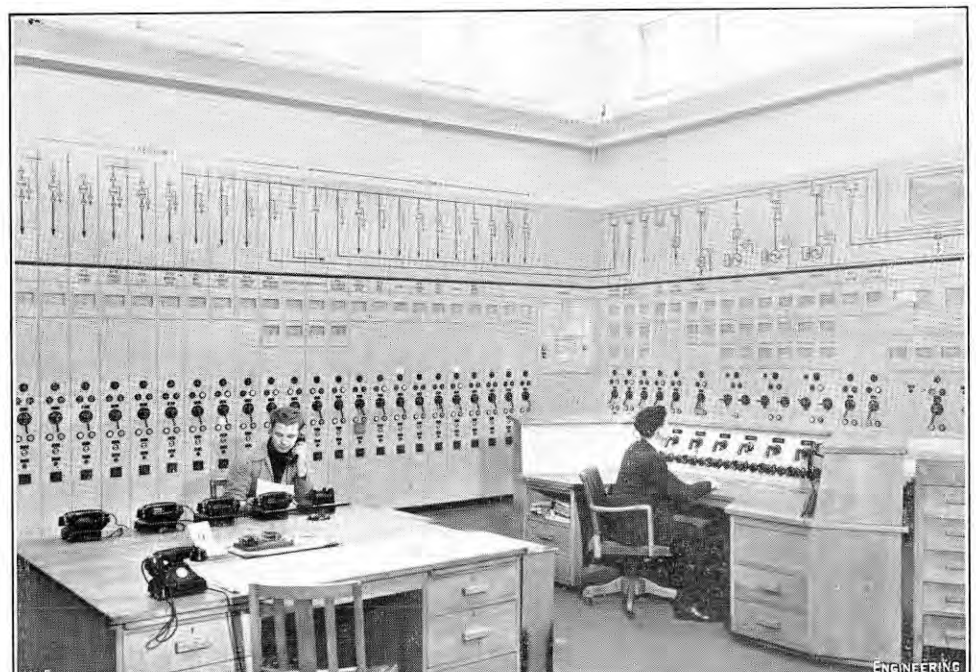


FIG. 5. CONTROL ROOM.

(To face page 77.)

WEST HAM "B" POWER STATION

FIG. 1. GENERAL VIEW OF STATION FROM CANNING TOWN BRIDGE.

main office block and control-room building, which measures 180 ft. by 80 ft., is also of reinforced concrete. The consulting engineers for the civil engineering work at the station were Sir Alexander Gibb and Partners, Queen Anne's Lodge, London, S.W.1, and the main contractors were Taylor Woodrow Construction, Limited, Southall, Middlesex. The station is illustrated in Fig. 1, on this page.

The coal-handling plant, for which W. J. Jenkins and Company, Limited, Retford, were the main contractors, is designed to receive rough small coal delivered either by barges or by rail. Arrangements are also being made to supply the station with coke breeze from the neighbouring gasworks. The water-borne coal is brought into Bow Creek, where the original jetty has been extended from 300 ft. to 650 ft. to accommodate ten 200-ton barges at a time, as well as two further barges for ashes. It is discharged by two Stothert and Pitt luffing cranes into a mixing bunker and is taken thence by conveyors, of which a view is given in Fig. 2, Plate VI, either to the boiler-house bunkers or to the coal store. This store, which has a capacity of 21,000 tons, when stocked to a depth of 5 ft., is spanned by a transporter bridge constructed by Fraser and Chalmers Engineering Works, Erith, which carries a distributing belt conveyor on its lower chord.

The two coal bunkers, each of which has a capacity of about 1,100 tons, are lined with reinforced high-density concrete and serve two boiler units. The steam-raising plant will ultimately consist of 12 "Radiant" boilers, by John Thompson Water Tube Boilers, Limited, Wolverhampton, of which four are at present installed. These boilers, which have an economical rating of 144,000 lb. of steam per hour and a maximum capacity of 180,000 lb. per hour at a pressure of 640 lb. per square inch and a temperature of 875 deg. F., are designed to burn Northumberland and Midland small coal, as well as a mixture of 80 per cent. coal and 20 per cent. coke breeze. Each boiler has a convection superheater, an interstage de-superheater of the contact type with automatic control, a Green's gilled-tube economiser, and an air heater.

Firing is effected by Underfeed chain-grate stokers of the L-type, which were constructed by International Combustion, Limited, Woburn-place, London, W.C.1. These are supplied with coal from the bunkers mentioned above by two traversing chutes. Draught is provided by two induced-draught, two forced-draught and two secondary Howden fans. The boilers are equipped with the Hagan system of pneumatic control, supplied by James Gordon and Company, Limited, Stanmore, Middlesex. This is arranged so that each of a set of four boilers can be controlled individually from a single master regulator or from the combustion engineers' office. These panels are illustrated in Fig. 3.

The ash-handling plant, which was constructed by B.V.C. Industrial Constructions, Limited, Kingsway, London, W.C.2, is of the high-pressure sluicing type. In this, the ash is removed from the hopper by water jets and forced along sluice-ways, through clinker grinders, into two sumps in the boiler-house basement. It is pumped thence into a 750-ton reinforced-concrete hopper, which is visible in Fig. 2, and is discharged through three hand-operated water-collecting gates into rail wagons or lorries. The dust in the flue gases is removed before the inlets to the induced-draught fans by Howden multi-cell centrifugal separators, and is collected in separate hoppers.

The generating plant will eventually consist of six turbo-alternators constructed by the English Electric Company, Limited, Queens House, Kingsway, London, W.C.2, of which two are at present in operation, as shown in Fig. 4, Plate VI. The turbines are single-line two-cylinder machines, and exhaust into twin-shell condensers which are three-pass on the water side. At maximum continuous rating, 21,000 gallons of water per minute are required, and this is at present supplied by three vertical-spindle circulating pumps, supplied by W. H. Allen, Sons and Company, Limited, driven by 550-h.p. squirrel-cage motors and operating against a head of 61 ft. Make-up water is drawn from the River Lea by three Allen pumps with a capacity of 2,700 gallons per minute, driven by 32-h.p. motors.

A reinforced-concrete cooling tower will eventually be erected for each pair of sets by J. L. Kier and Company, Limited, 7, Lygon-place, London, S.W.1. These towers, of which two have been constructed at present, are designed to cool 2,800,000 gallons of water per hour from a temperature of 82·5 deg. to 70 deg. F. at a dry-bulb temperature of 57 deg. F. and a relative humidity of 70 per cent. They are 280 ft. high with a maximum diameter of 192 ft., and are built over a rectangular pond in which the depth of water is 9 ft. The water is delivered through cast-iron culverts 42 in. in diameter.

The feed-heating system of each set comprises two main ejectors, one quick-start ejector and two extraction pumps, as well as two evaporators, three high-pressure heaters, and one low-pressure heater, all supplied by the English Electric Company. The final temperature of the feed water is 340 deg. F.

The alternators, which generate three-phase current at 11 kV and 50 cycles, and directly-coupled to main and pilot exciters and an automatic voltage regulator. They are ventilated by two separate fans, which are connected between the air-cooler outlet and the alternator inlet. Circulating water from the main condenser is used for cooling the air. One of the machines is connected to a 11-kV switchboard, which is, in turn, coupled through a 20-MVA Scott-connected transformer to the two-phase 'busbars in the "A" station. It is also connected through a 30-MVA transformer to the adjacent 66-kV grid substation. The second machine is only connected through a 33-MVA transformer and reactor to the grid substation. The alternators will be coupled either to the grid or to the 11-kV 'bus-bars.

The 11-kV main switchgear is of the oil and compound-filled metal-clad type and was manufactured by A. Reyrolle and Company, Limited, Hebburn, Co. Durham. It has a rupturing capacity of 750 MVA. Unit transformers are solidly "Tee'd"-off the connection between each alternator and its switchgear, and from them supplies are furnished at 3 kV and 415 volts to auxiliary circuits. The 3-kV "unit" boards, which were manufactured by the English Electric Company and carry indoor air-insulated air-break switchgear, are also connected to the 11-kV 'bus-bars through "station" transformers and boards, and give supplies for starting up and other purposes. The non-essential auxiliaries are usually supplied in groups from the "station" boards through auxiliary transformers, and the essential auxiliaries through the unit transformers. These auxiliaries, which consist of those associated directly with the boilers and turbo-alternators, and without which the station could not function, are remotely controlled from the boiler-control panel, from positions near the turbo-alternators and from the pump house. The other auxiliaries are controlled locally. The 66-kV switchgear, 11-kV main and distribution switchgear and their auxiliary supply circuits are controlled from the operating room illustrated in Fig. 5, Plate VI. The control of the generators is centralised on a desk in the same room.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

THE LATE MR. RICHARD C. M'PHEE.—The death occurred on July 12, at his home in Uddington, of Mr. Richard C. M'Phee, formerly general manager to William Baird & Co., Ltd., Glasgow. Mr. M'Phee was a pioneer in coal-face conveying, and, while engaged at Bothwell, he invented a new type of conveyor, which he named the Bothwell conveyor. Mr. M'Phee had been President of the Scottish Colliery Managers' Association and vice-president of the Mining Institute of Scotland.

STEELWORKS EXTENSIONS.—Plans for the erection at Dalzell Steelworks, Motherwell, of a bar mill cooling bay and effluent ponds and filters were approved on July 12 by the Motherwell and Wishaw Dean of Guild Court. Permission was also given for the erection of buildings at the works of the Lanarkshire Steel Company as an Ilgner and contact house. These extensions will cost 52,500*l*.

DECLINE IN IRON AND STEEL OUTPUTS.—The production of steel ingots and castings declined to an annual equivalent of 2,140,500 tons during June as against 2,276,400 tons in May, and 2,526,100 tons in June last year. On the basis of the latter figure, the drop in output amounted to 18 per cent. The production of pig iron was at an annual rate of 765,400 tons in June, compared with 807,600 tons during May, but, as a result of reduced furnace availability in June last year, production was then equivalent to 678,100 tons per annum only.

NEW RUNWAY AT PRESTWICK.—On July 9, the Scottish Aerodromes Board agreed to an alteration of the specification in connection with the contract for the new runway under construction at Prestwick. This provides for the use of a concrete sandwich in a section in which peaty clay subsoil had been found. Air Commodore J. G. Murray, Scottish divisional controller, Ministry of Civil Aviation, hopes, however, that the work will be completed to time table.

THE QUALITY OF COKE—Since the setting up of a metallurgical coke advisory panel in February last, the quality of coke has considerably improved and there is cause for believing that the improvement will be maintained, according to an announcement by the Scottish Board for Industry. In view of this, the panel will not meet again, unless requested to do so by the National Coal Board or by the representative organisations of the foundry industry.

CLEVELAND AND THE NORTHERN COUNTIES.

SCARCITY OF TEES-SIDE PRODUCTS.—Home and overseas customers for iron and steel are pressing persistently for larger supplies than producers can provide, and, to give increased attention to export demands, some curtailment of supply for pressing home needs cannot be avoided. The order of priority delivery is for defence purposes; then follow export and urgent needs for ordinary home commercial purposes. The position in regard to distributable home material is a little more hopeful, and deliveries of iron and steel scrap are more than maintained at recent improved levels, but these commodities are still wanted in vastly greater quantities than are available. There is continued complaint of a shortage of pig iron and the various classes of steel.

HEAVY-TRACTOR MANUFACTURE ON TYNESIDE.—Vickers-Armstrongs Ltd. are to undertake the manufacture of a heavy tractor at their Scotswood Works, Newcastle-upon-Tyne. It is stated that orders for the tractors have already been received from several parts of the world, and that, to manufacture these, approximately 1,000 more men are needed by the firm. Skilled and unskilled personnel are needed, including fitters, turners, gear-cutters and drillers. Additional draughtsmen will also be required.

SUMMER HOLIDAYS AND COAL OUTPUTS.—Largely owing to the incidence of summer holidays, the coal produced at collieries in the North-Eastern Yorkshire Division of the National Coal Board during the first week of July, namely, 906,761 tons, was upwards of 20,000 tons less than the output for the previous week.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL PRODUCTION.—Official figures for steel production during June show an improvement on those for May, but some Sheffield steel users are unable to obtain sufficient supplies to justify full-time working, and business has had to be refused, in some instances, because firms could not secure all the steel they required. It is expected that the production figures for Sheffield when available will reflect the consequences of the closing of five large open-hearth melting furnaces, owing to the shortage of scrap metal and imported ores. In some cases, wire-rod rollers, and strip and bar mills, have had to reduce the number of shifts worked, owing to lack of steel supplies.

POSSIBLE CLOSURE OF COAL SEAM.—The Shafton seam at Frickley Colliery, South Yorkshire, which was opened during the war period, has not reached its weekly target of 3,592 tons for some months, and, unless there is an improvement in production, the seam may have to be closed. A warning to that effect has been given to the 430 miners employed at the seam. An official at the colliery stated that the men were not implementing the conditions of an agreement signed in January last after two years' negotiations.

CIVIL DEFENCE AT YORKSHIRE STEELWORKS.—The nucleus of an industrial civil-defence organisation has been set up in Sheffield, and most of the firms belonging to the local Chamber of Commerce are sending representatives to the meetings of the Chamber's re-formed A.R.P. committee. Sheffield civil defence corps has trained a number of volunteers from the city's industrial establishments as instructors for civil defence units.

WATER FOR INDUSTRY.—According to the annual report of the Sheffield water undertaking for 1950, increased trade supplies accounted for an increase of 20,260*l*. in its income. The undertaking made a gross profit of 31,999*l*. during the year, an increase of 15,782*l*. on the figures for the previous twelve months. Miscellaneous income showed a decrease, partly because no compensation had been received for the military occupation of land owned by the waterworks.

INCREASE IN SHORT TIME.—The rolling mills of the Whitehead-Thomas Bar and Strip Co., at Redbourn Works, Scunthorpe, have been on short time recently, owing to continued shortages in the supplies of steel. Much larger quantities of scrap metal are required by the steel furnaces. Local brands of pig iron are in adequate supply, however, as the blast-furnaces can obtain ore from the North Lincolnshire ironfields.

STEEL PRODUCTION RECORD.—During the first six months of this year, the Normanby Park Steelworks, Scunthorpe, established a new record in its production of open-hearth steel, with an output of 179,781 tons. This represented an increase of 2,428 tons over the corresponding period of 1950.

THE MIDLANDS.

RAW MATERIALS.—In the Midlands, the shortage of iron and steel continues to be a major problem. Foundry pig is difficult enough to obtain, but the steel position is worse. Local re-rollers of bars, sections and sheets, who might otherwise do much to ease the position, are unable to obtain sufficient supplies of semi-finished steel, and the same applies to makers of bright-drawn products. Few of the works in either of these categories are operating to full capacity; some are working four days a week, and others are closing down for a week or two at a time. Some firms who require large quantities have depleted their normal stocks and are working from day to day. The holiday period is approaching, when steel works will be closed, and at least one firm, the Raleigh Cycle Co., have notified their employees that they may have to cease work until the steelworks resume.

BRIGHT FINISHES AND THE EXPORT TRADE.—In the case of non-ferrous metals most users have managed to find substitutes, but attention has been drawn to one possible effect of the shortage where alternatives may not be the solution to the problem. In Birmingham and parts of the Black Country, many products are made for export markets where a bright finish is essential; but the shortage of nickel may make it impossible to produce an acceptable article, and fears have been expressed that, if and when suitable non-ferrous metals are again available, these markets may have been lost.

THE INSTITUTE OF WELDING.—The new chairman of the Institute of Welding is Mr. Howard Thompson, chairman and managing director of Thompson Brothers (Bilston), Ltd., Bilston, Staffordshire.

THE INSTITUTE OF INDUSTRIAL SUPERVISORS.—A one-day conference of foremen was held at Darlaston, Staffordshire, on July 7. Over 200 foremen from various parts of the Midlands attended the conference, which was held under the auspices of the Institute of Industrial Supervisors. The purpose of the meeting was to discuss the possibility of offsetting the rise in the cost of materials by improved methods of handling. Mr. A. G. B. Owen, chairman and joint managing director of Rubery Owen & Co., Ltd., opened the conference, and the delegates then toured the Rubery Owen works to see mechanical handling equipment. Papers were delivered by Professor J. R. Immer, lately of the University of Minnesota, and by Mr. E. G. Taylor, of the General Electric Co.

THE RECEPTION OF FACTORY VISITORS.—Tube Investments, Ltd., have issued, for the use of appropriate members of their staff, a booklet entitled "A Guide to the Proper Treatment of Factory Visitors." This aspect of public relations work, which has become of increasing importance in recent years, is discussed humorously, but very sensibly. Attention is drawn to such details as the importance of memorising visitors' names, the dispensing of hospitality, how to fill up evenings when a visit lasts two or three days, subjects to be discussed, and how to conduct a visitor round the factory. The pamphlet has attracted so much attention, especially among overseas visitors, that the firm have authorised the British Association for Commercial and Industrial Education to prepare a special edition for general sale.

SOUTH-WEST ENGLAND AND SOUTH WALES.

CHLORINE GAS IMPORTS.—Cargoes of chlorine gas were discharged at Newport, Monmouthshire, last week, by means of a pipeline direct from M.S. Klor to road and rail tankcars for dispatch to the works of the Monsanto Chemical Co. in the town. This is believed to be the first time that such a cargo has been handled in Great Britain. The vessel, which is specially fitted for handling cargoes of this nature, brought 125 tons of the gas from Norway.

NEED FOR GREATER USE OF SOUTH WALES PORTS.—Reference is made in the July *Bulletin* of the cargo clearing-house of the Industrial Association of Wales and Monmouthshire to the disappointingly small amounts of local manufacturers' products that are shipped through South Wales ports. That so many goods manufactured within a few miles of well-equipped and well-served ports should be sent by road and rail for distances of 200 miles or more before shipment, involves, in the opinion of the clearing house, a wastage which could and should be eliminated.

IRON AND STEEL OUTPUT.—The production of pig iron and steel ingots and castings in South Wales during June was higher than the monthly average for more than a year. Returns of the British Iron and Steel Federation show that the average weekly production of pig iron in the area during June was 25,910 tons, compared with 25,150 tons a week during the second quarter of this year, 25,360 tons a week during the first six months of this year, and 23,820 tons a week during June, 1950. The weekly average production of steel ingots and castings during June last was 68,730 tons, against an average of 68,040 tons a week for the second quarter of this year and 67,760 tons a week during June, 1950.

COAL ORDERS FOR THE ARGENTINE.—It was reported in Cardiff, towards the end of last week, that the Argentine Railways had placed new business for half a million tons of Welsh coal. Shipments were resumed recently, after being held up for some months while negotiations on the new general trade agreement were in progress. Orders for about 250,000 tons of coal, under old contracts, were in arrear, so that, with the new sales, the total quantity in hand for these buyers was 750,000 tons. Delivery will be spread over the twelve months between June, 1950, and June, 1952. Smaller orders for coal are in hand for the Argentine public utility services.

COAL EXPORTS TO PORTUGAL.—Britain's coal trade with Portugal, which has been largely in abeyance since the end of June, is likely to be restarted soon. Allocations for the third quarter of the present year had been delayed but have now been made, and it is stated these will amount to between 25,000 and 30,000 tons during the three months ended in September next.

USK RESERVOIR SCHEME.—Good weather conditions and an increased labour force enabled considerably improved progress to be made on the Usk Reservoir scheme during June, according to a report made to the Usk Reservoir committee. Mr. T. B. Bowen, the Town Clerk of Usk, stated that the lowest tender for the laying of pipe lines for a reservoir, amounting to 597,000*l*., had been accepted.

COAL-MINE FLOODING AT EAST HOOK.—The new colliery at East Hook, Haverfordwest, which has already been sunk to a depth of 150 ft., has now been threatened with closure, owing to the possibility of extensive flooding from old workings. Mr. G. E. Aeron-Thomas, the chairman of the South Western Division of the National Coal Board, has discussed the position with representatives of the miners and the Haverfordwest Rural Council and a further meeting is to be arranged at an early date.

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.

INSTITUTE OF PHYSICS.—*Industrial Radiology Group*: Monday to Wednesday, July 23 to 25, at 47, Belgrave-square, S.W.1. Annual Summer Meeting. Monday, July 23, 2.15 p.m.: (i) "An Analysis of the Quality of Radiographs," by Mr. D. Bromley; and (ii) "Gamma-Ray Stereography," by Mr. J. Rhodes. Tuesday, July 24, 10 a.m., Discussion on "Penetrameters," to be opened by Mr. J. C. Rockley. 2 p.m., (i) "Growth of Radiography," by Mr. W. E. Schall; and (ii) "Correlation of Radiographic Results with Weld Strength," by Dr. H. Vinter. Wednesday, July 25, 9.45 a.m., (i) "Xeroradiography," by Dr. L. van Ouwerkerk; and (ii) "Short-Range Radiography," by Mr. E. van Someren. 2 p.m., "Site Radiography of Pipe Welds," by Mr. R. Piercey, Mr. S. H. Gottfeld and Mr. R. V. Walker.

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

CONTRACTS.

J. J. JOHNSTON & CO., LTD., 271, Uxbridge-road, London, W.12, have been awarded a contract by the Ministry of Supply for a number of large rotary snow ploughs for the Air Ministry. The aggregate power of the ploughing and propelling engines of each plough is in excess of 400 h.p. Two Meadows six-cylinder petrol engines, each developing 135 b.h.p., and driving through Vulcan-Sinclair hydraulic couplings of the traction type will supply the power for the ploughing motions. The four-wheel drive carrier, to be built by STEELS ENGINEERING PRODUCTS, LTD., Sunderland, will be driven by another 135-b.h.p. Meadows petrol engine identical and interchangeable with the ploughing engines.

BRITISH INSULATED CALLENDER'S CABLES, LTD., have received an order from the British Electricity Authority for high-voltage shunt capacitors totalling 22,500 kVA. These, when connected, will improve power-transmission conditions into South Wales and will help to meet future power-supply difficulties. Of the total, 12,000 kVA will operate on the 33-kV system and the balance of 10,500 kVA at 11 kV.

VICKERS-ARMSTRONGS LTD., Barrow-in-Furness, have received an order from the North American Shipping and Trading Co. (London), Ltd. (Stavros S. Niarchos), for the construction of two more tank steamers of 32,000 tons deadweight capacity. These new orders bring the total number of tankers ordered from Vickers-Armstrongs by these owners to ten, having an aggregate deadweight tonnage of 272,000. The new vessels will be propelled by steam-turbine machinery.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have been given an order by the Norwegian broadcasting authorities for a 200-kW long-wave installation for Oslo. The installation, comprising two 100-kW transmitters in parallel, is in a new range of air-cooled equipments recently designed by the Marconi Company. A novel feature is the use to which the exhausted air is put. After it has been heated in its passage through the transmitter, the air is employed to warm the transmitter building.

LEYLAND MOTORS, LTD., Leyland, Lancashire, have obtained a contract from the Argentine Government for 750 underfloor-engined 'buses, each having a 125-h.p. six-cylinder Leyland Diesel engine mounted between the front and rear axles under the floor of the passengers' saloon. Of the 750 vehicles, 300 will be Olympic chassisless 'buses, which incorporate Leyland engine units in bodies constructed by the METROPOLITAN-CAMMELL-WEYMANN MOTOR BODIES, LTD., and 450 will have Royal Tiger underfloor-engined chassis. Metropolitan-Cammell-Weymann will produce 200 bodies for the Royal Tiger chassis, SAUNDERS-ROE (ANGLESEY), LTD., will build 100 bodies, and the remaining 150 chassis will be shipped direct to the Argentine, where bodies for them will be constructed locally.

THE BURNTISLAND SHIPBUILDING CO., LTD., Burntisland, Fife, have secured a contract to build a bauxite-ore carrier of 7,850 tons deadweight for the Saguenay Terminals, Ltd., Montreal, associates of the Aluminium Co. of Canada. The main dimensions of the vessel will be 420 ft. between perpendiculars by 60 ft. 6 in. by 29 ft. 6 in., and her propelling machinery will consist of triple-expansion steam engines of 2,000 s.h.p., constructed by Rankin and Blackmore, Ltd., Greenock. The vessel is designed for trading between the company's aluminium works at Port Alfred, Quebec, and bauxite mines in British Guiana and Trinidad.

BRITISH STANDARD SPECIFICATIONS.

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

Flanged Cast-Iron Gate Valves for Petroleum Industry. —A further specification in the series now being prepared for the petroleum industry has been issued. It is designated B.S. No. 1735 and covers flanged cast-iron gate valves of classes 125 and 250. For saturated steam, the maximum permissible working pressure for class 125 valves, ranging from 1½ in. to 12 in. in size, is 125 lb. per square inch, and for class 250 valves, in the same size range, it is 250 lb. per square inch. The specification concerns flanged cast-iron gate valves fitted with either wedge gates or double disc gates and having either outside screw-and-yoke rising stems or inside screw non-rising stems, the seat rings being either separate or an integral part of the body wedge or discs. For liquid and gas at about atmospheric temperature the permissible pressure is a maximum of 400 lb. per square inch for class 250 valves of sizes 1½ in. to 12 in., and 300 lb. per square inch for class 250 valves of sizes 14 in. to 24 in. Corresponding maxima for class 125 valves are 175 lb. and 150 lb. per square inch. Clauses relating to design and manufacture, materials, workmanship, testing, inspection, dispatch and guarantee are given and four detailed drawings of valves are included. [Price 5*s*., postage included.]

Cast-Iron Smooth-Tube Economisers with Pressed Socket Joints.—This British Standard, No. 1713, is a new one, and covers economisers, of the type indicated by the title, having a maximum designed water pressure up to and including 325 lb. per square inch gauge, where the socket joints are not reinforced; and 475 lb. gauge, where the socket joints are reinforced in accordance with the requirements of the Standard. Formulæ are given for computing the design pressure for economiser sections with pressed socket joints; for the minimum thicknesses of headers, tubes and manifold pipes; and for determining flange dimensions. The appropriate numbers of flange bolts and studs are given, together with the minimum sizes of studs for certain pressures, and the minimum depth for the tapped holes. Installation requirements, and details of the mountings, are specified. Inspection during construction is stipulated, and particulars are given of the hydraulic tests required. [Price 2*s*., including postage.]

Filling Ratios for Liquefiable Gases.—The fourth report of the Gas Cylinders Research Committee of the Department of Scientific and Industrial Research contained certain recommendations which were adopted in B.S. No. 401, "Steel Cylinders for the Storage and Transport of Liquefiable Gases," together with a table giving recommended filling ratios for ten such gases; but, hitherto, there has been no British Standard for filling ratios. This lack has now been remedied by the issue of B.S. No. 1736, "Filling Ratios for Liquefiable Gases," covering 33 gases, two ethylene-oxide mixtures, and hydrocarbon gas mixtures. Different filling ratios are specified for temperate climates and tropical climates; and definitions are given of the relevant technical terms, together with a cautionary note on other factors, such as purity and dryness, which, though not included in the specification, may have some bearing on the safety of the filling operation. [Price 2*s*. net, postage included.]

NEW WORKS AND IMPROVEMENTS ON BRITISH RAILWAYS.—It is announced by the Railway Executive that more than 150 "large works schemes" are in progress or have been authorised for the improvement of freight traffic on British Railways. They include the construction of a railway, seven miles long, to serve colliery developments in Nottinghamshire; other new construction to serve the Fifeshire coalfield, where production is likely to expand considerably in the near future; and the modernisation and enlargement of seven goods stations and warehouses. The new railway in Nottinghamshire will connect the National Coal Board's colliery at Calverton, recently brought into production, with the existing railway at Hucknall; it will have double tracks, and is designed to carry the colliery's whole output, over a million tons a year. The Fifeshire coalfield programme, when completed, will enable more of the coal to be shipped from East Coast ports. At Port Talbot, 15 miles of additional sidings and five new signalboxes, and the diversion of running lines, will be needed to carry the extra traffic resulting from the new plants of the Steel Company of Wales; the cost will be about 1,100,000*l*. At Newport (Mon.), additional tracks, loops and sidings must be provided to supply to the new Uskmouth power station its eventual requirement of 2,000,000 tons of coal annually.

PERSONAL.

VICE-ADMIRAL W. Y. LA R. BEVERLEY is relinquishing the position of Admiral Superintendent, H.M. Dockyard, Portsmouth, in October and his successor is to be REAR-ADMIRAL A. G. V. HUBBACK.

MR. A. E. RUSSELL, B.Sc., F.R.Ae.S., chief designer, aircraft division, Bristol Aeroplane Co., Ltd., has been elected to the board. BRISTOL AEROPLANE CO. OF CANADA, LTD., have acquired the aero-engine repair business of the CANADIAN-WRIGHT, LTD., Montreal. As from July 1, this business will be carried on by a new company, BRISTOL AEROPLANE ENGINES (EASTERN), LTD., of which MR. W. R. VERDON SMITH will be President, MR. R. J. REYNOLDS deputy president, MR. H. V. WRIGHT managing director, and MR. J. A. LIMOGES vice-president and secretary-treasurer.

MR. J. P. A. MELDRUM, O.B.E., B.Sc., M.I.E.E., has been appointed special assistant, sales management, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17, and MR. J. E. STUBBS, sales manager in the switchgear department of the firm.

THE HON. L. W. DOUGLAS, who was American Ambassador to the Court of St. James from March, 1947, until November, 1950, and MR. I. C. R. ATKIN, M.C., vice-president of J. P. Morgan & Co., have been elected to the board of the International Nickel Co. of Canada, Ltd.

MR. W. E. W. PETTER, who was appointed deputy managing director of Folland Aircraft, Ltd., in September, 1950, has now succeeded MR. H. P. FOLLAND, M.B.E., F.R.Ae.S., as managing director of the firm. Mr. Folland relinquished this position on June 30 but has retained his seat on the board.

CAPTAIN R. W. RAVENHILL, C.B.E., D.S.C., R.N.(ret.), has been appointed naval representative of the Sperry Gyroscope Co., Ltd., Great West-road, Brentford, Middlesex.

DR. LILLIAN M. GILBRETH has been elected the first honorary Fellow of the British Institute of Management, Management House, 8, Hill-street, London, W.1.

THE BRUSH ABOE GROUP OF COMPANIES state that MR. H. G. IVATT, M.I.Mech.E., has accepted a directorship with Brush Bagnall Traction, Ltd., and will act as their technical consultant on Diesel-electric locomotives. As announced on page 15, *ante*, Mr. Ivatt retired on June 30 from the position of chief mechanical engineer, London Midland Region, British Railways.

MR. L. A. C. BARTLETT, A.M.I.Mech.E., and MR. W. A. H. MAY, M.C., have been appointed to the board of George Kent, Ltd., London and Luton. Mr. Bartlett became commercial manager some months ago and Mr. May is now the firm's administration manager.

MR. W. PIENE retired on June 30, under the age limit, from his position as managing director of Norske Veritas, Oslo. Mr. Piene's successor, as from July 1, is PROFESSOR GEORG VEDELER, Dr.Techn.

MR. M. A. CAMERON, principal traffic officer of the British Transport Commission, has been nominated by the Commission to be a member of the Central Transport Consultative Committee, in place of MR. MILES BEEVOR, who has resigned.

MR. F. J. STEPHENS has been appointed a managing director of the Anglo-Saxon Petroleum Co., Ltd., and the Shell Petroleum Co., Ltd., and a delegate member of the board of N. V. de Bataafsche Petroleum Maatschappij, The Hague, in succession to SIR GEORGE LEGH-JONES, who has retired. The organisations referred to are the three principal operating companies of the Royal Dutch-Shell group. The appointments became effective on July 11.

MR. DAVID EWAN, O.B.E., senior chief engineer of the tanker fleet of the Shell Petroleum Co., Ltd., retired on June 30, after 35 years' service with the company's tankers.

MR. A. COMAR WILSON has been elected a director of Associated Electrical Industries, Ltd., Crown House, Aldwych, London, W.C.2.

MR. H. K. MILLER has been made sales secretary of the Dunlop Rubber Co. (Scotland), Ltd., 48, North Wallace-street, Glasgow, C.4.

THE SKEFKO BALL BEARING CO., LTD., Luton, have opened a new branch office at 141, Dale-street, Kingsway, Liverpool, 2. (Telephone: Central 7226.) The branch will be in the charge of MR. E. BUCKLEY, under the control of the district manager, MR. N. A. WHYTE.

The PARSONS ENGINEERING CO., LTD., Town Quay, Southampton, have appointed Jenners of Thorpe, Ltd., Broadland Yachting Station, Norwich, as their agents in Norfolk and Suffolk.

INNOXA (ENGLAND), LTD., and their associated companies, will return to their pre-war premises at 1, Eden-street, Hampstead-road, London, N.W.1, on Monday next. (Telephone: EUSton 8575-9.) The purchasing department and works offices of the firm will remain at 233, Balls Pond-road, London, N.1.

LITTLEBROOK "C" POWER STATION.

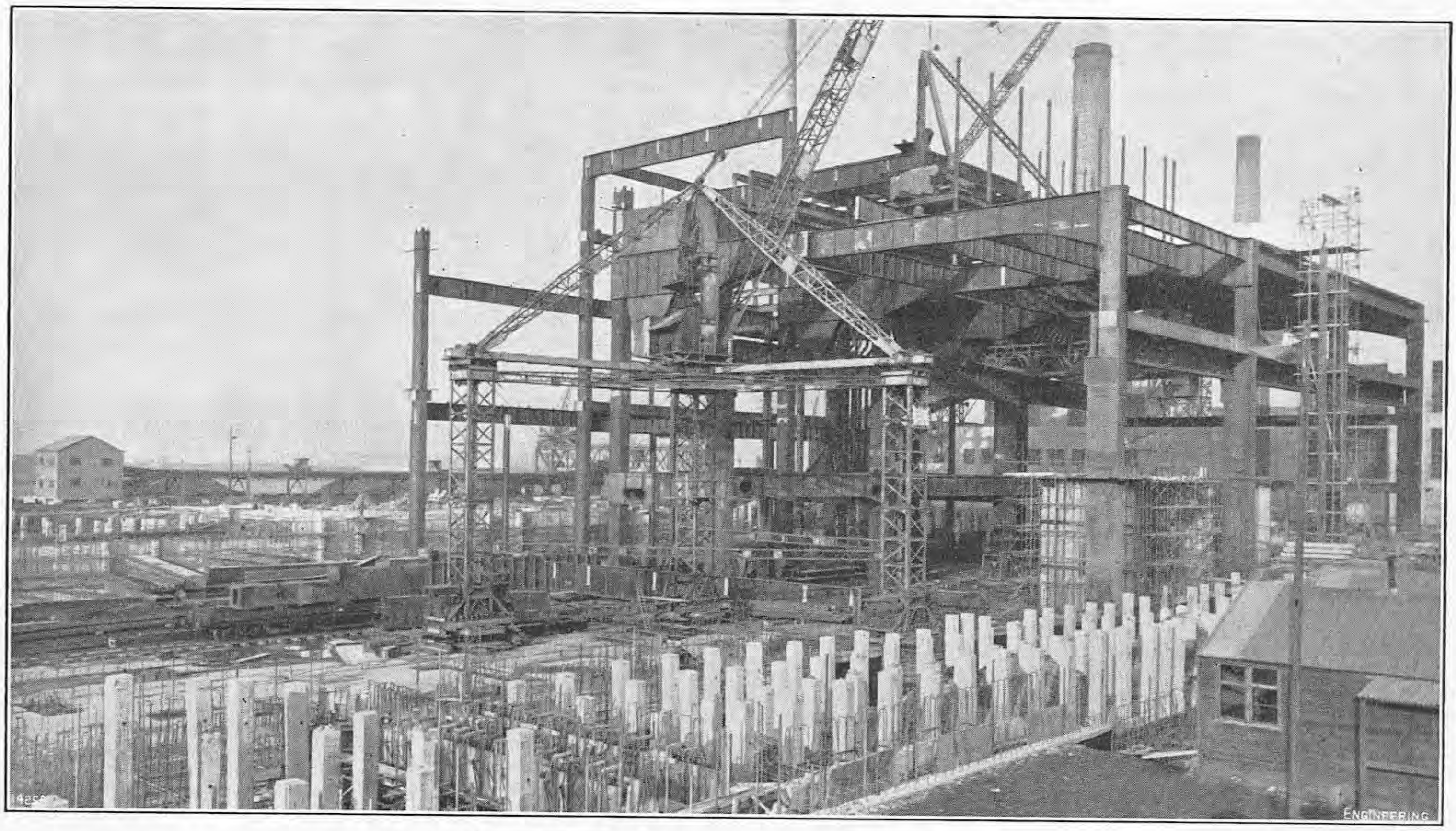


FIG. 1. BOILER HOUSE AND TURBINE HOUSE UNDER CONSTRUCTION.

NEW POWER STATIONS FOR THE B.E.A.: XXI.—LITTLEBROOK "C".

THE Littlebrook "C" station of the British Electricity Authority is situated on the south bank of the Thames, near Dartford, Kent, on a site of 150 acres. It lies adjacent to the "A" station, which has a capacity of 120 MW, and to the "B" station, of the same capacity, which is nearing completion; some particulars of the latter were given in No. VIII of this series, on page 468 of our 171st volume (1951). An illustration showing the framework of the boiler and turbine houses is given in Fig. 1, and Fig. 2 shows the excavations for the circulating-water system. The main civil engineering contractors are Holloway Brothers (London), Limited, the steelwork being supplied by Dorman, Long and Company, Limited.

Coal will be brought in mainly by water, and for this purpose the existing jetty will be extended and the capacity of the store increased by 80,000 tons. There will be eight water-tube boilers, designed for an output of 360,000 lb. of steam per hour at a pressure of 975 lb. per square inch and a temperature of 915 deg. F.; each boiler will be fitted with 12 tilting corner-fired burners supplied with pulverised fuel from three Lopulco mills. De-superheaters will not be fitted, the control of the steam temperature being effected solely by tilting the burners. The contractors for this part of the plant are International Combustion, Limited, Woburn-place, London, W.C.1. The flue gases will be cleaned by Sturtevant electrostatic precipitators.

The generating plant will consist of four 60-MW single-line three-cylinder reaction turbines, which are being constructed by Messrs. C. A. Parsons and Company, Limited, Newcastle-on-Tyne, and will be coupled to hydrogen-cooled alternators generating at 11 kV. Each turbine will exhaust into twin shell condensers with a total surface of 57,000 sq. ft., which will be cooled by river water circulated by Drysdale pumps with a capacity of 42,000 gallons per minute. The condensate will be heated in five stages to 385 deg. F., and returned to the boilers by feed pumps made by Mather and Platt, Limited, Manchester.

The output of two of the alternators will be stepped up to 66 kV and of the other two to 132-kV in 73-MVA transformers, constructed by the Fuller Electrical and Manufacturing Company, Limited, Walthamstow, London, E.17. The 66-kV circuits will be controlled by Reyrolle pneumatically-operated switchgear, and the 132-kV circuits by Metropolitan-Vickers fixed impulse type oil circuit-breakers, which will also be pneumatically operated. Each alternator will be connected to a 5-MVA transformer from which the 6-kV house-service boards will be supplied.

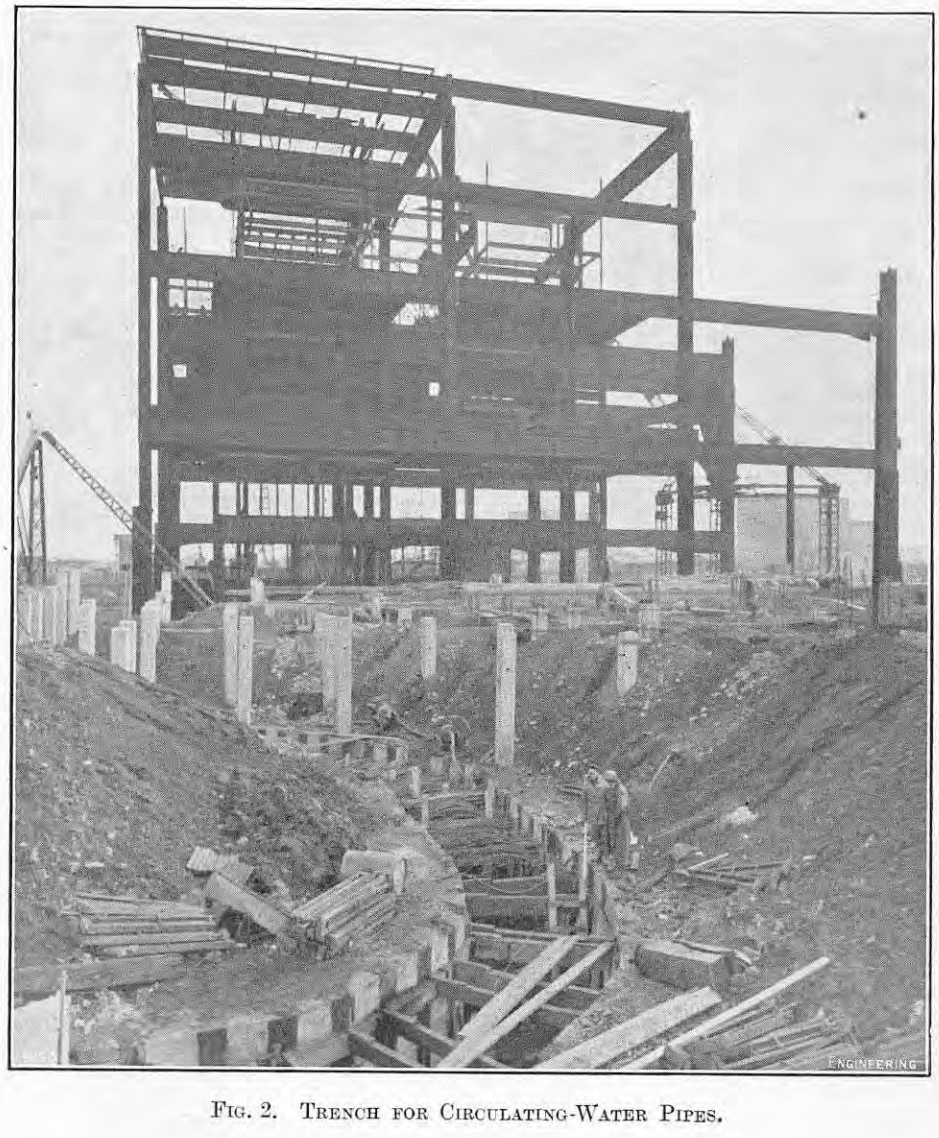


FIG. 2. TRENCH FOR CIRCULATING-WATER PIPES.

ENGINEERING,

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ENGINEERING

FRIDAY, JULY 20, 1951.

VOL. 172. No. 4460.

PRODUCTIVITY IN VALVE MANUFACTURE.

So varied and extensive are the ramifications of engineering in these days, and so numerous and intimate its contacts with scientific development, that the terminologies of both engineering and physical science are tending to overlap; as in some foreign languages, notably German and Chinese, one word has to do duty in several capacities, not always even casually related, and the particular usage intended in a given instance may only be ascertainable from a study of the context. It seems desirable, therefore, before discussing the subject indicated by the above title, to define the word "valve" as used in the present connection, which is the publication, by the Anglo-American Council on Productivity of the report on *Valves, Steel, Iron and Non-ferrous** presented by a team from the British (engineering) valve-making industry which visited the United States in November and December, 1950. For the purposes of this investigation and report, the inquiry was limited to "valves for the control of liquids and gases (in particular, oil, steam and water), of steel, iron or non-ferrous metals, including such valves as gate, check, reducing, reflux, safety, etc., but excluding plumbers' brass fittings."

There have been many of these Productivity Team reports and most of them have certain features in common. In every case, the reports have been unanimous, and the members of the teams appear to have been greatly impressed by the increased productivity per man in the United States, compared with what they have been accustomed to regard as normal at home. There have been differences between the reports, however, in the degree of emphasis that they have laid on the importance of adopting in this country the American attitude towards work and output. In this respect, the present report is the most emphatic that we can recall without making anew a detailed comparison of those previously issued; and it is the more unusual in that the section headed "Recommendations" is followed immediately by another, entitled "Recommendations for the man in the works."

There is the further feature that (to quote the preface) the valve-industry team was "one of the first Teams to devote a large proportion of its visit to the study of engineering machine shops." The fruits of that study include no fewer than 80 illustrations of American shop methods and "wrinkles"; though it is pointed out that "a large number of their machines, methods, tooling, and cutting feeds and speeds are similar to those in common use in our own country, and in some cases we have seen better methods being used in the U.K." But, the Team add, "this does not alter the fact that their overall productivity is higher than ours," though the diversity of the products manufactured made it impossible to arrive at any firm quantitative assessment of the difference. The nearest they could come to a decision on this point, after comparing the production of similar valves and components, was the conclusion that "the average productivity in the United States, while greater than, is not double that in the United Kingdom."

The Team consisted of 15 members, including the secretary, and was headed by Mr. K. M. Leach, B.Sc.(Eng.), managing director of the Audley Engineering Company. As in the case of other Teams sent out, the personnel were selected jointly by the Confederation of Shipbuilding and Engineering Unions, the Engineering and Allied Employers' National Federation, and the trade association directly concerned; in this case, the British Valve Manufacturers' Association. They came from a diversity of works, and represented a wide range of the products of an industry which, in this country, comprises some 60 firms, employing about 14,000 men and women on the manufacture of valves. It is mentioned that, in 1950, the output of industrial valves by these companies was valued at some 18,000,000*l*., and that half of the production came from firms employing 600 or more persons on valve manufacture. The corresponding output of the American industry was estimated to have a value of about 175 million dols.; and four companies produced half of the total. The Team toured a representative selection of 13 British valve factories before leaving for New York. In the United States, they visited 17 factories.

Having satisfied themselves that the level of productivity in the United States was higher than in the United Kingdom, the Team proceeded to evaluate the possible causes contributing to this result. First and foremost, they placed the mechanical handling of materials, in which direction they considered that "The U.S. valve industry is far ahead of us"; as an example, they cite the case of "a plant, including a forge shop but no foundry, producing an estimated 105 tons per month of steel valves from ½ in. to 12 in. diameter (but mainly ½ in. to 6 in.) in which all internal transport was being carried out by only four men, using fork trucks and a small amount of gravity roller." It is understandable that, coming from a country in which the use of fork-lift trucks is permitted by some unions only under severe restrictions, the Team found this example impressive.

* Published by the Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 3*s*. 6*d*., including postage.]

Second in their list of recommendations, the Team place the need to improve the utilisation of existing machines, pointing out that, though the British valve industry possesses much modern machinery, the manufacturers, for the most part, do not use those machines as effectively as machines are used in the United States. To increase efficiency in this respect, it is suggested that more use could be made of "effective jigs and fixtures," even for small batches, that there should be a "widespread introduction of air and electric chucks," better tooling and tool selection, and a closer study of tool-grinding techniques and of optimum speeds and feeds. It may be remarked that the compilers of the report display rather a fondness for the word "effective," as in the above reference to "effective jigs and fixtures"; even to the extent of implying that much of the equipment and practice to which they have been accustomed is not effective, though intended to be, and possibly regarded as such by those who have not seen the American equivalents. It may be that this impression was unintentional.

Other recommendations bearing on the question of tooling are that there should be more "special purpose and/or multi-operation machines wherever quantities justify them"—a suggestion which it is difficult to criticise or even to approve without a knowledge of the circumstances of a particular case; and that more attention should be given to the use of power devices such as air or electric impact wrenches, air vices, air-operated jigs, etc. This is a development, however, which has been progressing in this country for a considerable time, though the rate of progress differs greatly between one branch of engineering and another; as a broad generalisation, we should say that the recommendation would be justified in most of the lighter machining branches of engineering, concerned with production of a batch or jobbing character, but less so in the heavier kinds of machining and in repetition work involving large quantities.

On the administrative, technical and executive levels, several recommendations are made. One which merely echoes the findings of other reports is that to "study the advantages of specialisation, standardisation and simplification," on which there is little new to be said; but it is rather surprising to find that, while recognising that the size of the American market "gives their manufacturers a production advantage in that their batch sizes are usually larger" than in British practice, the Team adjudge that "the U.S. is not as far forward in this respect as we had expected." What is particularly encouraging is their opinion that "active work on it by ourselves can help to get us the bigger batches that are desirable." Like other Teams, the valve specialists found a contrast, to the disadvantage of Britain, between the use made of technically-educated staff, and the proportions of staff thus qualified, mentioning one United States firm who had 25 such trained engineers in a total personnel of 115; but that is a question too vast to be dismissed in a paragraph. The recommendation to "study the use of welding techniques for fabrication as well as for repairs and the deposition of hard seats" merely anticipates the inevitable trend, but here again there may be extraneous circumstances to be taken into account, which may totally transform the economics of an outwardly attractive suggestion. On one other point—the suggested need to organise the duties of senior management to enable it to maintain closer personal contact with its men and with the workshops"—the example given may arouse mixed feelings. If "the president of one U.S. company, employing 450," who has time to "tour his whole factory three times a day and make a point of speaking to a number of different operatives on each visit," is typical of American industry, it may be that a Productivity Team on the Activities of Top Managements could offer some useful suggestions.

NOTES.

The Abbey Works of the Steel Company of Wales.

The Abbey Works of the Steel Company of Wales at Port Talbot, which were formally opened by the Chancellor of the Exchequer (the Rt. Hon. H. T. N. Gaitskell) on Tuesday, July 17, form a principal part of a project, the object of which is the reconstruction of the South Wales sheet steel and tinplate industry. This project comprised the enlargement of the existing blast furnaces, coke-oven and coal and ore handling plant at Margam and the erection on the adjacent site of an 80-in. continuous strip mill with a melting shop and ancillary plant, making one factory, extending over $4\frac{1}{2}$ miles, with an annual output of about $1\frac{1}{2}$ million tons of ingots. Besides the continuous mill, a cold reduction mill is also nearing completion at Margam, while a second cold mill and tinplate plant is being installed at Trostre, near Llanelly. The construction of the works containing the new 80-in. mill required the solution of a number of engineering problems. Work was begun four years ago on ground consisting of sand dunes with water very near the surface, although a good ballast stratum, capable of taking a load of about 5 tons per square foot, was found at a depth of 20 ft. Precast in situ and bored piles of various types were driven to carry the foundations, during the preparation of which it was necessary to divert a culvert carrying the Ffrwdwyllt river and to make extensive alterations to the works and main-line railways. The level was also raised from 10 ft. to 12 ft. by depositing $4\frac{1}{2}$ million cubic yards of sand and slag. Considerable pumping was necessary and the lake formed is now used as a works reservoir. The inroad of the sea was prevented by planting marram grass, brushwood hedges and pine trees. The buildings consist of structural steel frames, in the erection of which the greatest possible use was made of welding. The equipment of the new works, of which we propose to give a detailed description later, consists at present of a melting shop in which the hot metal from the adjacent blast furnaces is poured into 800-ton mixers and then into four 200-ton oil-fired furnaces, the output of which is cast into 20-ton ingots. After passing through a stripper bay, these ingots are charged into gas-fired soaking pits and are next passed through a 45-in. slabbing mill and vertical edges and shears to one of three re-heating furnaces. The slabs from these furnaces are carried on rollers through a scale breaker to the first stand of the 80-in. continuous strip mill. They are next passed in turn through an edge squeezer and three more roughing stands over a delay table, 186 ft. long, and through a crop shearer to the six finishing stands. On emerging from the last of these stands, the 5-ft. strip, which is travelling at a maximum speed of 2,000 ft. per minute, is carried to one of two down coilers. All parts of the mill are electrically driven, the combined capacity of the motors being 46,000 h.p. The coils are finally taken on conveyors to a stock area and are thence transported at present to other works for cold reduction. About three quarters of the power required is being obtained from the grid over four 66-kV lines and the remainder from the works power station, in which nearly 20 MW of new plant is being installed.

The British India Liner "Kenya."

The latest addition to the fleet of the British India Steam Navigation Company, the twin-screw passenger and cargo liner Kenya, arrived on Sunday, July 15, at Tilbury, where she is now being prepared for her maiden voyage to the East Coast of Africa. The Kenya, which was built by Barclay, Curle and Company, Whiteinch, with boilers by the builders, and turbines and gearing supplied by the Wallsend Slipway and Engineering Company, is the largest vessel yet constructed for the British India Company. In due course, we hope to describe and illustrate the vessel in some detail, so it will suffice at present to record that she measures 540 ft. overall, by 71 ft. beam and 38 ft. 6 in. depth, with a gross tonnage of 14,443, and that her designed service speed is 16 knots loaded; this figure was exceeded by over 3 knots on her trials, when, of course, the vessel was light. There is accommodation for 150 first-class passengers in single-berth and two-berth rooms, and for 123 tourist-class passengers in cabins containing, two, three or four berths. All the cabins are "outside," with natural lighting, as also are the crew's quarters. The propelling machinery consists of three Babcock and Wilcox water-tube boilers, oil-fired and delivering steam at 430 lb. per square inch and 750 deg. F. to two sets of Parsons three-cylinder single-reduction geared turbines. Speaking at a luncheon on board the ship before she left the Clyde for Tilbury, Sir William Currie, chairman of the British India Steam Navigation Company, said that the Kenya was the 63rd ship built for them by Barclay, Curle and Company. The service to East Africa began in 1872, but their fleet had contained only one previous Kenya. The new Kenya and her sister ship, the Uganda, now completing, would replace the one-class "M" ships. The Company began in 1856 as the Calcutta and Burma Steam Navigation Company, and was renamed the British India Steam Navigation Company in 1862. During the recent war, 51 of their ships were lost, and 35 more had been since disposed of; but during and since the war 58 ships had been built or purchased, and five more were under construction. Subsequently, Sir William disclosed that orders were being placed for four more cargo ships.

Damage to Underground Cables.

It is seldom, in these days, that a case is reported in the daily papers which is of interest both to the lawyer and to the engineer. Paper shortage has rendered it impossible to report much of what takes place in the law courts, and the space available is generally devoted to cases which will attract the attention of the general public. In *The Times* of June 14, however, there appeared a report of a decision of the Court of Appeal relating to responsibility for damage to an underground electric cable. The facts were simple enough. The National Coal Board were the owners of a high-tension cable, carrying current at 30,000 volts, which had been installed by their predecessors in title. It ran at a depth of 3 ft. underground through certain land in Glamorganshire. In 1948, the County Council employed a contractor to make certain excavations. He employed another contractor to do the actual work, in the course of which a mechanical excavator broke a concrete slab protecting the cable, and damaged the cable. As the damage appeared at the time to be trivial, the matter was not reported, but eventually seepage took place, the cable fused, and the supply of electricity to certain collieries was cut off. In these circumstances, the Coal Board sued the two contractors for damages for trespass. It appeared that the County Council were unaware of the existence of the cable and so were the contractors, as the plan supplied for the purposes of the work did not show the cable. It may here be interposed that any interference with the land of another may constitute a trespass, and the "land" of a property owner includes anything below the surface. "Trespass" is a technical term. To amount to a trespass an act must be voluntary; but an act may be trespass although it is committed by mistake or without malice. In the case under notice, however, counsel for the defendant argued that, though a negligent act of commission may amount to a trespass, a person who has not been negligent cannot be a trespasser in respect of a voluntary and inevitable accident. Mr. Justice Donovan, before whom the case was tried in the first instance, while holding that neither of the two contractors had been negligent, felt constrained by certain old authorities to hold the defendants liable, and he awarded damages assessed at 500*l*. On appeal, this decision was reversed. Lord Justice Cohen said that the judge was right in holding that there was no evidence of negligence, and in rejecting a contention that the existence of pylons in the neighbourhood should have put the contractors on their guard. Nevertheless, he pointed out that the predecessors in title of the Coal Board had placed the cable on the land without the knowledge or permission of the County Council, and a clearer case could not be imagined of an accident happening entirely without any fault of the defendants. The report does not mention the authorities upon which Mr. Justice Donovan based his decision. Possibly he had in mind an old case in which a trespass was declared to be actionable though committed unintentionally or by mistake, as where the defendant mowed the grass on his neighbour's land in mistake for his own; but the Court of Appeal followed a decision of Mr. Justice Branson, given some 25 years ago (*Ilford Urban District Council* v. *Beal* (1925) 41 *Times* L.R.317). The facts were these. In 1900, a sewer authority laid a sewer under certain land which was conveyed to a Mrs. Judd in 1918. In the following year, damage was done to the sewer by a movement of a wall on the land. The sewer authority brought an action for damages against Mrs. Judd. It was held that, as she did not discover, and could not by any reasonable diligence discover, the existence of the sewer under the land, and, consequently, the existence and extent of her duty towards the plaintiffs in respect of the sewer, she was not liable for the damage done to the sewer. In his judgment, his Lordship quoted from *Comyn's Digest*—a hoary old volume well known to the "black-letter lawyer"—where it is stated that "an action upon the case for misfeasance does not lie where a man has not sufficient notice of his duty." That appears to be good law and good sense. If a man who buys land without any knowledge of what lies beneath the surface, and no warning that there may be a live cable or something liable to be injured if he goes below the surface, to buy land would be to incur grave risk. It is well known that, during the recent war, many miles of pipeline for oil was laid across country. Land owners generally were only too glad, for patriotic reasons, to grant a way leave. Some of the land so treated must inevitably change hands in the course of time. The decision of the Court of Appeal in the case under review serves to show that a purchaser who does not know, and has no reason to suspect, that he has oil flowing in a pipe beneath his garden or field, cannot be held responsible if damage occurs.

THE INTERNATIONAL CONFERENCE'S SPECIAL TRAIN.

Elsewhere on this page we print a letter from Mr. George Dow, public relations and publicity officer for the London Midland Region of British Railways, apologising for the "most regrettable inconvenience and discomfort" occasioned to the passengers in the special train which took the International Conference of Naval Architects and Marine Engineers from Euston to Glasgow on July 1. It would seem that the letter was drafted in reply to strictures that appeared in the *Daily Telegraph*, as reference was made there to the lack of soap and towels, which we did not mention in our comment on page 18, *ante*. Our criticism was written in Glasgow two days before the party left (in the same train) for Newcastle-on-Tyne, so there is a further chapter to add. As a result of representations made in Glasgow, some attempt was made to clean the train for the next stage of the journey, and to open some of the jammed ventilators; there was soap and water in each lavatory compartment, and a few paper towels; and the train ran well to time. For the return to London, the representations proved still more potent, for another train was provided; much more modern, and clean, though again minus towels and soap. The catering staff, moreover, were attired in neat white jackets; and the departure from Newcastle was supervised by the stationmaster in person. Possibly the ancient pageantry of his gleaming top-hat may have been some compensation to the overseas members and ladies for their previous tribulations; it is doubtful whether any other country's railways could show the like, and, for our own part, we should be sorry to see it superseded. Generally speaking, therefore, the return journey was much more tolerable; but it is to be hoped, nevertheless, that the special investigation which is being made will be rigorous and exhaustive. If individual home-country passengers would report on their personal experiences, either to British Railways or to their respective institutions, there is no doubt that the investigators would learn a great deal. The institutions are making official protests, and, no doubt, further apologies will be forthcoming: but we should like to see some guarantee that such a thing shall not be permitted to happen again. The passengers on that train had paid about 875*l*. for their tickets; including meals, their outlay was at least 1,000*l*.—and it is improbable that British Railways demanded and received from the organisers no more than that. If a contractor to British Railways, knowingly or inadvertently, delivered to them goods that were as far below standard as that train was below the average of main-line travel, he would be unwise to rely on squaring the account with an apology and a plea of the hardness of "present conditions."

LETTERS TO THE EDITOR.

FESTINIOG RAILWAY; PROPOSED PRESERVATION.

TO THE EDITOR OF ENGINEERING.

SIR,—Many former users of the Festiniog Railway were sorry to hear, in 1946, of the closure of this famous narrow-gauge line (1 ft. 11½ in.) in North Wales; and an attempt is now being organised to save the railway from the fate which, we feel, it does not deserve. It has been learned that a "warrant of abandonment," applied for by the Festiniog Railway Company in November, 1950, has been refused by the Minister of Transport. This is in accordance with a resolution passed at a meeting, convened by the Portmadoc Urban District Council, of various local authorities, inhabitants of the district, and railway enthusiasts, protesting against any attempt to abandon the railway.

Once the effects of war-time damage and post-war neglect have been overcome, I am convinced that the line could be worked without a deficit, on a non-profitmaking basis. Railcars have been suggested for winter services and for early-morning quarrymen's trains, the steam locomotives being used for the heavy summer traffic. The Festiniog Railway was probably the world's first public narrow-gauge line and the first to use locomotives (which were still in use in 1946); and it was the first railway in Britain to introduce bogie coaches.

It is proposed to hold a preliminary inspection of the locomotives and rolling stock this month, and a meeting to discuss the restoration of the railway is to be held in Birmingham during August, on a date still to be fixed. I shall be pleased to hear from anyone who is interested in the scheme—especially those who can contribute financial or professional support.

Yours faithfully,
LEONARD A. HEATH HUMPHRYS.

31, Ashton-hill,
Corston, Bath, Somerset.
July 1, 1951.

[We regret that pressure on our space has prevented the earlier publication of Mr. Heath Humphrys' letter.—ED., E.]

POST-GRADUATE SCHOOLS IN MECHANICAL ENGINEERING.

TO THE EDITOR OF ENGINEERING.

SIR,—Professor Small's letter, on page 53, *ante*, is timely, but there is one point that perhaps justifies special mention.

Following precedent, the term "post-graduate" has been applied to a number of recently-established schools of similar character, but the name should not be taken to imply that entrants must necessarily be graduates. Those who wish work in that type of school to qualify them for such degrees as M.Sc., M.Eng., or Ph.D., must have graduated previously, but the primary purpose of the school is to impart advanced instruction to those who already have appropriate technical knowledge and, preferably, industrial experience; a university degree is not a pre-requisite. This, at least, is the policy of the School of Applied Mechanics at Sheffield University. The main course is composed of three two-month terms with two intermediate vacations, each of one month. It provides opportunity for students with jobs in industry to return to them for useful vacation periods and thus to avoid any prolonged loss of contact.

Design methods in mechanical engineering have not, in general, kept pace with advance in basic knowledge and it is clearly the duty of a School of Applied Mechanics to offer help to industry in this respect. It was with this in mind that the course was planned to include advanced instruction in metrology, design of mechanisms and instruments, reduction of vibration and noise, and the use of electronics, photography and photoelasticity in engineering development work. A generous allocation of time to laboratory work offers the practical experience necessary for anyone who is to find much value in the highly-developed instruments of to-day.

Instruction by staff experienced in engineering design, research and development ensures emphasis on the need for special study of experimental technique, interpretation of observations and effective reporting. Opportunity is offered for students to take part in research work proceeding in the School and to carry out investigations of their own.

Yours faithfully,
W. A. TUPLIN,
Professor of Applied Mechanics.

School of Applied Mechanics,
Department of Applied Science,
St. George's-square, Sheffield, 1.
July 16, 1951.

THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—I was very distressed indeed to read in your issue of July 6, on page 18, *ante*, of the most unsatisfactory condition of the coaches used for the special train conveying home and overseas naval architects and marine engineers from Euston to their international conference in Glasgow. May I, on behalf of British Railways, convey to them through your columns my sincere apologies for the most regrettable inconvenience and discomfort they sustained?

Unfortunately, under present conditions it is not possible to provide soap and towels in all our main-line trains, but the other aspects of the matter are being specially investigated and every possible step will be taken to prevent any future breakdown of this kind in our arrangements for travellers. Meantime, I should like to assure passengers on this train that British Railways will gladly recompense them for any losses they may have sustained through the condition of our coaches.

Yours faithfully,
GEORGE DOW,
Public Relations and Publicity Officer.

The Railway Executive,
London Midland Region,
Euston House, London, N.W.1.
July 14, 1951.

SOME UNSOLVED PROBLEMS IN CIVIL ENGINEERING.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to Mr. B. M. Thornton's letter on page 19, *ante*, re the Parsons radial steam engine: there is a fully-illustrated description of this engine, as made by Kitson and Company, of Leeds, in ENGINEERING of March 14, 1884 (vol. 37, page 227). It is shown coupled to a Brush dynamo, and the results of a number of trials for steam consumption are given. A number of these engines were stated to have been made, one having been supplied to Portsmouth Dockyard.

Yours faithfully,
W. H. NEWMAN, M.I.Mech.E.

North-road,
Ditchling, Sussex.
July 12, 1951.

[We are obliged to Mr. Newman for this reminder. The article which he cites refers to this "very ingenious engine" as having been "invented by the Honourable C. A. Parsons," adding that several "have been made by his brother, the Honourable R. C. Parsons, a member of the firm of Kitson and Co., Leeds." The drawing of the engine is also reproduced as a folding plate in the late Lieut.-Colonel E. Kitson Clark's book, *Kitsons of Leeds*, published in 1938.—ED., E.]

OBITUARY.

SIR HARRY BRAND.

We regret to record the death on July 5, at his home in Crowborough, Sussex, of Sir Harry Brand, governing director of the firm of Messrs. Charles Brand and Son, and probably one of the best-known civil-engineering contractors in this country. Sir Harry, who was in his 78th year, had been seriously ill for a considerable time.

Harry Francis Brand was born on October 2, 1873, and was the fourth son of the late James Brand, of Glasgow. He was educated at Stonyhurst and at Glasgow University, and on leaving the university, trained as an engineer with Messrs. J. and A. Leslie and Reed, consulting engineers, Edinburgh. Later, he spent some time in London as an assistant engineer under Sir John Wolfe Barry. In 1899, he returned to Glasgow and joined his father in the family firm of Messrs. Charles Brand and Son, civil engineering contractors, which had been founded by his grandfather in 1828. The firm was engaged at this time in the construction of Grangemouth Docks for the Caledonian Railway Company, Sir John Wolfe Barry being the consulting engineer. Before long, his father entrusted him with sole responsibility for the contract, and, on its successful conclusion, assumed him into partnership in 1901. On James Brand's death in 1909, Harry became the senior partner, and when the firm became a private limited company in 1934, he was elected chairman, so that he spent practically the whole of his active life in the family business. Under his direction, the firm carried out many important and difficult contracts, including Rosslare harbour, Kirkcaldy harbour, parts of the Glasgow main drainage system, Loch Arklet waterworks in Stirlingshire, Leith graving dock, and Buckie harbour. Shortly after the 1914-18 war, he moved the headquarters of the firm to London, where he took an active part in the London Underground Railway extensions and improvements. Among other contracts undertaken in the period between the wars were the Golders Green and Morden extensions; enlarging the tunnels from Euston to the Angel station; improvements at Old Street, Kennington, Trafalgar Square, and St. Paul's extensions from Finsbury Park to Cockfosters and Baker-street to Finchley-road, and at Highgate, Liverpool-street to Bow-road, and Wanstead to Gants Hill. The firm also carried out, during this period, work for the Port of London Authority on the East India and Millwall Docks improvements; for the Southern Railway at Southampton, and on the Isle of Wight; sea defences at Sidmouth; circulating-water tunnels for Portishead power station; the Royal Edward Docks extension at Avonmouth, and the Dartford-Purfleet pilot tunnel. During the war, among other major works, they constructed the Royal Ordnance Factory at Bridgwater, the deep shelters at Clapham Common, the new Gloucester power station, and deep-water wharves at Belfast. Since the war, their contracts have included new power stations at Kingston-on-Thames and at Bromborough, and the pedestrian and cyclist tunnels, with escalator approaches, under the River Tyne at Jarrow.

Sir Harry, who received his knighthood in 1942, was an original and prominent member of the Federation of Civil Engineering Contractors, being one of those originally approached by the late Lord Cowdray when it was being formed in 1919. As a result of the working-rule agreement then made with the trade unions, and the operation of the Conciliation Board that was set up, there has been no major strike since, except the general strike of 1926. This is a record in which Sir Harry justifiably took some personal pride. He was also an original member of the Federation's Council, on which he served until his death. He was chairman of the Council in 1927-28 and President of the Federation from 1936 to 1940. He represented the Federation on the British Employers Confederation, of which he was President from 1940 to 1944. During this period, he was constantly in touch with various Ministers and Government departments, in particular, the Minister of Labour, in all matters affecting the full mobilisation of the national resources, for he had a great understanding of men, and his judgment was highly regarded by both employers and trade unionists. During the war, he also served as Regional Works Adviser for the South Eastern Region under the Ministry of Home Security.

MR. NEVILE G. GWYNNE, C.B.E.

A link with the early days of an engineering business of world-wide repute was broken by the death on July 9, as the result of an accident, of Mr. Nevile Gwyn Gwynne, for nearly 40 years managing director of the engineering firm of Gwynnes Pumps, Limited, of Hammersmith and Lincoln. Mr. Gwynne had almost completed his 83rd year, having been born, in London, on August 2, 1868. He was the son of James Eglington Anderson Gwynne, eldest of the three sons of John Gwynne, founder of the business in 1849, and patentee, in 1851, of the multi-stage turbine pump. Originally, the works were at the foot of Essex-street, Strand, but, after John Gwynne's death, they were transferred to a site off Holborn. Meanwhile, John and Henry Gwynne (Mr. Nevile Gwynne's uncles) had started in Hammersmith a separate business which became, in 1898, J. and H. Gwynne, Limited; and, in 1904, James E. A. Gwynne sold to his brother, John Gwynne, the whole of his business at Brooke-street, Holborn, which was transferred to Hammersmith. The two firms combined to form Gwynnes, Limited, and Mr. Nevile Gwynne joined his uncle, John, at Hammersmith, succeeding him as managing director in 1912, when John Gwynne died.

Mr. Nevile Gwynne was educated at Lancing College and at Pembroke College, Cambridge, where he graduated B.A. in 1890, being one of the first engineering graduates. He received the M.A. degree in due course, and by then had completed a period of shop training in his father's business, partly in the Essex-street works, before going up to Cambridge, and partly at Brooke-street, after receiving his B.A. He was appointed manager of the Brook-street works in 1892 and continued to hold that post until the fusion of interests with Hammersmith; but he was also a director of the Hammersmith works for a number of years before the amalgamation, so that he was well prepared to succeed his uncle and to direct the affairs of the firm through the difficulties of the first World War. During that war, he took a leading part in the introduction and production, to the total of more than 4,000, of the Clerget rotary aero-engine and its successor, the Bentley rotary engine; for which service he was awarded the C.B.E. This development, undertaken at the instigation of the Admiralty, left the firm at the end of the war with a large factory at Chiswick, equipped with fairly modern repetition tools, which were used to make the Albert 11-h.p. motor car, and a smaller car, the Gwynne Eight. This venture, however, did not survive the depression between the wars. Mr. Gwynne was a member (for 40 years in each case) of the Institution of Mechanical Engineers and the Institution of Naval Architects. He served for many years on the Council of the British Engineers' Association, of which he was President in 1921 and 1922; and on the Grand Council of the Federation of British Industries.

British Industries Fair, 1952.—Next year's British Industries Fair will be held in London at Earl's Court and Olympia, and in Birmingham at Castle Bromwich The dates will be from Monday, May 5, to Friday, May 16. Further information may be obtained from the director of the Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1.

N.E. Coast Engineering Directory for 1951.—The North-East Engineering Bureau have issued a revised edition of their directory, "The Home of Engineering" in a small size, suitable for carrying in the pocket. This contains a list of the names and addresses of the firms belonging to the Bureau, and particulars of the services and products which they supply. There is also a comprehensive subject-matter index. The directory is bound in stiff covers and copies may be obtained, free of charge, from the general manager of the Bureau, Guildhall Chambers, 13, Sandhill, Newcastle-upon-Tyne, 1.

ENGINEERING IN THE FESTIVAL OF BRITAIN.*

VIII.—Exhibition of Industrial Power, Glasgow.

(*Continued from page* 35.)

From the Coal Hall, the exhibits in which were described in last week's article, the visitor's route leads to the Steel Hall, and then to Power for Industry. The historical sketch in the Steel Hall includes references to the early ironmasters and steelmasters, and to the development of techniques for forming metals, starting with the village blacksmith, proceeding to the origins of mass production, and culminating in a small machine shop, and a display to show the significance of standardisation.

Many of the exhibits are of products which have been selected to illustrate fine craftsmanship in metals. These include tools, gauges, instruments, knives, scissors, and parts such as gearwheels, a turbine disc, rolled-steel sections, castings, etc. The centre lathe in the machine shop was made by the Crowthorn Engineering Company, Limited, Reddish, near Stockport, and is illustrated in Fig. 124, opposite. It is their 12-in. heavy-duty centre lathe, with an all-geared head, giving a 24-in. swing over the bed and a 38-in. swing in the gap. The bed is 12 ft. 9 in. long, with inverted-V slides, and is 8 ft. between centres. The hollow spindle admits a $3\frac{3}{8}$-in. diameter workpiece, and is mounted on Timken taper-roller bearings at the front and parallel-roller bearings at the rear. There is a centralised gear-change control on the headstock, incorporating speed-indicating dials. The lathe is driven by a 10-h.p. motor, mounted at the rear, through V belts and a multi-disc friction clutch. It is a precision machine tool, built to Schlesinger limits, and, during the Exhibition, is being operated by a member of the firm's staff.

An all-steel welded press brake, lent by the Bronx Engineering Company, Limited, Lye, near Stourbridge, is illustrated in Fig. 125. This machine is designed to exert a pressure of 60 tons and to deal with 8 ft. by $\frac{1}{8}$ in. mild steel. To simplify the work of the operator, the bottom dead centre is indicated on a large dial in the top of the crown of the press. Counter indicators are also provided for each connecting rod, to facilitate tool changing. The shut height has been increased so that standard punch sets can be employed and deep box trays formed. The frame is of welded annealed steel. The drive is by a 5-h.p. motor through V belts to a pulley integral with the flywheel clutch and brake, all of which are mounted on the first motion shaft. From this shaft, which is carried in anti-friction bearings, the drive is through helical gearing to the second-motion shaft. The final drive is through double-reduction pinions, at each end of the frame, to twin eccentric shafts. These shafts, which are machined from solid-steel forgings, are carried in phosphor-bronze bearings, mounted in the steel crown. Power is transmitted to the steel-plate top beam by cast-iron pitmans, fitted with phosphor-bronze worm wheels and high-tensile spherical-ended screws. A ram stop mechanism brings the press to rest automatically at the top dead centre after a single stroke. This mechanism can be disconnected by moving a lever, and the machine will then work as a normal press brake. Inching can be effected at any position in the cycle by operating a multi-plate dry clutch. The position of the top beam can be adjusted by means of a 2-h.p. motor, the drive being fitted with safety limit switches to prevent the top beam over-running when tool adjustments are being made. Should the top-beam tool stick below the bottom centre, owing to incorrect setting, the beam itself can be released by barring-up lugs, cast on the outside of the overhung brake casting for this purpose.

The hydraulically-operated shaping machine pro-

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

EXHIBITS AT THE EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

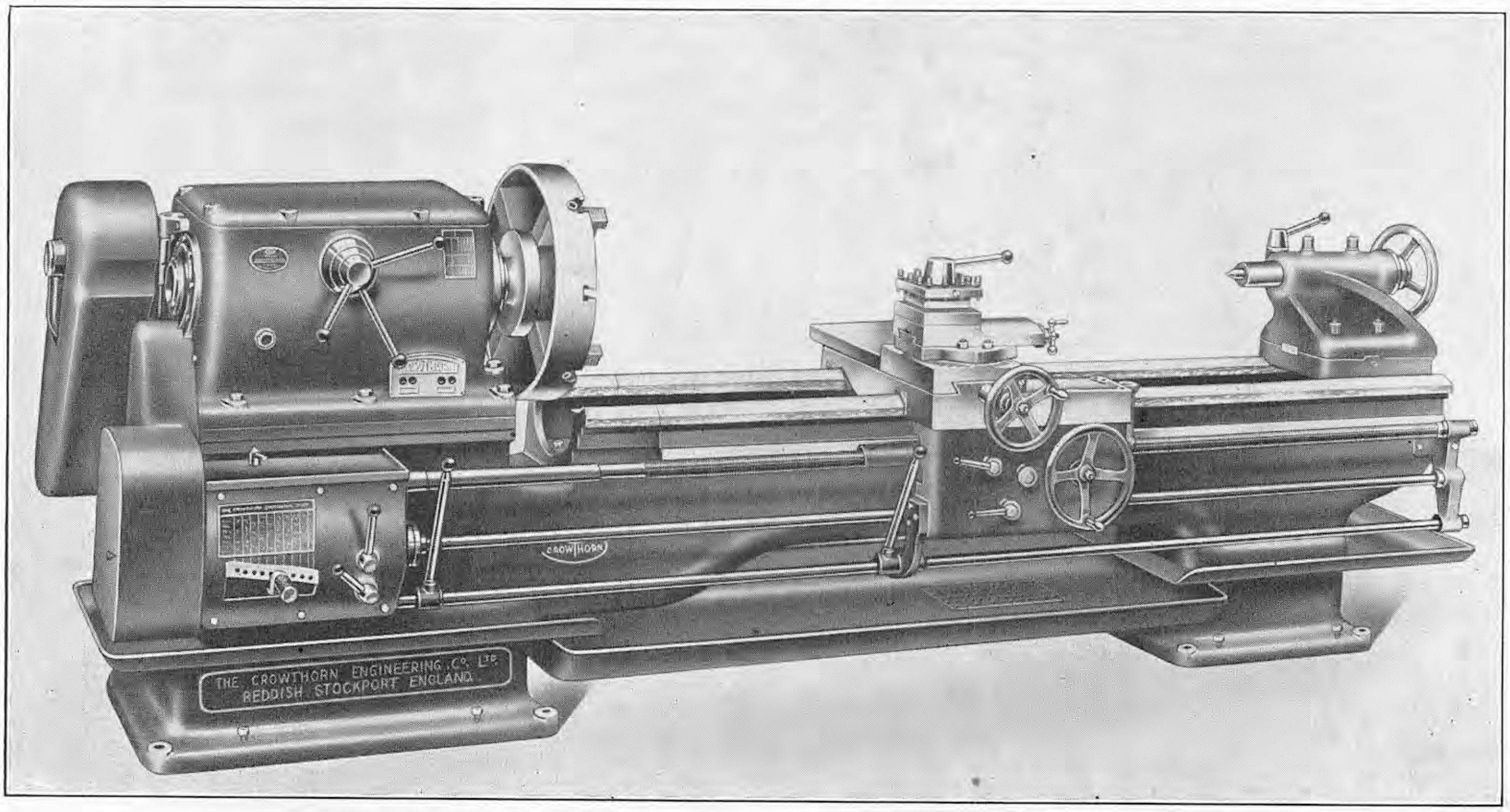


FIG. 124. 12-IN. CENTRE LATHE: CROWTHORN ENGINEERING COMPANY, LIMITED.

FIG. 125. ALL-WELDED PRESS BRAKE: BRONX ENGINEERING COMPANY, LIMITED.

vided by the Engineers' Tool and Supply Company, Limited, 40, Monkton-street, London, S.E.11, is illustrated in Fig. 126, on page 86. The maximum stroke of the ram is 24 in.; the down feed of the tool head is 6 in.; the longitudinal feed of the table is 22 in.; and the vertical feed of the table is 8½ in. The speed of the ram is adjustable up to 110 ft. per minute, and the quick return can be at either 1¼ times or 2½ times the cutting speed. The top of the table is 24 in. by 14¼ in., and the side is 14 in. by 14½ in. The machine, known as the Hydetsco Model 4H, is driven by a 5-h.p. motor, flange-mounted at the back, which is coupled to a variable-delivery pump, to provide the variation of cutting speed. A manually-operated valve is used to stop and start the shaper. The ram is reversed by a main reversing valve which is actuated by a pilot valve; the latter can be operated either by trip dogs or by hand. The feed mechanism of the table is also controlled by the pilot-valve hydraulic circuit. The shaper is fitted with a swivelling table.

Messrs. Taylor, Taylor and Hobson, Limited, Stoughton-street, Leicester, have provided the exhibition with a toolmaker's microscope and the Model 3 Talysurf surface-measuring instrument shown in Fig. 127, on page 86. It provides both a graph and an average reading. The equipment consists of an average meter, a stand for supporting the workpiece, a gearbox, a pick-up and stylus, pen recorder and amplifier. A unique feature is the inkless-pen recorder, giving a graph in which the ordinates are straight and, at the same time, the scale is linear. The texture of grinding, turning, lapping, etc., on flat, cylindrical surfaces, ball races, gear teeth, etc., can be investigated, and vibrational defects like chatter can be measured. A useful accessory, known as the datum attachment, has been introduced recently. It is for obtaining a curved datum, convex or concave, over a continuous range from ⅛-in. to 2-in. radius, also for chatter and waves, as distinct from roughness. In addition, it provides a straight-line datum for very small components, otherwise unobtainable on the standard Talysurf model.

The vertical mechanical comparator shown in Fig. 128, on page 86, is made by the Sigma Instrument Company, of Letchworth, for whom Alfred Herbert, Limited, Coventry, act as agents for the instrument. It is intended for repetition checking at a machine or in the inspection department, and is made with vertical capacities of 6, 9, 12 and 24 in., and with magnifications of 500, 1,000 and 3,000. Adjustment is provided on the head and the table, but the final setting is made on the scale. All moving parts are mounted on ball bearings, to ensure repeated accuracy of readings, and a magnetic clamping device prevents oscillations of the spindle and the transmission of shock to the mechanism. The instrument is particularly suitable for percentage checking at the machine, in connection with

EXHIBITS AT THE EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

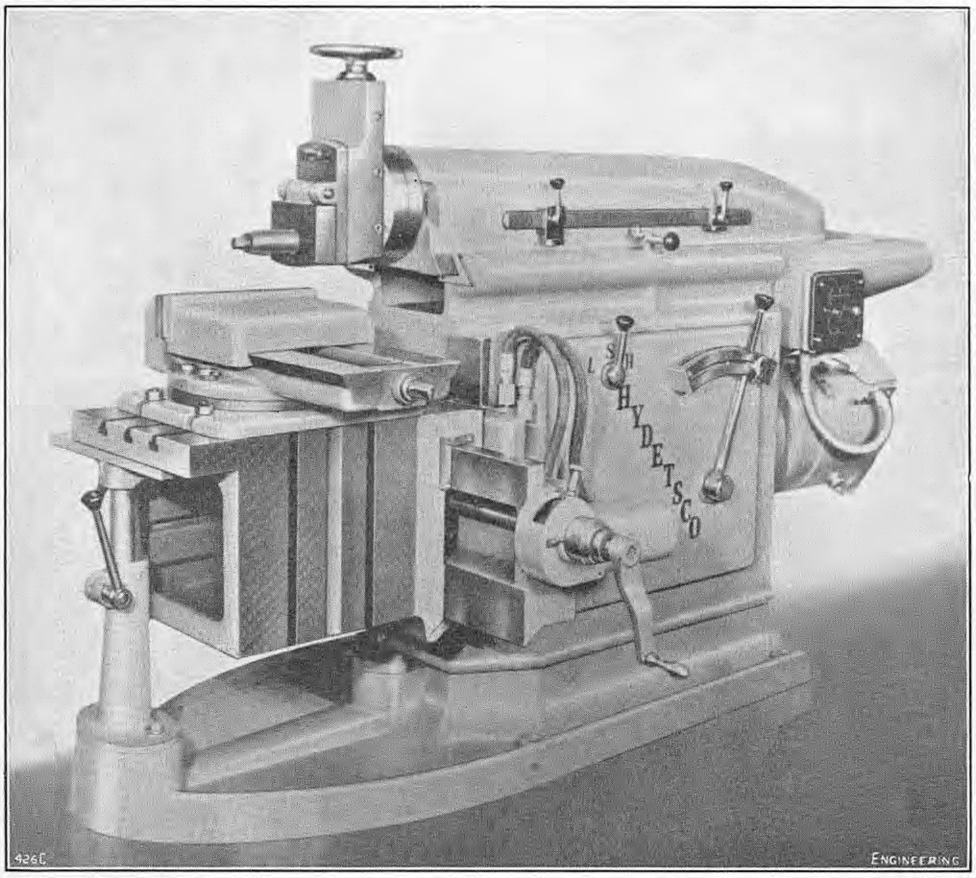


FIG. 126. "HYDETSCO" SHAPING MACHINE: ENGINEERING TOOL AND SUPPLY COMPANY, LIMITED.

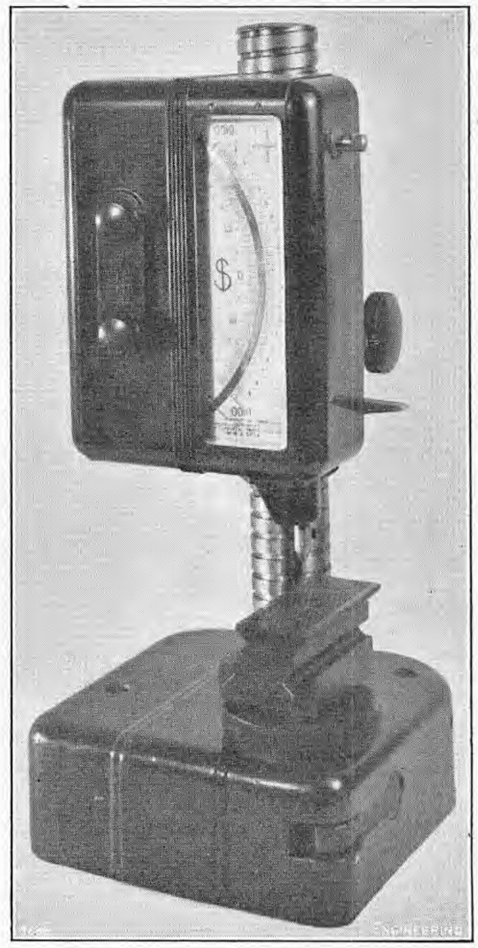


FIG. 128. VERTICAL MECHANICAL COMPARATOR: SIGMA INSTRUMENT COMPANY, LIMITED.

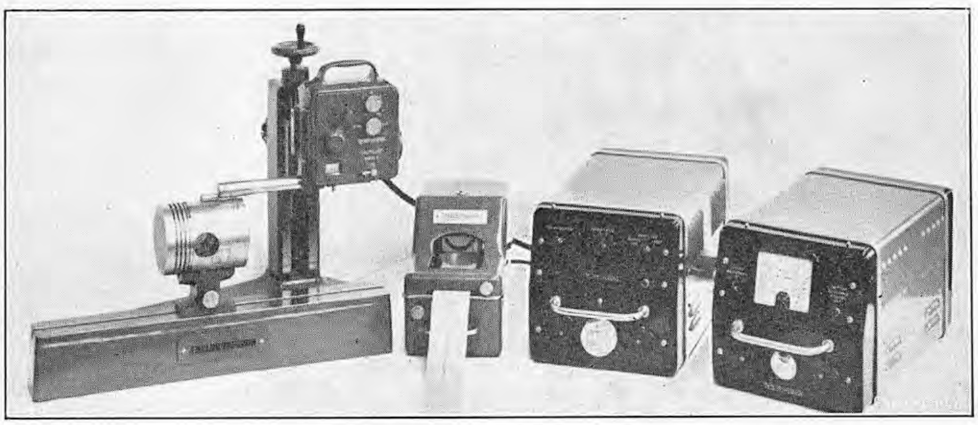


FIG. 127. MODEL 3 "TALYSURF" SURFACE ANALYSER: TAYLOR, TAYLOR AND HOBSON, LIMITED.

quality control; and one comparator can be used for checking several different dimensions by means of appropriate fixtures. These are designed so that the height of the fixture, plus the mean size of the dimension to be measured, is the same for all fixtures; and that the tolerance boundaries are symmetrically disposed about the zero reading on the scale.

Among the other tools and equipment displayed in the Steel Hall, mention may be made of an electric drill in the blacksmith's shop and the electric overhead travelling crane in the machine shop. The overhead crane, of 5 tons capacity, was built by Messrs. Herbert Morris, Limited, Loughborough. It has a span of 36 ft. 6 in. and is driven by three motors, one for the main winch, one for traversing the crane, and the third for the longitudinal travelling motion. The crane structure is of riveted steel sections. The crab has been designed to give reasonable compactness combined with accessibility. An electro-mechanical brake holds the load whenever the hoisting circuit is broken. The gearbox is totally enclosed and contains the first-reduction gears, which are of the double-helical type, and the other gears, which are straight spur wheels and pinions. The hoisting-gear spur-wheels are of normalised high-carbon steel, mounted on shafts of nickel-chrome or high-carbon steel; and all the pinions are cut from solid blanks of nickel-chrome steel. A feature of the crab is the grease-gun lubrication of the crab wheels and the outer drum-shaft bearing; all the grease nipples are brought together on a plate which can be reached by the crane operator without leaving his platform.

The $\frac{3}{8}$-in. heavy-duty electric drill was provided by Messrs. Black and Decker, Limited, Harmondsworth, Middlesex. It is one of their range of electric tools. The no-load speed is 900 r.p.m., and it weighs $10\frac{1}{2}$ lb. The motor drives through triple-reduction gears, and ball and needle-roller bearings are used on the various spindles.

(To be continued.)

IMPORTS OF TUNGSTEN.—The Ministry of Materials, Horse Guards-avenue, London, S.W.1, announce that, as from July 30, they will become the only importers and distributors, in this country, of tungsten ores and concentrates. The Ministry hope shortly to appoint certain firms in the trade to act as joint agents. Shipments already licensed and sold to consumers will not be affected by these arrangements.

THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

(Continued from page 42.)

THE technical sessions in London of the International Conference of Naval Architects and Marine Engineers were resumed on the morning of Wednesday, June 27, when the chair was taken by Mr. James Turnbull, O.B.E., chairman of Council of the Institute of Marine Engineers. The first paper before the meeting (the third paper in the Conference programme) was on the subject of "Higher Steam Conditions for Ships' Machinery." It was contributed by Mr. Mark L. Ireland, jun., Mr. H. W. Semar and Mr. H. L. Mochel, members of the Society of Naval Architects and Marine Engineers, New York; and was presented by Mr. Ireland.

HIGHER STEAM CONDITIONS.

The paper had a sub-title, "Problems in the Selection and Application of Cycle Components and High Temperature Materials," and, for the purposes of the authors' argument, "higher steam conditions" were defined as those which required a consideration of the effects of temperature upon the long-term properties of the materials used in the construction of ships' machinery. Attention was directed particularly to the geared-turbine drive, as applied to merchant ships and to the warships engaged in World War II; as was explained in the introduction, security considerations prevented the authors from extending their survey beyond those limits. After reviewing the combinations of pressure and temperature available, the various steam cycles, the selection of the principal machinery components and auxiliaries, the limitations and physical properties of known materials, the problems of construction and fabrication, and the design of control equipment, the authors came to the conclusion that further advances in power-station steam conditions, beyond the present maxima of 2,500 lb. per square inch boiler pressure, and beyond a steam temperature of 1,050 deg. F. associated with a somewhat lower pressure, appeared to be likely in the near future. Such developments, presumably, would influence marine practice. Three "super-tankers," one using steam at 1,020 deg. F., were referred to in the paper, but most post-war installations were at about 600 lb. per square inch and 850 deg. F.; though a prototype C-3 cargo ship was under construction, which would work at 850 lb. per square inch and 900 deg. F. It appeared probable, in the authors' view, that new construction in the near future would be restricted to about 850 deg. F. steam temperature by the shortage of chromium, which was in demand for more vital defence equipment. If and when that restriction could be removed, increases in steam pressure and temperature were to be expected.

The discussion was opened by the Engineer-in-Chief of the Fleet, Vice-Admiral (E) the Hon. D. C. Maxwell, C.B., C.B.E., who welcomed the paper as "one of very great merit," in which the authors had collected a wide range of knowledge from many sources, to which they had added their own great experience. It was written, however, from the aspect of merchant-ship machinery, and Vice-Admiral Maxwell thought that some remarks from the naval viewpoint might be of value. Naval machinery designs differed basically from mercantile requirements, one essential difference being that naval machinery ran at full or high power for only a very small proportion of its life; therefore, the Navy was prepared to sacrifice some full-load efficiency to obtain optimum part-load performance. The authors stated that a steam-temperature characteristic rising with boiler output was desirable. Some naval designs called for higher steam temperature at the lower powers, to obtain the best efficiency at cruising speed; thus full use could be made of the fact that centrifugal stresses were much reduced below full power. A boiler characteristic of this type required control of steam temperature, which allowed the temperature to be greatly reduced during manoeuvring and whenever there were rapid changes in power. Naval designs were largely governed by considerations of space, and, in turbines, this had led to the use of high blade speeds, with by-passed stages in the high-pressure turbine and high leaving losses from the low-pressure turbine. The authors pointed out that, with high temperatures, by-passing of the initial stages of the high-pressure turbine introduced difficulties in design; but the alternatives involved additional space and weight, and, for naval purposes, this must be carefully balanced against the improved efficiency of the cycle.

Almost as important as the bulk of the machinery was the requirement for minimum weight of machinery plus fuel; in some cases, it paid to design for 25 in. or 26 in. vacuum at full power instead of the $28\frac{1}{2}$ in. which was normal in the merchant service. The saving in weight of condenser and turbine allowed more fuel to be carried and increased the radius of action, while, at the lower powers at which naval ships normally operated, a high vacuum was readily obtained. Should higher steam temperatures be adopted without a great increase of steam pressure, the L.P. turbine exhaust was likely to be considerably superheated; so far, there was no positive evidence of the effect of this upon condenser design, and he would welcome any experience the authors might have in that respect.

Little had been done in naval engineering in the way of multi-stage bled-steam feed heating, because of the weight of the heaters and pipes, and the complications which might arise when frequently changing power. Naval practice was to use non-condensing steam-driven auxiliaries, the exhaust from which was used for feed-heating; this gave the equivalent of single-stage bleed feed-heating, while preserving the lightness of the installation. Higher steam temperatures posed a considerable problem in the lay-out of auxiliaries, due to the complication of the steam and exhaust pipes. The common solution in the merchant service was to use electric drive, but this, as a complete solution, was not so attractive for naval ships because of the danger of interruption to electric supplies during battle. One more difference between mercantile and naval practice in design was that of cost. In merchant-ship work, first costs, operating costs and maintenance costs were the three guiding principles in deciding steam conditions. In the naval design, it was necessary to be certain that the taxpayer got value for money, value in that case being the military qualities of the ship. Not only must the Navy reject a design which involved unduly complicated techniques, provided a less complicated design would serve the purpose, but it must ensure that designs in peace did not call for materials which were not to be had in time of war. Stock-piling could not be relied upon as a full solution of the supply problem, and it might be necessary to limit steam conditions because of the danger of material shortages.

Mr. A. R. Gatewood said that the paper made numerous references to the American Bureau of Shipping's "Interim Guide" for high-temperature steam installations, so that it seemed appropriate to point out two cases in which subsequent investigations had shown it desirable to modify the recommendations. Both these investigations were commented on in detail in the paper. The recommendation that circularity of the pipes in the way of bends be maintained within 2 per cent. was found to be somewhat restrictive from the practical point of view; out-of-roundness resulted in purely localised stress, which relieved itself rapidly when the pipe was put into service. In some cases, combined stresses might result in out-of-roundness of as much as 9 per cent.; and since it was not desirable to encourage poor workmanship, the Bureau now recommended that the circularity of piping be maintained within 5 per cent., a figure which could easily be met. Secondly, the authors explained why it was preferable to normalise the low chromium-molybdenum steels after bending. It was thought originally that pipes could be bent, and then welded and normalised. This procedure indicated that the normalising lowered the rupture strength.

Dr. T. W. F. Brown said that, as the paper dealt specifically with geared steam turbines, some mention of gearing might be made. It could be objected that gearing was not greatly affected by advanced steam conditions; but that was not so, because, with advanced steam conditions, there was a greater heat drop to be dealt with in the turbines. If the turbines were kept small, they must revolve even faster than before, and the gearing had to carry a greater reduction ratio. As against this, vast improvements had been made in gear-cutting, both in the United States and in Britain. He asked how those two factors were reconciled in advanced designs, i.e., the ability to effect greater reduction ratios in the gearcases, and, at the same time, to reduce gearcase weight in relation to the higher loadings that could be carried. The paper seemed to suggest that the average steam conditions in the British merchant ships were rather lower than in American ships; but the figures given by the authors, of about 600 lb. per square inch and 850 deg. F. as the average levels of temperature and pressure in America, were about the same as in this country for new construction. The authors referred to certain steam conditions as having been chosen to meet increasing Diesel competition, but in Britain, the position was exactly the opposite. Particularly in tanker work, the steam turbine was slowly ousting the direct-coupled Diesel engine, even in powers which are easily within the capabilities of the Diesel engine. Of course, in the big tankers now coming into service, single-screw steam-turbine machinery was being used at powers for which direct-coupled single-screw Diesel engines could not be used.

With regard to materials, particularly for superheaters, he noted that the authors did not refer to vanadium attack. It was still not certain whether the vanadium came as vanadium pentoxide, sodium vanadate or some other compound, but it was certain that, even in austenitic materials, if the surface of the tubes was at a temperature of the order of 1,200 deg. F., it would be destroyed. There were no high-temperature alloys in common use which would resist that form of attack, and until the question was solved, it set a practical upper limit to the steam temperatures which could be used in turbines. Having seen machinery for Philadelphia Tankers Incorporated being constructed for a total steam temperature of 1,020 deg. F., Dr. Brown felt a little mystified by the authors' over-cautious approval of temperature rises at the end of the paper, especially as, in many cases, designers were urged to look at the optimum condition and then to take as their aim a point slightly higher.

Commander L. Baker thought that British turbine practice had been somewhat handicapped by the relatively great success achieved with Diesel propulsion. The majority of ships had been built in the power range in which the Diesel competed very successfully with steam; only since the war had powers increased to a point at which steam could, if it would, become attractive. He did not understand the American preference for header-type boilers. British experience of them was that the ease with which tubes could be plugged was matched by the frequency with which they needed to be plugged. The normal two-drum type was not so prone to troubles. The header-type boiler was undoubtedly heavier for a given output and undue costly to maintain; factors which operated over the whole life of the ship. British engineers had had little experience of the risk of thermal shock with advanced steam conditions, but fluctuations of temperature must arise in service, and there was always the risk of either water or salt carry-over into the steam lines. Available data suggested that 1,200 lb. per square inch was the point at which the solution of the solids directly in the steam became important. He had, however, experienced one case of the deposition of "gooseberries" of pure sodium phosphate in the manœuvring valve of a Victory ship at 450 lb. per square inch and 750 deg. F., and therefore he had fitted, in new steamers, special detection devices to avoid the risk of damage by water or solids.

Captain R. A. Smyth, U.S.C.G., remarked that the successful operation of marine boilers at higher temperatures and with maximum efficiency would mean the maintenance of heat exchangers in the system; and he hoped that the experience of past failures in this respect would lead to improved design and arrangements for their proper routine maintenance.

Mr. H. N. Pemberton commented on the authors' statement that the major incentive for advances in steam conditions of commercial vessels was the prospect of reduced fuel consumption. Several ships had been built in the United Kingdom in recent years with turbines operating at about 600 lb. per square inch and 800 deg. to 850 deg. F. With provision for steam reheat, a fuel consumption for propulsion of about $\frac{1}{2}$ lb. per shaft horse-power per hour could be obtained. Those installations were not particularly complicated, and, in general, the steam piping was of plain carbon steel, a few pipe lengths of $\frac{1}{2}$ per cent. molybdenum steel being used in certain cases. These ships were regarded as modern and they were proving reliable. He wondered, therefore, when studying the paper, how much farther they might expect to go. The shipowner had little interest in pioneering advances in steam conditions beyond those which had proved to be thoroughly reliable, and which permitted him to burn the cheapest form of fuel oil at a reasonable rate of consumption. Mr. Pemberton's own view was that there would be a period of consolidation at figures approximating to those he had mentioned. No doubt, however, there would be further advances in marine plant, if only because, in the long run, marine practice was bound to follow land practice, and it would become increasingly necessary to compete with the gas turbine for high powers. British marine engineers used mild steel for steam pipes in a somewhat extravagant way. Permissible working stresses were lower than they need be, but this weight of material was probably partly responsible for the rarity of steam-pipe failures in ships. With the higher stress conditions contemplated, such extravagance in materials could not be afforded; partly because of the higher cost of the steel alloys required, and because thermal conditions demanded that the piping should be as thin as possible. Allowable stress figures, as recommended in the "Interim Guide," were based on values for rupture strength extrapolated from the results of 1,000-hour creep tests. The authors referred to the dangers of extrapolated values which took no account of deterioration in material exposed to temperature and stress over periods much longer than 1,000 hours. With this in mind, Mr. Pemberton asked on what type of creep tests those recommended stresses were based. Dr. R. W. Bailey, one of the foremost British authorities on creep testing, had pointed out on more than one occasion, that 1,000-hour creep tests at the working temperature, using stress to accelerate creep strain, brought into account only to an insignificant extent the influence of thermal action on the material; whereas his method of testing at the working stress and using temperature as the creep-accelerating factor did bring the thermal action into account.

Mr. A. W. Davis said that, so far as marine propulsion was concerned, the gas turbine has acted very much as a catalyst in the approach to the steam turbine; but, with the steam turbine, there were the added difficulties of high pressure associated with high temperature. These circumstances could be mitigated to some extent, and other advantages gained, by the adoption of reheating. It would be interesting to have Mr. Ireland's remarks on the adoption of reheat, and of using relatively low-temperature steam for reheating. With regard to piping, engineers were somewhat handicapped in the United Kingdom by the heavier scantlings required, which made it more difficult to provide for expansion. The authors commented on the wisdom of allowing no more than one-third cold pull-up in assessing the stresses, and Mr. Davis invited their views on whether the adoption of much higher temperatures might lead to the allowance becoming (say) two-thirds, by reason of the fact that any effective creep would mitigate undue stresses that might exist at the start.

Mr. Ireland, replying to the discussion, said that practically all of Vice-Admiral Maxwell's points were being considered seriously for United States naval work also. He could not answer specifically the question on the influence of superheated exhaust on condenser performance, because there were two sets of results available, neither complete and both contradictory. Apparently, however, if the tubes became completely dry, the heat-transfer rate would suffer. In reply to Dr. Brown: recent advances made in the United States in the art of gear-cutting had standardised commercial work to the point where all the leading manufacturers were willing to offer designs based on K factors of 100 for the high-speed reduction and 75 for the low-speed reduction. It was interesting that steam conditions in both countries were at the same level. The limitation of 850 deg. F. in the United States was due to the chromium shortage; when that need had been surmounted, it would be possible to advance to 950 deg. F. in routine commercial designs, and higher still for special cases. He was interested to note that Commander Baker favoured the two-drum boiler; as shipbuilders, his own firm maintained a completely open mind on that matter, and worked entirely to owners' preferences.

Mr. Pemberton questioned the extrapolation of creep and rupture-test values. The paper contained a few references to rather long-time tests. Generally, the position was that, within the temperature and stress range where materials maintain metallurgical stability, it appeared to be perfectly safe to extrapolate. That had been confirmed by tests lasting 10,000, 15,000 and 20,000 hours on a number of materials, and, in a few tests, as long as 100,000 hours. Mr. Davis asked about reheat. Reheat was introduced into the United States when a temperature level was established; and Mr. Ireland thought that the position should again be the same —that, so long as increases of temperature appeared possible, it was as well to adhere to that line of endeavour. When a temperature level was reached which appeared to be established for some years, it would be time to reconsider reheat. With regard to cold pull-up, 100 per cent. physical cold pull-up was the authors' recommendation. The limitation of one-third was the amount of credit to be taken for such cold pull-up in making the extrapolations.

(*To be continued.*)

LABOUR NOTES.

INDUSTRIAL pensions for employees in the engineering industry are suggested by Mr. W. B. Beard, O.B.E., the general secretary of the United Patternmakers Association, in the Association's *Monthly Report* for July. He states that he cannot understand why operatives engaged in productive employment, such as engineers, should not endeavour to obtain some such provision for themselves, especially as these workpeople provide part of the cost of the pensions of employees in less competitive and more sheltered occupations. When the national insurance scheme was introduced, giving higher State pensions, many trade-union leaders and others hoped that the problem had been solved, but, as industries have become nationalised or have been transferred to some other kind of public ownership, workpeople in these industries have established, with some success, their right to receive contributory industrial pensions, additional to those granted under the State scheme.

Such supplementary pension schemes have resulted Mr. Beard states, in some inequalities of treatment to members of the same unions. Indeed, some men, although possessing the same degree of skill and performing similar services, are being less favourably treated than others, solely owing to the chance of their having different employers. Part of the provision for pensions and sickness payments are provided by an increase in the price of the commodity produced, or the services rendered, and this is paid by the consuming person or industry. The ability of Britain to continue these benefits, and, in fact, to maintain the ordinary standard of living, depends upon the country's exports, of which the engineering industry provides no less than 36 per cent. It does not appear equitable, therefore, that workpeople in this and other productive industries should be less favourably rewarded than operatives in more secure occupations. Mr. Beard refers to their being a few firms which make provision for their employees to supplement their trade-union and State allowances, but emphasises that this is not the general practice. He concludes by quoting details of the private scheme in operation at the works of the Ford Motor Co., Ltd.

Increases in profits are referred to by Mr. Beard elsewhere in his editorial article. Profits have been reaching very high figures, he states, and, for industries engaged in export trade, this is not, perhaps, a bad thing for the country. It means, in effect, that the nation is receiving high prices for its products, to counter the "rake-off" some countries are getting for their raw materials. It is difficult to devise the means of controlling profits in the national interest and, indeed, it would not be wise to introduce machinery which would have the effect of putting a premium on efficiency. What can be done and, in fact, has been accomplished by the Chancellor of the Exchequer, is to increase the tax on distributed profits and on the higher range of incomes. The tax on dividends has been increased from 30 per cent. to 50 per cent. and income tax has been increased for the higher-scale of incomes. We are only at the commencement of the rearmament programme, however, and the sources of extra revenue are decidedly limited regarding the higher-income groups. A capital levy, for example, he informs the members of his trade union, could be used effectively no more than once.

Four training courses, each of two weeks' duration, have been arranged by the Railway Executive for their railway employees and will be held at Dillington House, near Ilminster, Somerset, an adult residential centre for higher education, established by the Somerset education committee. These courses, the first of which commenced last week, are designed to provide a better understanding of the problems with which British Railways are faced and to secure the co-operation of the railwaymen in dealing with them. Subjects covered by the courses will include the organisation and integration of British transport, fundamental problems confronting the railways, railway staff problems, and the relationships between the railways and their customers. Report writing, costs, charges, and the interpretation of plans and diagrams will also be discussed. Each course will accommodate about thirty men, and will be open to employees from all Regions and of all grades.

Returns issued by the Ministry of Labour on July 11 show that the number of unemployed persons in Great Britain registered for work on June 18 had declined to 190,776, compared with 215,700 on May 21. The June figure represented about 0·9 per cent. of the estimated total number of persons in employment and the figure for May about 1 per cent. The corresponding percentage for June, 1950, was 1·4. Of the total of 190,776 persons unemployed on June 18 last, 122,070 were men aged 18 and over, 3,393 boys of less than 18 years old, 62,201 women aged 18 and over, and 3,112 girls of less than 18 years old. The Ministry estimated that there were then 7,459 persons temporarily disengaged and 183,317 wholly unemployed. Of the latter figure, some 85,818 persons (62,878 men and boys, and 22,940 women and girls) had been unemployed for more than eight weeks, and the remaining 97,499 persons for periods varying from one day to eight weeks. The total for June 18 is understood to be the lowest level of unemployment recorded in Great Britain for many years, and is attributed in part to the growing momentum of the rearmament drive.

There was an increase of 20,000 persons, all women, in the total working population of Great Britain during May last, although an increase is not usual in that month, when there are few young people leaving school to enter employment. At the end of the month, the number of persons, aged 15 and over, who were working for pay or gain in Great Britain, or who had registered themselves as available for such work, numbered 23,287,000, of whom 15,937,000 were men and boys, and 7,350,000 women and girls. Of that total, 22,256,000 persons were engaged in civil employment (industry, commerce and services of all kinds), an increase of 46,000 on the total for the end of April. The size of the armed Forces rose by 4,000 during May, to an end-of-the-month total of 822,000, and there were 6,000 ex-Service men and women on release leave seeking employment, at the end of the month. The remainder of the working population, 203,000 persons, were registered as unemployed.

There was an increase of 25,000 during May in the number of persons employed in the basic industries, which comprise mining, quarrying, agriculture, fishing, gas, electricity, water, transport and communications. The total number employed in these industries at the end of that month was 4,153,000. There were, however, some 5,000 fewer men and women engaged in the engineering, metal, and vehicle industries, thereby bringing the number of workpeople employed in this group to 4,114,000. In the textile industry, there was a decline of 2,000 in the number of employees, bringing the end-of-month total to 1,037,000. A decline of 1,000 took place in the clothing industry, which, at the close of May, employed 725,000 persons. Employees in the chemical and allied industries increased in number by 1,000, to 492,000, and, in the food, drink and tobacco industries, by 2,000, to 805,000. Other manufacturing industries employed a total of 1,514,000 workpeople, the same number as at the end of April. In all, some 8,687,000 men and women were at work in the manufacturing group of industries at the close of May.

Serious shortages of railway staff in several industrial areas have led the Railway Executive to suggest to the three railway unions that some concessions in their working conditions should be made by the railwaymen. The proposals put forward by the Executive include an extension of the working week from 44 to 46 or 48 hours for certain traffic grades in under-staffed areas, the extra hours worked to be paid for as overtime. It was suggested also that, in some cases, key employees should be asked to work during the second of their two weeks' annual paid holiday. Volunteers for this work would be paid a normal week's wage, together with any ordinary overtime money due to them, and a special bonus equivalent to a further week's pay at time-and-a-quarter rates. Another proposal of the Executive to ease the labour shortage was that the age for retirement should be raised from 65 to 70 in some instances.

British Railways estimate that the labour equivalent of some 20,000 railwaymen must be provided, if a serious curtailment of freight and passenger transport is to be avoided. It has been suggested that the approval of the Ministry of Labour should be sought, to enable Italians to be recruited for employment on certain types of less-skilled work, including permanent-way and signalling duties. The proposals of the Executive are at present under consideration by the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen, as the two unions chiefly concerned with the operative grades. On the whole, the former union is understood to be favourably inclined towards the suggestions, as likely to forward its own plans for an all-round increase in railwaymen's wages. The Locomotive Engineers, however, appear to be opposed to any concessions on working conditions. This union considers that much would be done to ease the labour situation if railwaymen were excused military service.

PRECISION MEASUREMENT OF ROCKWELL DIAMOND PENETRATORS.

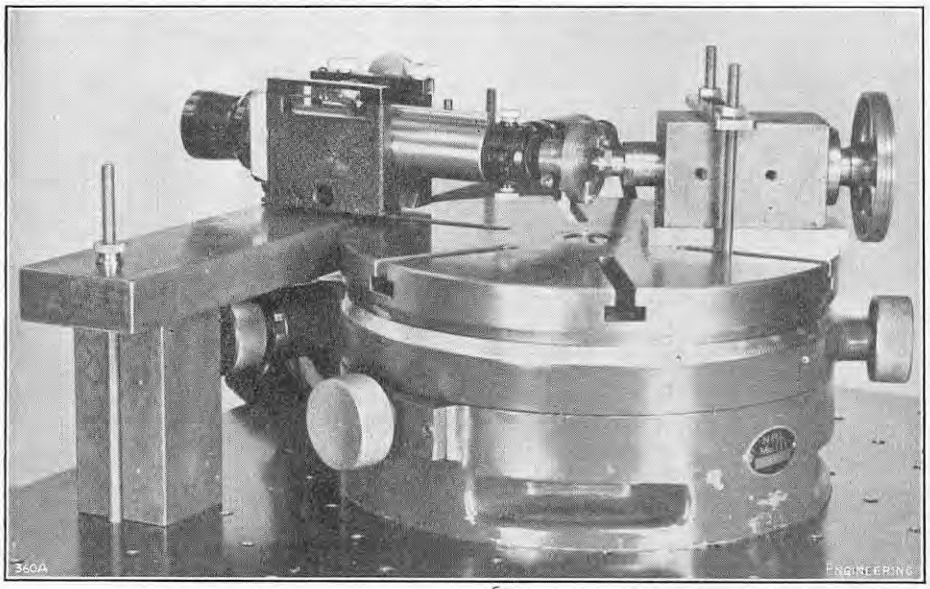


FIG. 1. APPARATUS FOR ANGULAR MEASUREMENT.

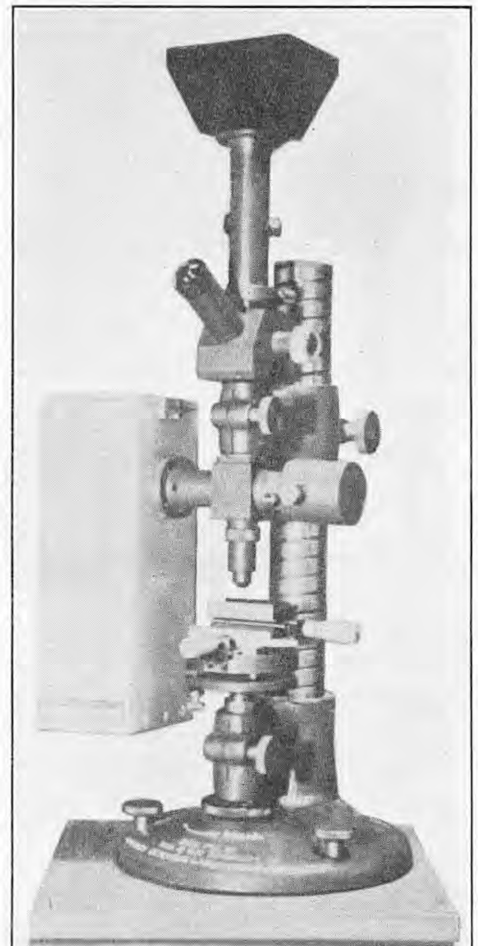


FIG. 4. "LINNIK" INTERFERENCE MICROSCOPE.

Fig. 2.

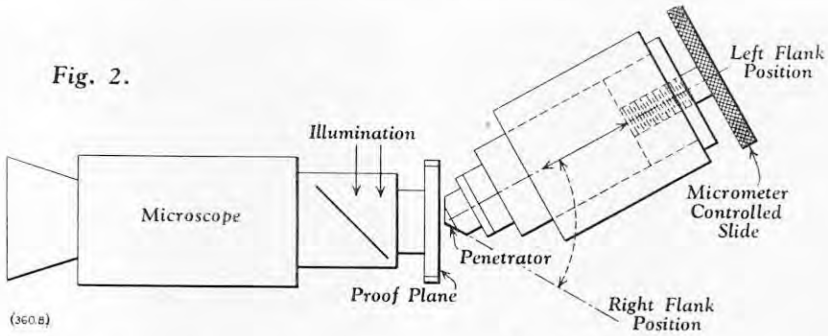
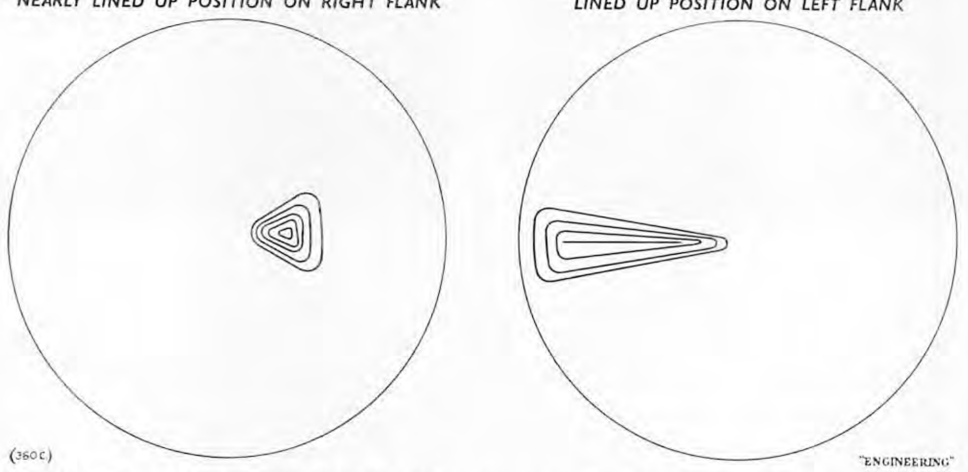


Fig. 3. (a) "NEARLY LINED UP" POSITION ON RIGHT FLANK

Fig. 3. (b) "LINED UP" POSITION ON LEFT FLANK



PRECISION MEASUREMENT OF ROCKWELL HARDNESS DIAMOND PENETRATORS.*

By F. R. TOLMON and JILL G. WOOD, B.Sc. (Eng.).

IN their paper analysing the Rockwell hardness test,† C. E. Phillips and A. J. Fenner describe the experiments they made to determine the influence on the resulting hardness number of departures from the nominal form of the conical diamond penetrators used. The penetrators were measured in the Metrology Division of the Laboratory and the present paper gives an account of the methods employed. The prescribed form for the penetrator is laid down in B.S. 891 : 1940 and is repeated below for ease of reference: "The conical penetrator shall be a diamond with an angle of 120 deg. to an accuracy of $\pm$ 0·1 deg. in any axial plane. The point of the penetrator shall be rounded to a radius of 0·20 mm. and the profile shall conform to the radius of 0·20 mm. within an accuracy of $\pm$ 0·005 mm. The round and conical surfaces shall join in a truly tangential manner. The penetrator shall be clean, have a good polish and be free from cracks and surface blemishes, and shall be solidly mounted in a suitable holder." The only measurements required, therefore, are of the angle of the cone and of the radius of the point, the other features mentioned being appraised by visual inspection.

An investigation was first made of the accuracy with which the angle of the cone could be measured by the standard method developed at the Laboratory for determining the flank angles of screw-gauges, namely by measurement on an optically projected image by means of a shadow protractor.* The magnification of the optical projector was increased from the usual $\times$ 50 to $\times$ 85 in order to produce an image of the penetrator flank of a length equal to that of the protractor arm, but it was found impossible to achieve an accuracy of measurement better than $\pm$ 6 minutes of arc, although a large number of readings was made. It became necessary, therefore, to seek a new method of measurement which would give an improved accuracy. The following technique was devised, the apparatus used being illustrated in its final form in Fig. 1.

The penetrator was mounted on an accurately divided rotary table with the axis of the cone horizontal and its point close to the axis of rotation of the table. The penetrator could be moved axially by means of an accurate slide controlled by a micrometer screw. In effect the supplement of the cone angle was measured in a horizontal plane by setting each flank in turn parallel with a datum plane formed by the semi-reflecting proof plane of an interference microscope. The arrangement is shown diagrammatically in Fig. 2. By bringing the penetrator flank close to the proof plane in the manner indicated in Fig. 2, and illuminating it with white light, a coloured interference pattern was obtained; this pattern is illustrated in Fig. 3 (*a*), in which the lines represent successive spectra.

The form of the pattern was found to be extremely sensitive to any out-of-parallelism between the flank and proof plane, an angular movement of 1 minute of arc, equivalent to 0·00001 in. over the length of the flank, being readily observable providing the flank was sufficiently straight. The interference pattern with the flank set parallel to the plane is shown in Fig. 3 (*b*). It is characterised by a central straight band which, in this condition, has reached a maximum length. Over the greater part of its length, this central band appears as one colour, graduating to the next spectral colour at each end in such a way as to provide a symmetrical appearance. This symmetry of colour was of considerable assistance in obtaining the correct setting, and was responsible for the choice of white light in preference to the more commonly used monochromatic light for work of this type. The method described enables the angle of the cone to be measured to an accuracy of $\pm$ 1 minute of arc. By turning the penetrator about its axis, the measurement may be repeated in different axial planes.

As mentioned by Phillips and Fenner (*loc. cit.*), there is some doubt as to the proper interpretation of the tolerance given in B.S. 891 for the contour of the radiused point of the penetrator. The more liberal interpretation allows the contour to fall anywhere within concentric bands lying 0·005 mm. (0·0002 in.) on each side of the nominal profile. (See Fig. 4 of

* Communication from the National Physical Laboratory. Abridged.

† See ENGINEERING, July 13, 1951, page 57.

* Notes on Screw Gauges, Fifth Edition. H.M.S.O., 1944.

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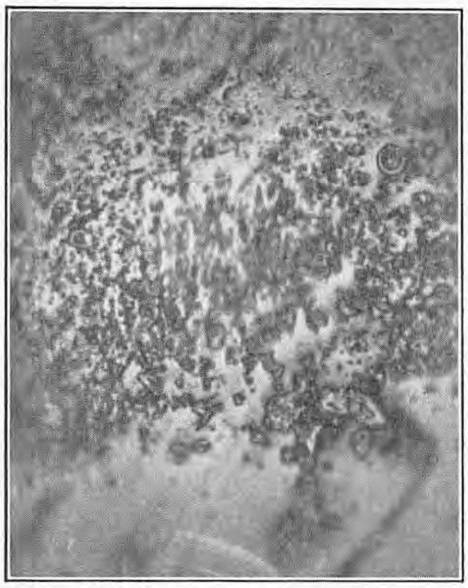

Fig. 5. Pitted Tip. × 720.

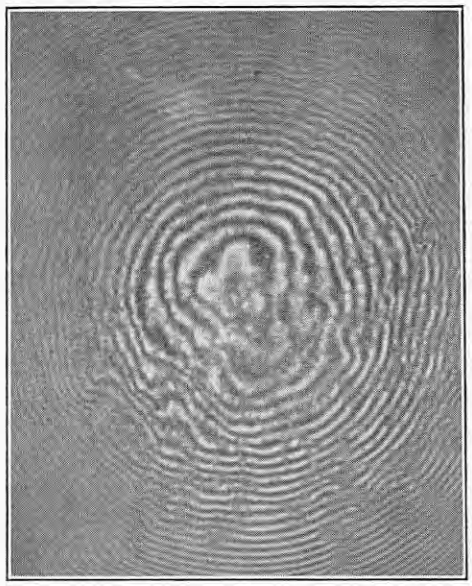

Fig. 6. Micro-Interferogram of Tip Shown in Fig. 5. × 720.

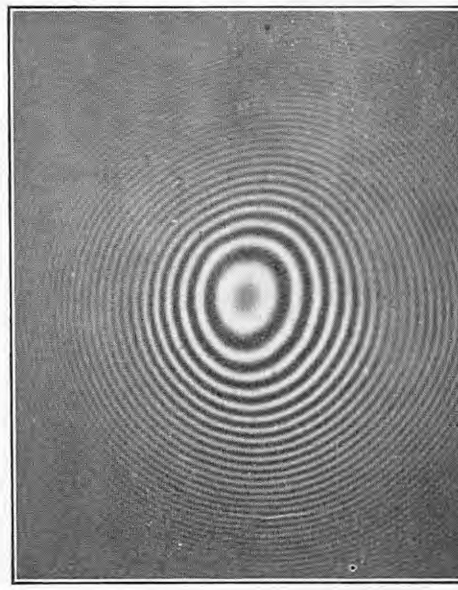

Fig. 7.

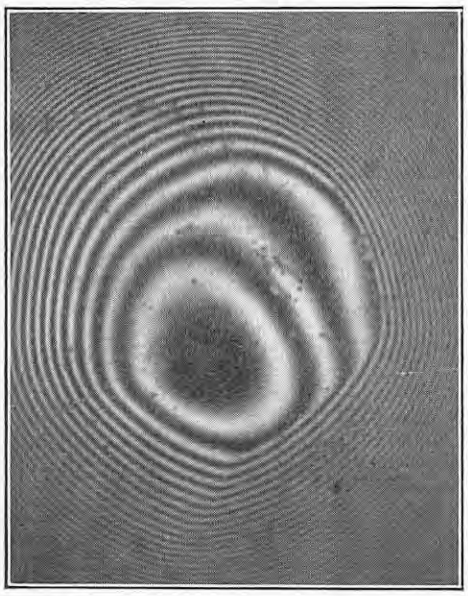

Fig. 8.

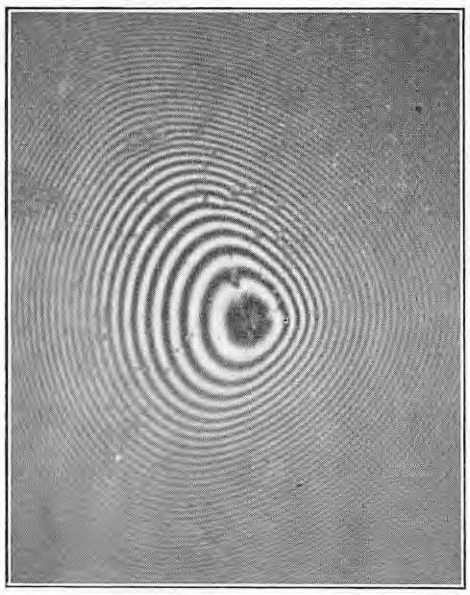

Fig. 9.

Figs. 7, 8 and 9. Micro-Interferograms of Defective Points. × 720.

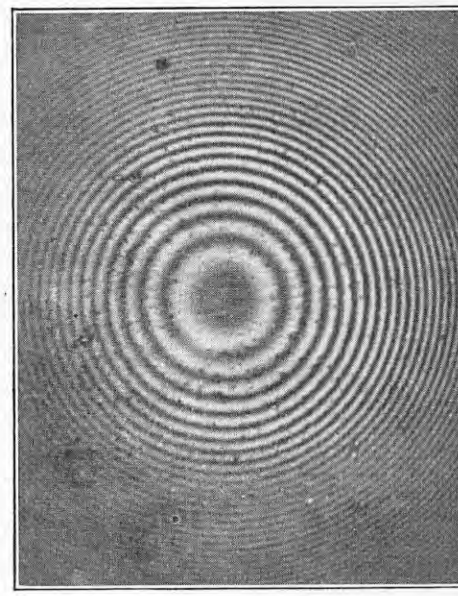

Fig. 10. Interferogram of Steel Ball. × 720.

Phillips and Fenner's paper, page 58, *ante*). Even with this tolerance, it was not found practicable to determine satisfactorily whether the point conformed to requirements when projected at magnifications up to 100 diameters on a standard gauge projector, though it was possible when the magnification was raised to 200 diameters. For the purposes of the investigation an even higher accuracy of measurement was desired, and the magnification was therefore increased to 1000 diameters by the use of a projection lens system in which a 1-in. Zeiss objective was used in combination with a × 12 Leitz eyepiece. Slightly convergent light, using a 500-watt mercury-vapour lamp as source, was found to improve the contrast on the shadowgraph without distortion. Although both contrast and definition were inferior to that obtainable at lower magnifications, these disadvantages were more than offset by the large tolerance band, 10 mm. wide, made available, and it was possible, by reference to a 1,000-diameter projection drawing, to estimate the departure of the profile from nominal to an accuracy of 1 mm. at the image on the screen, namely to 0·001 mm. on the penetrator point itself. At this magnification the radiused point and flank could be readily checked for smooth blending. By rotating the penetrator both contour and blending could be examined in various axial planes.

It was considered desirable to augment this inspection by a more critical examination of the accuracy of form of the penetrator at its extreme tip. The Zeiss " Linnik " interference microscope, adapted for use with mercury green illumination, Fig. 4, page 89, enabled the quality of finish of the surface to be observed by direct viewing and the general contour to be determined by examining the Newton's rings formed between the radiused point and an optical flat. This instrument gives a visual magnification of 600 diameters and is fitted with a photographic attachment which enables a permanent record to be made at half this magnification. Used as a direct microscope, the Linnik readily enables surface blemishes to be detected and Fig. 5 is an example of a tip showing excessive pitting. A micro-interferogram of the same surface is shown in Fig. 6, and it will be seen that the fringe pattern is distorted by the irregularities in the surface.

It was found that photographs taken on the Linnik interference microscope gave a very clear general impression of the shape and surface of the tip of the penetrator over a restricted distance corresponding to an axial depth of about 0·0002 in. from the apex of the penetrator. Beyond this, the interference fringes were too close together to be of practical value. These micro-interferograms, which are, in effect, contour maps of the point of the penetrator in planes at successive axial distances from the apex of half wavelengths of mercury-green light, i.e., at intervals of 0·00001 in., reveal clearly the presence of flats and pitting. The particular examples illustrated in Figs. 7, 8 and 9 are of points which are out of round and display a certain amount of lobing. Additionally one of the points (Fig. 8) is flattened and offset from the penetrator axis. It is of interest to record that, although observations of the point illustrated in Fig. 9 were made on the 1,000-diameter projector in three equally spaced axial sections, the lobing which is so apparent in the interferogram was not revealed. Furthermore, two surface blemishes, undetected by any other technique, may also be seen. When interpreting the micro-interferograms it was found helpful to compare them with an interferogram of a steel ball, diameter 0·4 mm., as shown in Fig. 10.

In passing, it may be noted that an approximate value of the radius at the extreme tip of the penetrator may be deduced from a knowledge of the distribution of the fringes and the magnification of the micro-interferogram, providing the tip has a good surface finish and is free from lobing.

" Ships' Structures: A Century of Progress ": Erratum.—On page 25, *ante*, in the third column, it was stated that " Henry Bessemer took out his early patents in 1885." This date is incorrect and should read " 1855." We are indebted to the author of the paper, Mr. R. B. Shepheard, C.B.E., for drawing our attention to the error, which appeared in the pre-printed text.

Season Tickets for Festival of Britain.—Weekly and monthly season tickets can now be obtained for the Festival of Britain exhibitions. Weekly tickets cost 1*l*. 5*s*. and admit the holder to the South Bank Exhibition the Exhibition of Science at South Kensington and the Exhibition of Architecture at Poplar. Monthly tickets cost 4*l*. and admit to the same exhibitions for one calendar month, July, August or September. They are obtainable from the Festival of Britain advance ticket office, Whitehall-place, London, S.W.1.

SOME MEMORIALS OF EARLY CHEMICAL ENGINEERS.*

By PROFESSOR D. M. NEWITT, M.C., D.Sc., F.R.S.

"Experienc'd Antiquity hath afforded faithfull (though not frequent) Discoveries. Past Ages have like Rivers conveied downe to us (upon the floate) the more light, and Sophistical pieces of Learning; but what were Profound and Misterious, the weight and solidity thereof, sinks to the Bottome; whence everyone who attempts to dive, cannot easily fetch them up."

Elias Ashmole,
Theatrum Chemicum Britannicum, 1651.

"The history of mechanic arts is a necessary part of that knowledge, upon which alone, as on a firm basis, can be built that true science of nature, which is not taken up in vain and fruitless specialities, but effectually labours to relieve the necessities of human life."

Francis Bacon,
De Augmentis Scientiarum, 1623.

THE *Transactions* of our Institution are rightly concerned with the practice of to-day and with pioneering work which may be expected to contribute to the developments of to-morrow; nevertheless, it is not inappropriate that we should, once in a while, glance backwards at some of the difficulties and perplexities of our predecessors and the way in which they overcame them. Chemical engineering, as a distinct branch of engineering, cannot claim to be more than a century and a half old; most of us would be willing to regard Edward Charles Howard (1774-1816) as being the first chemical engineer of any eminence. During the preceding century, however, we can trace clearly the origins of the heavy chemical industry and other associated industries which eventually gave rise to the need for this special type of technology.

In the middle years of the Seventeenth Century, stimulated by the philosophical teachings of Francis Bacon, the great scientific academies of Europe were founded in quick succession: the Accademia del Cimento in Florence in 1657, the Royal Society in London in 1662, the Académie des Sciences in Paris in 1666, and the Collegium Curiosum sive Experimental, the forerunner of the Berlin Academy, in 1672. The fame of those associated with the origins and early years of these renowned bodies are to-day a part of the heritage of this race. Galileo Galilei did not live to see the formation of the Accademia, but two of his distinguished pupils, Viviani and Torricelli, were associated with its early history; Boyle, Hooke, Newton and Wren were among the early Fellows of the Royal Society; Descartes, Pascal, Gassendi and Huygens were associated with the Académie; Leibnitz was the moving spirit of the Berlin Academy.

These foundations were under the patronage of reigning princes, who took a close and personal interest in their proceedings and were, indeed, adepts in their own right. The two Medicis, Ferdinand II and Leopold, had their own laboratories in Florence; Charles II had a laboratory in Whitehall; the Paris Academicians met in a room of the Royal Library. An active correspondence took place between their members, and travellers of distinction had the honour of being invited to their deliberations.

It must not be supposed that their interests were confined to the pure sciences. The early volumes of the *Philosophical Transactions* contain many references to technological matters, and the Académie des Sciences published some 20 volumes, giving fully illustrated accounts of the useful arts. It was largely through the influence of the Académie that the Conservatoire des Arts et Métiers, the first museum of science and technology, was founded in Paris towards the end of the Eighteenth Century.

This period of history is not without interest to the chemical engineer. It is true that not even a rudimentary chemical industry could be said then to exist, nor had chemistry itself been freed from the entanglements of alchemy. Some of the basic operations of chemical engineering, however, and some of its indispensable tools and equipment, formed the subject of earnest inquiry and experiment.

By the end of the Sixteenth Century, such industries as there were had reached that stage of growth at which further progress was handicapped by the want of sources of power to replace the horse and the primitive waterwheel; and of materials of construction to enable the newly discovered principles of mechanics and hydraulics to be applied in more refined forms than had been possible up till then. For the time being, theory had far outstripped practice.

Contemporary writings (among which must be included patent grants and specifications) contain abundant evidence of inventions which, owing to the lack of materials and tools, could not be incorporated in the industrial practice of those days. One remarkable example is that of the rotary pump, described and illustrated in a work published in Paris in 1588 and entitled *Le Diverse et Artificiese Machine del Capitano Agostino Ramelli*. Ramelli was one of the distinguished band of military engineers which gathered about Leonardo da Vinci in his later days.

One of the best illustrations of the difficulties engineers were meeting is afforded by the mining industry, which was becoming involved in deep mining operations on an ever-increasing scale. Improved methods of haulage, pumping and ventilating were badly needed, and many new devices were suggested and tried out. A number of these were described and illustrated in the first modern classic on technology, the *De Re Metallica*, compiled by Georgius Agricola (Bauer) in 1556.

Somewhat similar problems faced the civil engineers, who had the task of providing increased and better water supplies for the rapidly growing capital cities of Europe. A variety of methods, in which great mechanical ingenuity was employed, were introduced for raising water. The water-works in Augsburg, which made use of the Archimedian screw, were famous in the late Sixteenth Century; in 1582, power-driven pumping machinery was installed under the arches of London Bridge; and, in 1608, a somewhat similar system was installed below the Pont Neuf in Paris, to supply the Louvre and the Tuileries.

It is sometimes a matter of surprise that the applications of the steam engine and the force pump for raising water were so long delayed. The early volumes of the *Philosophical Transactions* contain numerous references to successful demonstrations of models of these engines, but attempts to construct and operate large units were, for a long time, unsuccessful. The reasons for this are two-fold: machine tools were not available for accurately boring cylinders, and the skill in casting metals was not sufficient to enable pipelines to be constructed of adequate strength.

The early history of cylinder construction is bound up with gunmaking and with the efforts of civil engineers to build force pumps and pipelines for the raising and distribution of water supplies. The first gunmakers borrowed their technique from the coopers and built guns like casks—a series of longitudinal bars, held together by iron hoops. When brass guns were introduced, they were bored by a hand-operated boring bit. There are surviving some interesting records of an ordnance factory established by Charles I at Vauxhall, and at one time in occupation by that picturesque character, the second Marquis of Worcester (1601-1667) and his associate, Caspar Calthoff, a Dutch mechanic of great skill. An inventory of the workshops, made in 1645, contains the entry:*

"1. In the great boring rooms, one mill for the boring of guns, two iron Spindles, one Truck, six Engines belonging to the Mill, one wooden engine, more not finished, two little Engines to hould barrells, one little engine to trie barrels whether they be right bored, one other little engine to turne wheeles for firelocks, one deale Chest, one modell for a water works and a wooden grate to the same, two iron holdfasts, one other little engine for boring uses, and wooden stools with three leggs, one Viceboard, one box full of iron shavings, one iron hooke to stringe crossbowes, with divers small poles belonging to the said roome."

In a small room next to the boring room there are found "divers pieces of brasse for spindles to run in"—an early reference to bearings—and "In the Cellar, three woodden frames to set beere upon, and one brazen cock to lett out Ye water into the river of Thames when the Cellar is overflowen."

The Marquis of Worcester is now best remembered, perhaps, as the author of a curious book entitled *A Century of the Names and Scantlings of Inventions by me already Practiced* (1663). He seems to have been a typical inventive genius, fertile of ideas, but without the practical faculty for working them out. There is, however, in his book a significant entry:—

"No. 68. An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be as the Philosopher calleth it, *Intra spharram activitates*, which is but at such a distance. But this way hath no Boundes, if the Vessels be strong enough; For I have taken a piece of a whole Cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and scruing up the broken end; as also the Touch-hole; and making a constant fire under it, within 24 hours it burst and made a great crack; So that having a way to make my Vessels, so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant Fountaine-stream forty foot high: one Vessel of water rarified by fire driveth up to forty of cold water." As in so many other instances, the author gives no details of the principles upon which this important claim is founded.

Another interesting personality, known to all lovers of Pepys' Diary, is Sir Samuel Morland (1625-1695), Master of Mechanicks to the King. We are, among other things, indebted to him for the first quantitative measurement of the relative volume of steam evaporated from a given volume of water, for data on the capacity of pipes, and for being the author of the first engineers' pocket-book.

A far more practical character than the Marquis of Worcester was his contemporary, Thomas Savery (1650-1716), a military engineer of inventive turn and considerable commercial acumen. Though his claims have been challenged, it must be conceded that he made considerable technical advances in pumping practice. A steam engine for pumping water out of mines was patented by him in 1698 and a working model was demonstrated to the Royal Society in the following year.* The practical application of his invention was retarded, however, by the difficulty of constructing a safe boiler and cylinder.

"Captain Savery," said a contemporary, "made a great many experiments to bring this machine to perfection, and did erect several, which raised water very well for gentlemen's seats; but could not succeed for mines, or supplying town, where the water was to be raised very high and in great quantities; for then the steam required being boiled up to such a strength, as to be ready to tear all the vessels to pieces . . . I have known Captain Savery at York-buildings make steam eight or ten times stronger than common air; and then its heat was so great, that it would melt common soft solder; and its strength so great as to blow open several joints of his machine so that he was forced to be at the pains and charge to have all his joints soldered with spelter or hard solder." Even so, the operation of a boiler constructed on this principle must have been extremely hazardous.

Savery later employed Newcomen, who made substantial improvements not only in the design of his engine but also in the methods of construction. In particular, he replaced the brass cylinders and lead pipes of the early engines by cast-iron cylinders and pipes, which he obtained from the famous ironworks at Coalbrookdale, in Shropshire.

There is little doubt that it was at these works, then recently taken over by Abraham Darby, the first of a great dynasty of ironmasters, that the process of smelting iron with mineral fuel was first successfully practised.† By 1724, his works were largely engaged in the production of cast-iron cylinders, barrels and pipes for pumps.

The next important advance in cylinder technique was due to John Wilkinson of the Bersham Iron Works, who, about 1775, introduced a method of boring by means of a long stiff cylindrical bar, mounted on bearings at each end and fitted with a cutter head which could be traversed along the bar‡. For many years, Wilkinson supplied all the cylinders used by Boulton and Watt. Improvements in the design of boring machines and other machine tools were rapid, and the availability of well cast and accurately bored cylinders lead to an immediate expansion in the use of steam power in industry.

From the standpoint of the chemical engineer, the most important phase of this new application is to be found in salt and sugar-refining processes. Progress in the technology of these industries forms an interesting comparison, since both are largely concerned with the unit operation of evaporation.

During the period about which I am speaking, salt occupied an important position in the economy of this country; not only was it an essential element in food preservation, but it was also an exportable product, in great demand in Europe and Asia. From the time of the Commonwealth until 1824, the salt tax was considered by a succession of Chancellors as affording one of the most certain and easily collected sources of revenue; it was steadily increased until, at the time of its abolition, it amounted to 15*s*. on a bushel of salt worth about sixpence.

The best account of the technology of salt manufacture in the early Eighteenth Century is contained in a remarkable work by William Brownrigg entitled *The Art of Making Common Salt as now Practiced in Most Parts of the World; with Several Improvements Proposed in the Art, for the Use of the British Dominions*

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* Presidential address to the Institution of Chemical Engineers, delivered in London on May 18, 1951. Abridged.

* Public Records Office, *Land Revenue Enrolments*, vol. 113, page 41; and *The Engineer*, vol. 128, page 506 (1919).

* *Phil. Trans.*, vol. 21, pages 189 and 228 (1699).

† "Notes on Coalbrookdale and the Darbys," by J. W. Hall. *Trans. Newcomen Soc.*, vol. 5, page 1 (1924-25).

‡ "The Early History of the Cylinder Boring Machine," by E. A. FORWARD. *Trans. Newcomen Soc.*, vol. 5, page 24 (1924-25).

(London, 1748.) This book might serve in many respects as a model technological treatise in dealing, as it does, with the history of the industry, the chemical and physical processes involved in the manufacture, the design and lay-out of the plant, the method of operation, and suggested improvements. The author, William Brownrigg (1711-1800), was a medical practitioner, trained in London and Leyden, and practising in his native city of Whitehaven. He appears to have been an original and talented experimentalist and to have taken a great interest in local industries. The records of the Royal Society contain a number of his papers on the subject of the gaseous exhalations from coal mines; he was elected a Fellow in 1741 and received the Copley Medal in 1766. It is interesting to note that he had a supply of firedamp piped to his laboratory and used it for heating furnaces.

Salt manufacture, as then practised in this country, consisted in evaporating brine in shallow flat-bottomed rectangular pans, sometimes as much as 20 ft. in length and 12 ft. in breadth. "The pan is placed over the furnace, being supported at the four corners by brick-work; but along the middle, and at the sides and ends, by round pillars of cast iron called taplins, which are placed at three feet distance from each other. . . . By means of these pillars the heat of the fire penetrates equally to all parts of the bottom of the pan, its four corners only excepted. They are commonly made of plates of iron, joined together with nails, and the joints are filled with a strong cement. Within the pan five or six strong beams of iron are fixed to its opposite sides, at equal distances, parallel to each other and to the bottom of the pan, from which they are distant about eight inches. From these beams hang down strong iron hooks, which are linked to other hooks or clasps of iron firmly nailed to the bottom of the pan; and thus the bottom of the pan is supported and prevented from bending down or changing its figure."

The plates used to form the pans were of malleable iron, about 4 ft. 6 in. long, 1 ft. broad and one-third of an inch thick. To avoid corrosion, the sides of the pan were sometimes made of lead. The pans were contained in enclosed buildings, known as "salterns," provision being made for the escape of steam through openings in the roof.

Brownrigg gives full details of the method of evaporation, including means for precipitating colloidal material, for removing insoluble carbonates and sulphates, and for regulating the size and purity of the product. He also gives one interesting footnote, which indicates that fuel economy was beginning, even in those days, to occupy the attention of the salt manufacturers: "At Blyth in Northumberland," he wrote, "besides the common salt pans, they have a preparing pan placed between two salt pans. . . . The sea water being received into the preparing pan is there heated and in part evaporated by the flame and heat conveyed under it through flues from the two furnaces of the salt pans. . . . various other contrivances have been invented to lessen the expense of fuel."

Heat conservation and fuel economy, though much in the minds of Eighteenth-Century technologists, made slow progress. Various tentative suggestions are to be found among the patent specifications of those days for utilising the sensible heat of the flue gases and the latent heat of the steam from the boiling pans. John Baker, for example, proposed, in 1764, to enclose salt pans completely and to pass the flue gases over the surface of the evaporating brine; and Daniel Scott and John Mackay patented (1772) an arrangement for constructing the pans in tiers, the upper ones being jacketed and heated by the steam from the lower ones. The application of the principle of multiple-effect evaporation, whereby the steam from the liquid evaporating in one pan could be used to boil the liquid in the succeeding pan, had to await the development of vacuum technique, owed primarily to the technologists of the sugar industry.

Up to a point, the sugar industry followed much the same pattern as the salt industry in respect of evaporation technique. The "equipage," "copper wall" or "Jamaica train" of the sugar refinery corresponded with the "saltern" and consisted usually of a battery of five boiling pans, heated by means of a furnace. The pans were of relatively small capacity and a stricter control of the rate of boiling was necessary than with brine, in view of the danger of boiling over, with consequent fire hazard. No special arrangements for heat conservation and recovery appear to have been introduced until as late as 1785, when Thomas Ward proposed the use of double-bottomed or jacketed pans, heated by steam.

The early years of the Nineteenth Century, from which may be said to date the birth of chemical engineering as a distinct technology, saw two big advances in evaporation technique, which established the basis for design of much of the plant in use to-day. The first was the introduction of steam heating by means of fixed coils immersed in the liquid; and an extension of this method by William Cleland (British Patent No. 5520 of 1827) and Wetzel, whereby partly immersed coils were rotated and a crude form of film evaporation took place. The second was the invention of the vacuum pan with its ancillary equipment by Edward Charles Howard.

Howard was a brother of the 12th Duke of Norfolk and was a chemist of some distinction. Through the influence of his father-in-law, a well-known London sugar refiner, he was given the appointment of consultant to the West Indian Association of Merchants and Planters, and, during his short career, made contributions to the technology of refining of the utmost importance. His patent on vacuum evaporation (No. 3754, 1813) well deserves to be studied for its clear and comprehensive exposition of the principles of the process. In it he states: "I do evaporate the same [cane juice] in closed vessels, heated by any means, but in preference by steam, and do make and keep up a vacuum more or less perfect in the said vessel, but by preference so perfect at the commencement of working as not to support more than one inch of mercury; and of the various means by which this may be effected I do prefer and employ a pump with a condenser for steam by injection, as is used in the steam engine." He also gives details of the relation between pressure and boiling point, and of various devices for operating vacuum vessels.

Vacuum evaporation was immediately adopted by the industry, and the records of Boulton and Watt* contain details of a number of refineries equipped by them with this type of plant; the royalties paid to Howard between 1813 and the year of his death, 1816, bear witness to the rapid exploitation of his invention.

One of the most important aspects of Howard's work is the stimulus it gave to the development of multiple-effect evaporation. Between 1825 and 1840, numerous crude forms of multiple effect were tried out, both in the sugar and salt industries. William Cleland, the inventor of the Cleland pan, is usually given the credit of having originated the idea; but an examination of his patent (No. 5394, 1826) indicates that he had only a very imperfect understanding of the relation between the various stages. Degrand,† Pecqueur‡ and Derosne§ produced rather more refined designs, but there is little doubt that the first efficient double-effect and triple-effect evaporators were the work of Norber Rillieux.|| Born in New Orleans in 1806, Rillieux was educated in Paris and, for some time, was a lecturer in mechanical engineering at the Ecole Centrale. During this period he began his studies of evaporation.

He later returned to New Orleans, where, after several failures, he constructed and operated a large triple-effect evaporator. By the middle of the century, the process had been extensively adopted by the sugar industry in the West Indies and in the Americas, and by the sugar-beet and salt industries in Europe. Rillieux returned to Europe, where he continued his work on evaporation; he died in Paris in his 89th year.¶

The pestle and mortar, the flat stone, and the edge-runner mills date back to a remote antiquity. The three-roll mill is a comparatively modern product and its development is closely associated with the sugar industry; it is said to have been invented by Pietro Speciale, Prefect of Sicily, in 1449. In its earlier forms, the rolls were constructed of wood and were mounted with their axes vertical, the centre roll being geared to the two outer ones. Iron-plated rolls were introduced in the beginning of the Seventeenth Century and later (1652) George Sitwell of Renishaw constructed rolls consisting of iron shells covering wooden cores.

The horizontal three-roll mill first appears among a collection of drawings by John Smeaton, the inventor of the blowing cylinder, in possession of the Royal Society,** and one is known to have been constructed by John Collinge in 1794. Improvements, particularly in the design of the headstock, were made by Buchanan (1858) and Rousselot (1871).†† The three-roll mill revolutionised the operations of grinding and crushing in many industries, and can be regarded as another development of the first importance to chemical engineers.

I cannot close my brief survey of Eighteenth-Century technology without a reference to two individuals, John Stewart and John Roebuck, who, in different spheres, made important contributions to industrial practice. Stewart was an American who, for some obscure reason, was also known as Robert Rainey. He was associated for many years with the sugar industry, and, about the middle of the century, conceived the idea that the "fire engine" could be adapted to the driving of crushing rolls, steam from the evaporating train being used to operate the engine. He envisaged evaporating under pressures above atmospheric and generating power in condensing engines at about 5 lb. gauge.* He wrote feelingly of the intractability of mules, of which, he says, 30 were required for a factory making two tons of sugar a day.

In 1777, he was in England and presented a paper (not printed) to the Royal Society on the application of the steam engine to machinery in general. Some record of his activities survive in the *Minutes* of the Jamaica Assembly, which, for December 23, 1770, contain the entry: "An act to enable Robert Rainey, otherwise known as John Stewart, to carry into execution his newly invented mill for grinding sugar canes with the power of a fire engine."

John Roebuck (1718-1794) is known to those interested in the history of the iron and steel industry as one of the founders of the Carron Ironworks, but he also has claims to be considered as one of the first practising chemical engineers. Born in Sheffield in 1718, he studied medicine at Edinburgh, where he came under the influence of J. Black and imbibed that love of experimental research which influenced his whole subsequent career.

Roebuck practised medicine for a time in Birmingham, but gradually became more and more associated with industrial problems and, in particular, with the applications of chemistry to industry. Working in his own laboratory, he was responsible for numerous improvements in the methods of refining gold and silver, and, as a consequence, was led to interest himself in the manufacture of vitriol. In 1746, he and his partner, Samuel Garbett, constructed the first lead house or chamber, and later (1749) built the first chamber acid factory at Prestonpans. The introduction of the lead house did for the heavy chemical industry what the vacuum pan did for the sugar and salt industries, and must rank with it as one of the major contributions to chemical technology of the Eighteenth Century.

A manuscript by W. E. Sheffield of Birmingham (1771-1790), quoted by Guttman,† contains a full description of one of the earliest lead houses. He writes "The lead house is 6 ft. wide in front at bottom, 4 ft. broad from front to back, and raised or cast in the solid, without any soldering, 6 in. deep. The bottom is made of 9 lb. lead. Two sheets of milled lead, 3½ lb. to the foot, are riveted together and joined one upon the other, each 4 ft. broad and 20 ft. long, and also joined with lead rivets to the bottom. Thus the 'house' is 8½ ft. long, 6 ft. high and 4 ft. wide. The top of the house is slightly convex, and fastened by 'breaking over the sides.' In front and 8 in. from the bottom is a round hole of 10 in. diameter closed by a lead stopper. The house stands in sand and is supported in a wooden frame."

In operating the lead house, successive charges of 1 lb. of a well-ground sulphur and nitre mixture, in the proportion of eight of the former to one of the latter, were ignited and burned for some two hours. The house contained initially 5 cwt. of water, which, after one month's operation, became converted to an acid of specific gravity 1·25 (33·43 per cent. H_2SO_4). The dilute acid was subsequently evaporated in lead pans, 6 ft. long by 2 ft. wide and 1 ft. deep, to a specific gravity of 1·5, when it was known as "weak spirit of salt" or "pickle," or further to a specific gravity of 2·0, which was the adopted standard of oil of vitriol.

The adoption of the chamber process led to an immediate reduction in the price of acid and gave a tremendous impetus to the heavy chemical industry. By 1790, lead houses 20 ft. long by 11 ft. high were in use and, in 1820, there were 23 sulphuric-acid factories operating in England, seven of them in London.

I have by no means exhausted the list of lesser worthies who, during the period immediately antecedent to the Industrial Revolution, made significant contributions to science and technology; but, by making a selection from among those engaged in a wide variety of industries, I hope to have sufficiently emphasised the great, and sometimes quite unexpected, influence which discoveries of a minor character may exert on the direction and progress of industry in general.

* Boulton and Watt Collection, Birmingham Reference Library.

† French Patent of April 15, 1833.

‡ French Patent No. 6886, of 1834.

§ English Patent No. 7082 of 1836.

|| United States Patent No. 3237 (1843).

¶ *Trans. Newcomen Society*, vol. 22, page 12 (1941-42).

** *Trans. Roy. Soc.*, vol. 19, page 120 (1754).

†† *Trans. Newcomen Soc.*, vol. 21, page 7 (1940-41).

* English Patent No. 859 of 1766.

† *Jl. Soc. Chem. Ind.*, vol. 20, page 5 (1901).

EXPERIMENTAL SHALE-OIL PLANT IN COLORADO.—The United States Bureau of Mines announce that they have placed a contract with the Blaw-Knox Construction Company, Pittsburgh, Pennsylvania, for a "demonstration-scale" retort plant for the continuous extraction of oil from shale. The plant will be erected at Rifle, Colorado, and will have a capacity of 150 to 400 tons of shale daily. It is intended to extend the experience gained with a pilot plant, handling six tons a day, which was built to test the new "gas combustion" process, which utilises gas obtained from the shale itself.

PACKAGING MACHINE FOR STOCKINGS.

MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL.

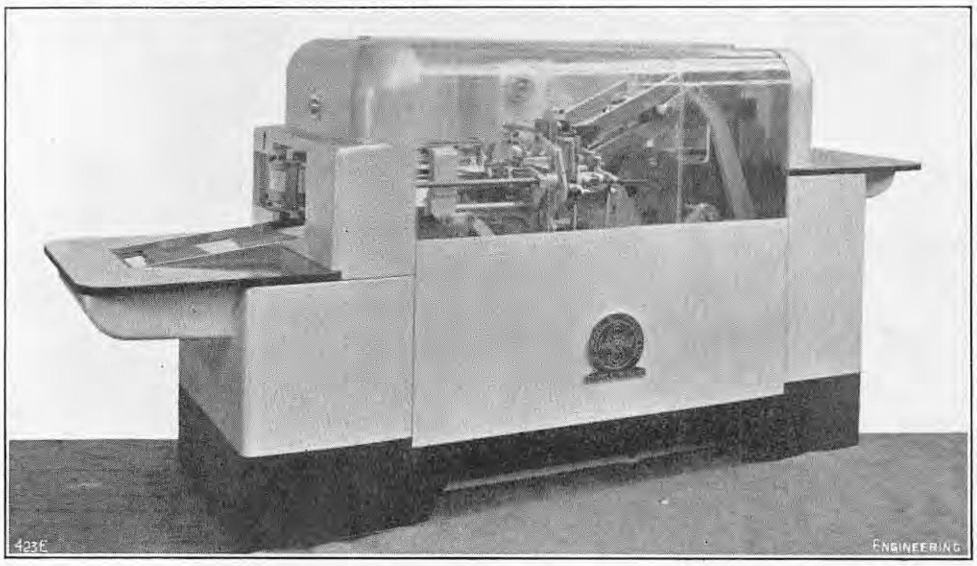


FIG. 1. GENERAL VIEW OF STOCKING PACKER.

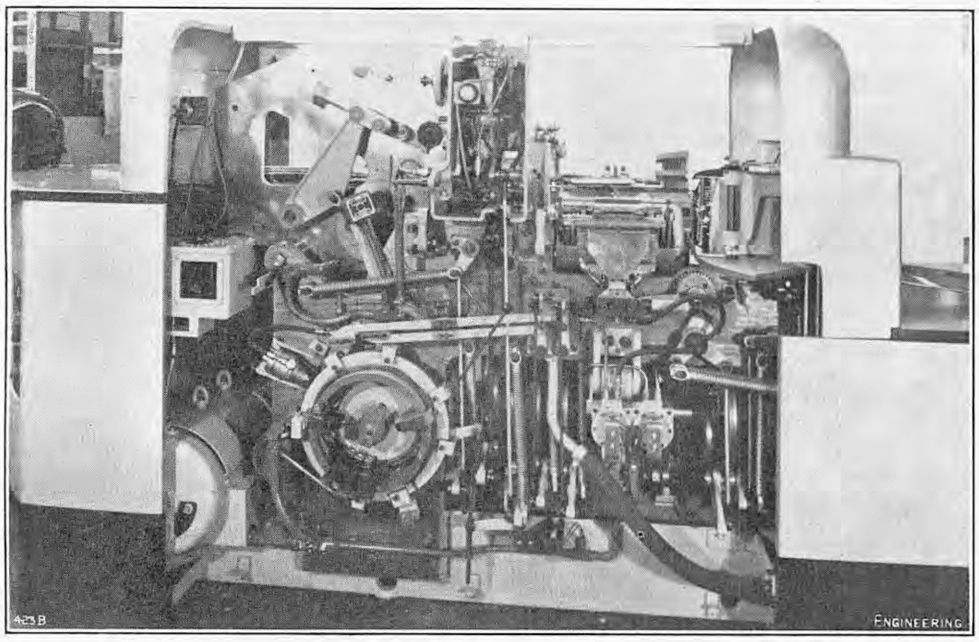


FIG. 2. LEFT-HAND SIDE OF MACHINE WITH COVERS REMOVED.

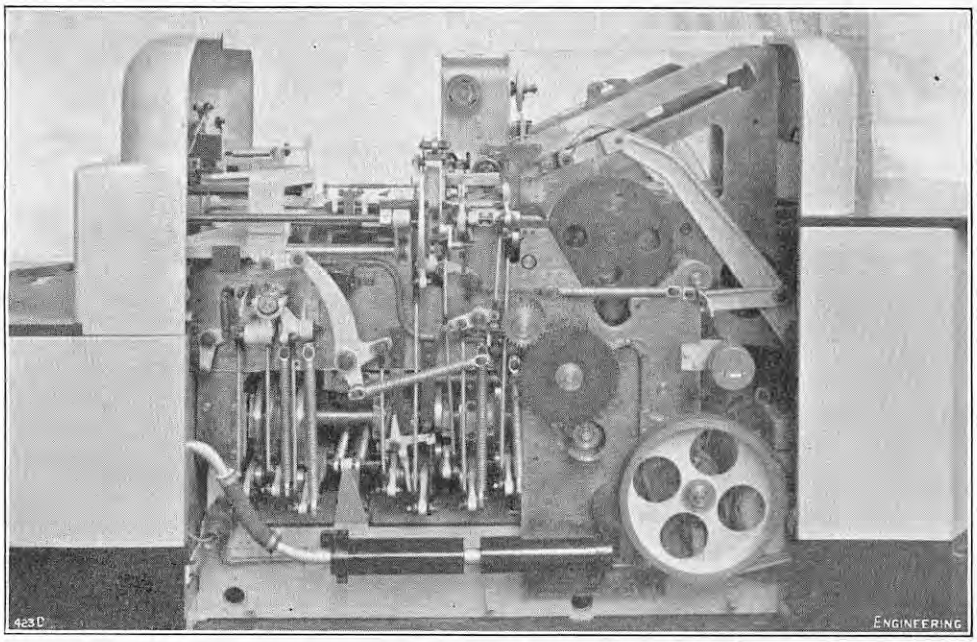


FIG. 3. RIGHT-HAND SIDE OF MACHINE WITH COVERS REMOVED.

PACKAGING MACHINE FOR STOCKINGS.

IN recent years the practice of packing stockings in individual transparent envelopes has been widely adopted by the hosiery industry. Until this year it has been necessary to carry out the operation by hand; but an automatic stocking-packing machine, known as the "Whitehall," was demonstrated in public for the first time at the Second National Packaging Exhibition, held at Olympia in January this year. The machine, which is now in production, is being adopted by a number of British and Continental hosiery manufacturers. The prototype machine has already been in service for more than a year in the factory of a hosiery firm who are co-operating with the constructors, Messrs. Strachan and Henshaw, Limited, Whitehall, Bristol, in the development of the machine; it has been tested at speeds up to 35 packs a minute, although normally a running speed of 25 to 30 packs a minute is considered to be as high as the average operator can handle. It is estimated that the machine reduces packing costs to about one-third of hand packing.

The actions of the machine, which are carried out by a combination of mechanical movements and suction, may be summarised briefly as follows: at one end of the machine a pair of stockings, already folded, is placed on a conveyor belt. As the stockings are detected by the machine, a Cellophane bag is extracted from a magazine, is opened by suction, and is conveyed to the filling station, where the stockings are inserted mechanically into the bag. The end of the bag is then folded and a sealing tab is applied. The sealed packages are delivered in piles of six at the other end of the machine.

Photographs of the Whitehall stocking packer are reproduced in Figs. 1, 2 and 3, the latter two showing opposite sides of the machine with the aluminium side-guards and the Perspex cover removed to give access to the adjustable working parts, all of which are arranged on the outside of the framework. A 40-watt fluorescent lamp is housed in the bridge spanning the machine to facilitate setting and adjustment. The Perspex covers slide in grooves in the side panels and bridge. Most of the working parts are made of heat-treated magnesium castings. Cast-iron side frames supporting the mechanism are carried on a rigid cast-iron base, sufficiently deep in section to avoid flexing on an uneven floor.

The machine operates on a three-phase electrical supply. A 3-h.p. B.T.H. commutator motor, at the delivery end of the machine, drives through a V-belt and double spur reduction gear, thence through bevel gears to two longitudinal camshafts. The cams, of flame-hardened Meehanite, operate rocker levers on two rocker shafts below the cam shafts. The rocker levers actuate the various mechanical motions through extruded magnesium push-rods, fitted with hardened-steel ball joints at each end. The main drive shafts are carried in ball or roller bearings, the principal cam rollers being carried in ball bearings. The minor pivots are either self-lubricating bronze bushes or hardened-steel ball joints; it will be appreciated that the extensive use of magnesium parts in the sliding motions tends to keep the bearing loads light. Below the feed table is a Northey suction pump driven by a 1-h.p. Crompton Parkinson motor. Special measures have been taken to attain a low noise level: the pump and motor unit is carried on Silentbloc mountings and is enclosed by a Burgess acoustic cover. A double silencer is fitted to the exhaust, and rubber coupling pipes are used.

Two machine operators are required, one to feed the stockings at the right-hand end of the machine as viewed in Fig. 1, and the other to receive the packaged stockings which emerge in piles of six from the delivery end. The stockings arrive at the machine folded in pairs, as is customary in hand-packing, to a length of just over 9 in.; the feed operator places them, during a stationary period, on an intermittently-moving twin-belt conveyor, which is driven through a Geneva motion and a spur-gear train from the main-drive bevel cross shaft. The stockings pass into the machine at approximately 9-in. intervals, and are "detected" by a cam-operated pad, the motion of which is obstructed by the stockings. If, however, the feed operator has "missed" and there are no stockings present, the detector is able to complete its full stroke and in so doing it operates a valve in the suction system and thereby alters the setting of a pin-wheel which controls the sequence of the actions. The detector has a range of adjustment which enables both the finest Nylon stockings and stockings $\frac{1}{2}$ in. thick when folded to be detected.

The Cellophane bags are placed with their edges vertical in a magazine, with a capacity of 500. The magazine is mounted on arms which can be swung forward through the end aperture for loading. The bags are fed into the machine only when a pair of stockings is detected; two suction pads grip the bottom corners

PACKAGING MACHINE FOR STOCKINGS.

MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL.

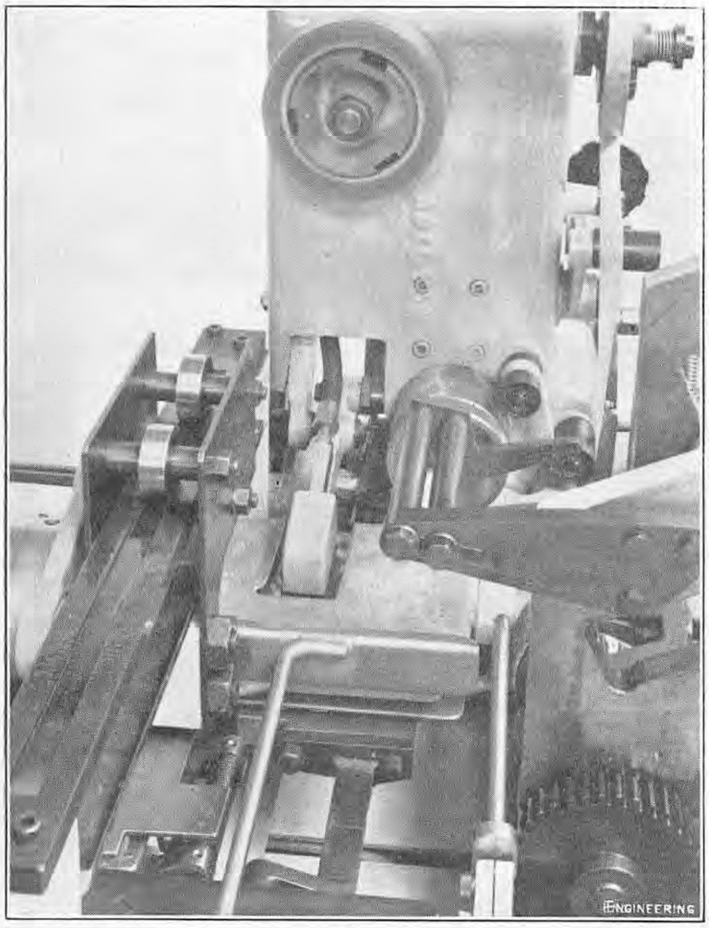


FIG. 4. SEALING-TAB APPLICATOR.

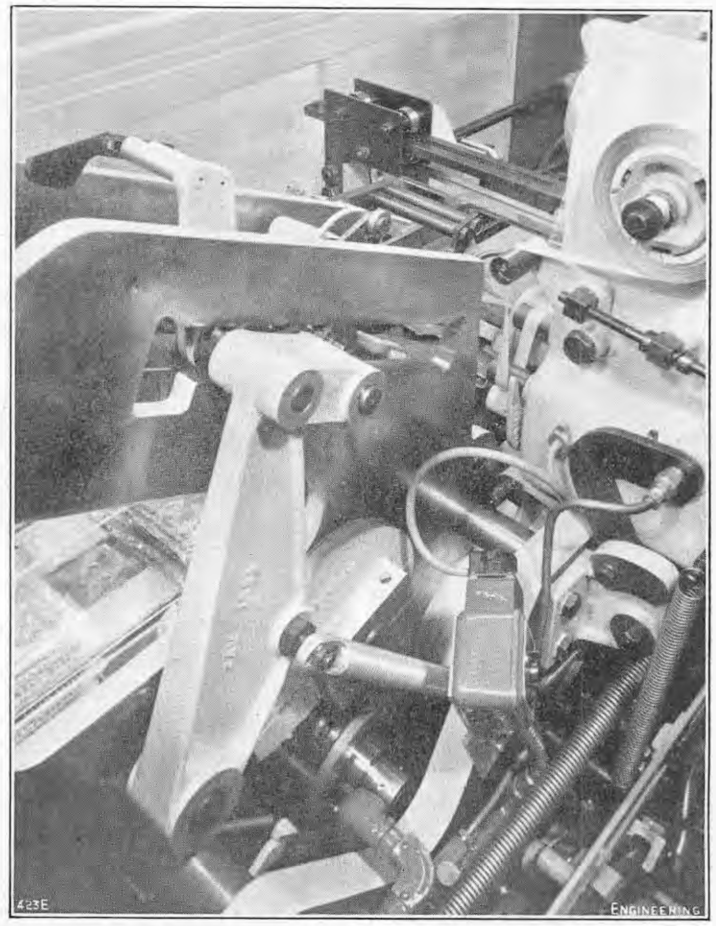


FIG. 5. PACKAGE DELIVERY MECHANISM.

of the leading bag and draw it from the magazine, the rest of the bags being retained by clamps. The suction head is rotated through 90 deg. by a push-rod operated quadrant, to the position shown on the right of Fig. 2, and presents the bag to a second suction head, which is pivoted about a longitudinal horizontal axis. The second suction head carries two suction boxes which close on each side of the bag and are then moved apart by a cam as the head swings to the loading position, opening the mouth of the bag; further rotation of the suction head causes curved parts to enter the mouth of the bag to form guides for the stocking during the filling operation. After turning through 180 deg., the second head finishes with the open bag held vertically downwards, its mouth over the gap between the twin feed belts on which a pair of stockings lies ready for insertion.

A vertical stainless-steel plate is housed below the feed belts on a carriage travelling on vertical double rack-and-pinion tracks; when the stockings arrive at the loading position, this carriage, which is shown in Fig. 6, is propelled upwards by the rocker mechanism and the vertical plate rises through the gap between the belts, lifting the stockings, which drape over the plate, into the bag. At the end of its stroke, the plate lifts the bag from the suction boxes, thereby ensuring that the stocking is right up to the end of the bag, into jaws which are tripped by the final movement of the plate. The jaws grip the stockings through a gap in the feed plate, which then withdraws. The jaws are attached to a carriage, which now rotates through 90 deg. and transfers the pack on to a horizontal traversing carriage which moves about 10 in. towards the delivery end of the machine, passing between a pair of rocker-operated blades which fold the open end of the bag upwards. The bag, which is carried on a transfer plate mounted on rollers, is then traversed towards the centre-line of the machine through suitable guides which finally form the fold; as the transfer plate withdraws, the sealing-tab applicator operates, as shown in Fig. 4, and retains the package until the transfer plate is clear.

The sealing tab consists of a short strip of $1\frac{1}{2}$-in. wide adhesive Cellophane tape which fixes a strip of non-adhesive tape to the fold of the bag. Each tape is carried on a reel on the tab-feeding unit, as may be seen in Fig. 4. When the machine is at rest with the mechanism at a certain position, indicated by the

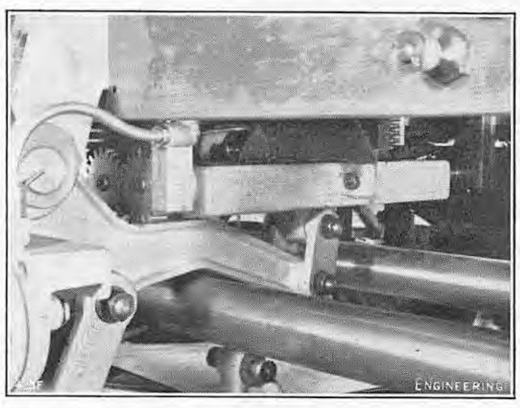


FIG. 6. PARTLY-ASSEMBLED MACHINE, SHOWING INSERTION MECHANISM.

lighting-up of an indicator lamp, the entire tab-feeding unit can be swung sideways for loading the reels of tape. The two tapes pass around a common guide roll and are held there by suction except during the actual tab-feeding movement when the two tapes are advanced by rotation of the reels; a knife then cuts the tab with a scissors action and it is picked up by a traversing suction arm and applied to the folded flap of the bag. The motions of the two reels and the guide roll, the suction valve, the knife and the traversing arm are all controlled by a linkage within the tab-feeding unit from a single push-rod and rocker movement.

To deliver the package the right way up for "boxing," the guide in which it is supported rotates through about 125 deg. and presents the pack to a delivery gripper which reciprocates up and down the inclined track which can be seen at the right of Figs. 1 and 3, and at the left of Fig. 2. The first part of the upward movement is fairly rapid, to withdraw the pack from its carrier as soon as possible, but after that the motion slows down to a uniform low speed. During the latter part of its travel the gripper is tripped and the packet falls on to the delivery belt, which moves forward only when a stocking has been detected. The position at which the gripper is tripped is progressively shifted by a second travelling carriage which carries the tripping cam, shown at the top of Fig. 5, in such a way that six packs are delivered in a pile; the second carriage then returns rapidly to its original position and the cycle is repeated. The traversing of the second carriage is carried out by a clutch-controlled cam and spring-loaded rocker mechanism. The cam, which is driven through a reduction gear, performs one-sixth of a revolution for each revolution of the driven member of the clutch, which is engaged only when a pair of stockings has been detected; the clutch also controls the movement of the delivery belt.

The pinwheel which controls the sequence of operations is driven at one-fifth camshaft speed. It can be seen on the left of Fig. 2. It carries five pins operating successively the levers actuating the valves which control the suction to the first and second suction heads, a catch which restrains the motion of the rocker operating the feed tab unit, and the clutch mechanism driving the delivery stacker. When, however, the absence of a pair of stockings is detected by the cam-operated pad, a pin is displaced sideways by the action of a suction cylinder so that it no longer actuates the various mechanisms.

The main panel for the electrical equipment, below the delivery table, can be inspected by removing an aluminium cover retained by spring clips. It contains the reversing contactors for the main motor (which is fitted with an Igranic "plugging" relay for bringing it quickly to rest), and for the pilot motor which alters the setting of the brush gear of the main motor; the pump-motor contactor; the relay for the control circuits; and the transformer and choke for the 40-watt fluorescent lamp.

There are, in effect, two control circuits allowing "inching" or "running." The main selector switch has four positions, "off," "inch," "run" and a position for testing. In the off position, everything in the panel is isolated and no "live" metal is accessible when the panel is opened. In the "run" position, the machine is protected against the effects of misfeeds of bags or stockings by six automatic trip circuits; operation of the "run" pushbutton actuates the pilot-motor speed-up gear, which sets the main brush gear so that the motor runs up to a pre-set speed controlled by an adjustable limit switch. Should one of the trip circuits stop the machine, the motor will be automatically restored to the bottom-speed setting. It is

190-H.P. DIESEL-HYDRAULIC LOCOMOTIVE.

NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, GLASGOW.

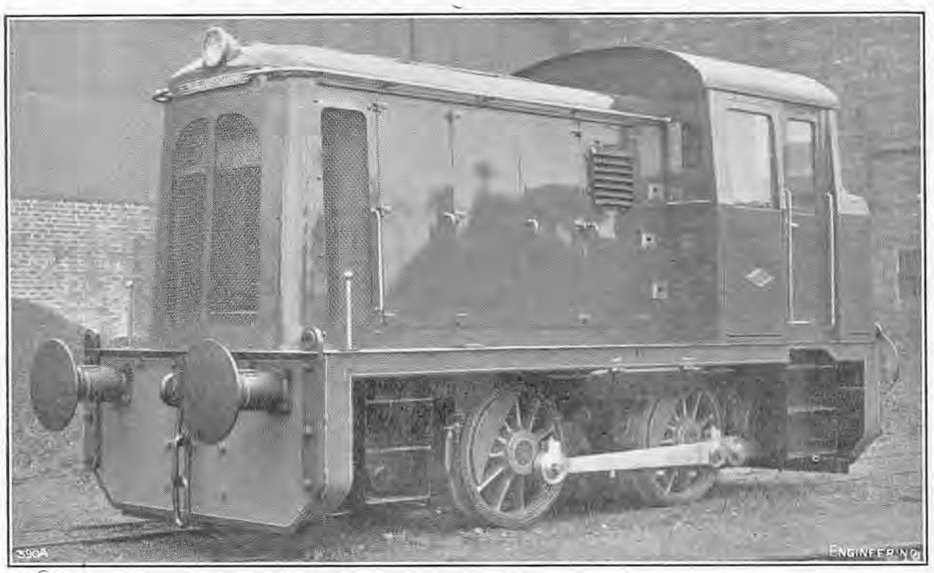


FIG. 1.

then no longer possible to operate the machine by the "run" push-button, but by operating one of the "inch" push-buttons, provided on each side of the machine, the operator can "inch" the machine to remove the cause of the trouble. When inching, the automatic trip circuits and the brush-gear pilot motor are isolated, and the machine can be inched only at the lowest speed of about 10 packs per minute. In the "inch" position of the selector switch the "run" button is isolated, and the machine can be inched only, giving greater safety for the operator when adjustment is necessary. In both the "run" and "inch" settings, a low-speed interlocking mechanism ensures that the main motor cannot be started unless the brush gear is in the low-speed setting.

The automatic trip circuits each comprise a timing switch operated by a cam on the main drive shaft, which breaks the control circuit of the driving-motor contactor; the timing switches can be seen at the left of Fig. 2. In parallel with the six timing switches are micro-switches which must be closed at the instant the timing switches are opened if the machine is to continue running normally. The first and second suction heads each operate two micro-switches in parallel with their timing switches, one operated by a suction diaphragm and one on the link operating the suction valve; the second switch covers the legitimate inaction of the suction micro-switch when no stockings are in the machine. Two further trip circuits are controlled by mechanically-operated micro-switches on the bag-folding motions; one is operated by a suction diaphragm on the tab-feed unit. Finally, a master switch is operated by the delivery gripper in the absence of a package.

With the selector switch set for testing, the pump-motor contactor is isolated so that the machine can be run without vacuum. Six testing switches are fitted in the back of the panel for isolating the trip circuits individually; another switch isolates all the trip circuits from the three-phase supply, but connects them to the transformer so that they may be tested on a single-phase supply in conjunction with an indicating lamp.

TRADE PUBLICATIONS.

Crucible Furnaces.—A leaflet illustrating and describing their lift-out oil or gas-fired crucible furnace, designated F.D. 5, has been issued by the Morgan Crucible Co., Ltd., Battersea Church-road, London, S.W.11. The furnace is in four sizes, the crucible capacity for melting brass being 30 lb. to 50 lb., 60 lb. to 120 lb., 150 lb. to 200 lb., and 250 lb. to 350 lb.

Welded Roof Trusses.—The Constructional Design Department of the Quasi-Arc Co., Ltd., Bilston, Staffordshire, have produced a useful brochure entitled "Welded Roof Trusses," the first of a series of brocnures on welded structures which the firm have in hand. The series is being produced to supply the demand for information on the subject received by the department in the past few years; in particular, as a result of the courses of lectures for designers given by the department in London and Bilston.

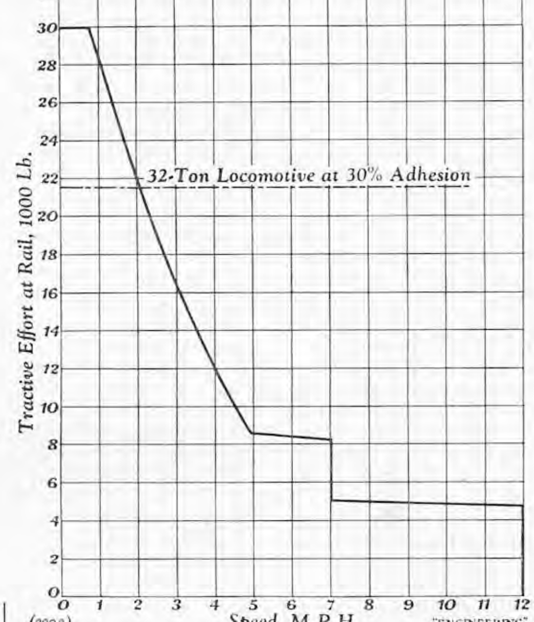
200-H.P. DIESEL SHUNTING LOCOMOTIVE WITH VOITH HYDRAULIC TRANSMISSION.

IN an article which appeared on page 720, in our issue of June 15, 1951, the application of the Voith hydraulic transmission to a Diesel mine locomotive was described, and it was indicated that the North British Locomotive Company, Limited, 110, Flemington-street, Springburn, Glasgow, N., having been granted the manufacturing rights in this country, were arranging to build transmission units of this type up to 1,500 h.p. They have recently completed the first two of a range of Diesel-hydraulic locomotives for industrial and railway shunting duties, one of which is shown in Fig. 1, herewith. The North British Locomotive Company are using one themselves and the other is in use at the Corby works of Messrs. Stewarts and Lloyds, Limited. The principle of the transmission system is basically similar to that used on the mine locomotive, but there are two fluid couplings instead of one.

The new design is rated at 200 h.p. and employs an 0-4-0 wheel arrangement with a short wheelbase. The locomotive weighs 32 tons and is intended for general yard and railway duties. The Voith transmission unit, including the final drive and reverse gearbox, enables the driver's controls to be limited to a throttle, a reverse lever and a brake, changing from one hydraulic circuit to the next being automatic, both for acceleration and deceleration. The unit is the type L 33y, in which there are three hydraulic circuits: a torque converter for starting and low speeds, and two fluid couplings, one for the medium speed range and one for the high range. In each circuit the input shaft drives an impeller which acts as a pump, imparting energy to the oil in the circuit and driving a runner which is geared to the output shaft. As the locomotive gathers speed, the action of the governor is to fill the first coupling and empty the converter at a predetermined track speed. At a higher predetermined speed, the governor directs the oil into the second coupling and empties the first coupling. If greater resistance is encountered, as when ascending a gradient, the governor causes a change from the second coupling to the first. Smooth application of power is therefore available under any load, and shock cannot be transmitted to the Diesel engine.

The power unit of the locomotive is a type-6RPH six-cylinder in-line four-stroke engine made by Messrs. Davey, Paxman and Company, Limited, Colchester. It has a continuous rating of 200 h.p. at 1,000 r.p.m.; the cylinder bore is 7 in. and the stroke is $7\frac{3}{4}$ in. The combustion system is the Ricardo Comet Mark III. The crankcase is a one-piece casting which carries the crankshaft in underslung bearings. The cylinder liners are dry, and are chromium-plated for prolonged life, and the pistons are heat-treated "Y"-alloy castings. The C.A.V. fuel pump and injectors are controlled by a Paxman hydraulic governor throughout the engine speed range. The engine lubricating oil pressure is used to operate the fuel-pump control, so that, in the event of a pressure failure, the engine is automatically shut down.

Fig. 2.



The main frames are built up as a welded structure of heavy-section steel plates. Ample access to the engine compartment is provided by doors on each side of the superstructure, which is removable in parts or as a unit for repair work. The fuel tank is in the roof of this compartment and the fuel oil flows by gravity to a gear pump, which ensures a constant flow to the injection pumps. Driving controls, comprising throttle and brake, are duplicated on each side of the cab. An air compressor is belt-driven by the engine and supplies low-pressure air for the brakes, sanding and horn. A 24-volt battery is charged by an engine-driven dynamo through a regulator and cut-out, and the engine is started by a C.A.V. electric starter motor. The engine start and stop controls are combined in a single lever. The radiator cooling system includes a section in which heat from the transmission oil is dissipated. The overall length of the locomotive (23 ft. $5\frac{1}{2}$ in. over buffers) has been kept as short as possible to reduce the overhang of the buffers, and the short wheelbase (6 ft.) allows it to traverse very sharp curves. Independent laminated springs are used. Other dimensions and particulars of the locomotive are: wheel diameter, 3 ft. 6 in.; tractive effort, 21,500 lb.; maximum speed, 12 m.p.h.; minimum radius of curve, 75 ft.; and fuel-oil capacity, 155 gallons.

RADAR FOR BRITISH RAILWAYS' VESSELS.—All sea-going vessels, passenger and cargo, belonging to the British Railways fleet, will shortly be fitted with radar as an additional aid to navigation. At present, 42 vessels, covering most of the principal passenger routes, are equipped, and a further 31, mainly cargo ships, are now to be fitted.

INTERNATIONAL ACTION TO REDUCE ACCIDENTS AT LEVEL CROSSINGS.—A working party of the United Nations Economic Commission for Europe has urged the elimination of level crossings on railways where traffic is heavy or visibility is poor. In 1949, level-crossing accidents in 14 European countries totalled 4,500, and resulted in the loss of over 500 lives and over 600 cases of serious injury.

REGULATIONS ON WORKS TRUCKS.—Certain amendments to the Motor Vehicles (Construction and Use) Regulations, 1947, came into force on July 16, under Regulations made by the Minister of Transport. They permit the limited use of works trucks between, for example, neighbouring factory premises; introduce minor relaxations in respect of pedestrian-controlled vehicles (such as hand-operated electric milk floats) and road-sweeping vehicles; authorise the drawing of certain trailers of up to 45 cwt. total weight (instead of 40 cwt. as at present) without an attendant; and revoke the requirement that the size of tyre must be marked on the wheels of heavy motor cars. Copies of the Regulations, which are entitled The Motor Vehicles (Construction and Use) (Amendment) (No. 2) Regulations, 1951, can be obtained from H.M. Stationery Office, price 3*d*.

CONFERENCE ON HEAT TRANSFER.

MODERN developments in the mechanism of the transference of heat and in the design of apparatus constructed for such purposes will be discussed at a conference to be held in London on Tuesday, Wednesday and Thursday, September 11, 12 and 13, at the Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1, and at Caxton Hall, Caxton-street, Victoria-street, S.W.1. The arrangements for the conference are being made by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers, with whom some 30 British, Commonwealth and European technical societies are co-operating. The programme contains approximately 100 papers, which will be presented in abstract, to allow the maximum amount of time for discussions.

The conference will open at 10 a.m. on Tuesday, September 11, at Caxton Hall. The opening ceremony will be followed immediately, between 10.15 a.m. and 12.30 p.m., by Session I, on "Heat Transfer with Change of State." Session II, on "Heat Transfer Between Fluids and Surfaces," will take place on the afternoon of the same day, from 2 p.m. to 4.30 p.m.; and in the evening, from 8 p.m. to 11.15 p.m., a reception and conversazione will be held at the Science Museum, South Kensington, S.W.7, for members of the Conference and of participating societies.

Session III, on "Conduction in Solids and Fluids," will be held on the morning of Wednesday, September 12, from 10 a.m. to 12.30 p.m. The afternoon will be devoted to Session IV, on "Radiation, Instrumentation, Measurement Techniques, and Analogies," from 2 p.m. to 4.30 p.m.

A James Clayton Lecture will be delivered by Professor A. P. Colburn, head of the Chemical Engineering Division of the University of Delaware, Newark, New Jersey, U.S.A., on the Wednesday evening, commencing at 8.30 p.m. Session V will deal with special problems, such as heat transfer in turbine-blade cooling, liquid metals, gas turbines, piston engines, and the mercury boiler. It will be held, from 10 a.m. to 12.30 p.m., on Thursday, September 13, and will be followed, in the afternoon of that day, at 2 p.m., by the final technical session. This, like the opening session, will be held at Caxton Hall. On the Thursday evening, at 7 for 7.30 p.m., a dinner will be held at St. Ermin's Hotel, Caxton-street, S.W.1, for members of the Conference and of participating societies. This function will be open to men only.

Preprints of the papers will be available, some time before the commencement of the Conference, at 15s. a complete set. Bound volumes of the Conference proceedings, including the discussions, will be obtainable in due course. If ordered in advance, together with a set of preprints, the combined price will be 2l. 12s.; but bound volumes of the proceedings will be available after the Conference at a cost of 2l. 5s. Applications for tickets to attend the Conference, or for preprints or volumes of the proceedings, should be made to the secretary, Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W.1. The address of the American Society of Mechanical Engineers is 29, West 39th-street, New York 18, U.S.A.

LAUNCHES AND TRIAL TRIPS.

M.S. "CALLISTO."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the N. V. Maatschappij Zeevaart, Rotterdam. Main dimensions: 435 ft. between perpendiculars by 58 ft. 9 in. beam, and 38 ft. depth to shelter deck; deadweight, about 10,320 tons on a draught of 25 ft. 11 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine developing 3,300 b.h.p. at 109 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 12½ knots. Trial trip, June 29.

M.S. "BLUE HAZE II."—Single-screw trawler, built by John Lewis & Sons, Ltd., Aberdeen, for Job Brothers & Co., Ltd., St. John's, Newfoundland. Third vessel of a series of four. Main dimensions: 120 ft. between perpendiculars by 25 ft. by 12 ft. 6 in.; fishroom capacity, 7,000 cub. ft.; gross tonnage, about 300. Mirrlees six-cylinder direct-drive and reversing oil engine, developing 650 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Speed in service, 11½ knots. Launch, July 5.

M.S. "KADOURA."—Twin-screw cargo vessel for transporting bananas, carrying twelve passengers, built by J. Samuel White & Co., Ltd., Cowes, Isle of Wight, for the Chargeurs Réunis, Cie. Française de Navigation à Vapeur, Paris. Main dimensions: 328 ft. between perpendiculars, 50 ft. 6 in. beam, and by 32 ft. 9½ in. depth to upper deck; deadweight, 2,520 tons on a draught of 20 ft. 8 in.; gross tonnage 3,650. Two eight-cylinder single-acting two-stroke Diesel engines, constructed by Burmeister & Wain, Copenhagen, developing a total of 6,500 b.h.p. at 165 r.p.m. Speed, 17 knots. Launch, July 5.

THE BRITISH ASSOCIATION MEETING AT EDINBURGH.

As announced previously in our columns, the British Association for the Advancement of Science is holding its meeting this year in Edinburgh under the presidency of H.R.H. The Duke of Edinburgh, K.G., F.R.S. This is the sixth occasion on which the Scottish capital has been selected as the meeting place—the last was in 1921—and the Duke is the third member of the Royal Family to have presided. At the first general assembly of the members, to be held in the McEwan Hall on the evening of Wednesday, August 8, His Royal Highness will receive the honorary degree of Doctor of Laws from the University of Edinburgh and, later, will deliver his presidential address on "The British Contribution to Science and Technology in the Past Hundred Years." Owing to the limited accommodation at the McEwan Hall, arrangements have been made to transmit the whole of the proceedings by television to the Usher Hall, Lothian-road, where the audience will be able to see the proceedings on a screen measuring 16 ft. by 12 ft. This will be the first occasion on which the Association has made use of television in this way and will be the first demonstration in the North of large-screen television employing a radio link between the transmitter and receiver. The Usher Hall accommodates over 2,000 persons, and the audience there is expected to be the largest ever to view television on a large screen. The arrangements are in the hands of Messrs. Cinema Television, Limited, Worsley Bridge-road, London, S.E.26. The whole of the President's address will also be broadcast on the Home Service of the British Broadcasting Corporation.

The meetings of the various sections begin on the morning of Thursday, August 9, and Section G (Engineering), with which we shall be mainly concerned, will meet in the Heriot-Watt College, Chambers-street. The President of the section this year is Sir Claude Gibb, C.B.E., F.R.S., whose address, on Friday, August 10, will be on the subject "Two Thousand Years of Engineering." In accordance with previous practice, the proceedings will be conducted in two sessions, running, for the most part, concurrently. On the Thursday morning, Session A will have a paper by Dr. A. Alan Taylor on "The Use of High-Ash Coals in the Electricity Supply Industry," followed by one by Mr. W. G. Marskell on "The Design of Large Boiler Plant for Using High-Ash Coal." In Session B, at the same time, Mr. T. A. L. Paton will be speaking on "Hydro-Electric Schemes—Modern Trends in Civil Engineering," and will be followed by Mr. R. W. Weekes and Mr. A. Feiner on "Water Turbines for Hydro-Electric Projects." After the President's address on Friday morning, Mr. A. G. Curr will speak to the combined sessions on "Printing," an industry with which Edinburgh has many associations. There will be no formal sessions on Saturday, August 11; instead, excursions have been arranged to the North of Scotland hydro-electric scheme at Loch Sloy and to the Exhibition of Industrial Power in Glasgow.

When the meetings resume on Monday, August 13, Session A will hear a paper by Mr. C. E. Iliffe on "Recent Developments in the Methods of Proportioning Contra-Flow Heat Exchange Apparatus" and one by Mr. A. Hampson on "Heat Transfer During Condensation of Steam" while Session B is addressed by Mr. T. G. N. Haldane on "The Development of High-Voltage Power Transmission with Particular Reference to Hydro-Electric Projects" and by Mr. T. Lawrie on "Electrical Aspects of Modern Hydro-Electric Development in Scotland." Following a programme of visits to industrial undertakings in the city and to the University's engineering department in the afternoon of the same day, members of Section G will be the guests of the Governors of the Heriot-Watt College at a Conversazione there in the evening.

Tuesday, August 14, is the last day on which meetings of the Engineering Section will be held. In the morning, there will be a joint discussion with Section B (Chemistry) on "Metals and Alloys," under the chairmanship of Sir Andrew McCance. Dr. F. D. Richardson will deliver a paper on "The Chemistry of Metal Extraction," Professor A. H. Cottrell will discuss "The Strength of Metals," Professor A. G. Quarrell will talk about "Modern Alloys," and Mr. T. S. Robertson will speak on "Brittle Fracture of Mild Steel." The other session will consist of a series of papers by young engineers. The speakers and their subjects will be: Dr. A. L. Cullen on "The Measurement of Microwave Power by Radiation Pressure"; Dr. A. H. Chilver on "Some Features of the Behaviour of Thin-Walled Structural Members in Compression"; "A Theory of Imperfection for the Vibrations of Elastic Bodies of Revolution" by Dr. S. A. Tobias; "Cantilever Sheet Piling of Cohesionless Soil" by Dr. P. W. Rowe; Mr. J. D. Lawson on "A Note on the Construction of, and Preliminary Experiments on, a Model of Aberdeen Harbour"; and Mr. Peter Clarkson on "Heat-Treated Concrete." The customary programme of daily afternoon visits to engineering works and places of technical interest has been arranged. The Recorder for Section G is Professor W. F. Cassie, King's College, Newcastle-upon-Tyne, and the secretaries are Mr. E. C. Cherry and Mr. D. H. McPherson. The local secretaries are Mr. J. D. Robson and Dr. G. B. Warburton.

BOOKS RECEIVED.

Ministry of Transport. Notes on the Public Utilities Street Works Act, 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]

Ministry of Transport. Railway Accidents. Report on the Derailment which Occurred on 20th December, 1950, *at Greenford in the Western Region British Railways.* [Price 6d. net.] *Report on the Collision which Occurred on 10th January* 1951 *at Alloa Junction in the Scottish Region British Railways.* [Price 6d. net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Fourth Empire Mining and Metallurgical Congress, 1949. *Proceedings.* Parts One and Two, in two volumes. Edited by F. HIGHAM. Offices of the Congress, 436, Salisbury House, Finsbury-circus, London, E.C.2. [Price, each volume, 20s.]

United States National Bureau of Standards. Circular No. 508. *Reference Tables for Thermocouples.* By HENRY SHENKER, JOHN I. LAURITZEN, JR., and ROBERT J. CORRUCCINI. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 35 cents.]

Applied Mechanics for Engineers. By PROFESSOR SIR CHARLES INGLIS. Cambridge University Press, Bentley House, 200, Euston-road, London, N.W.1. [Price 42s. net.]

Advanced Strength of Materials. By D. A. R. CLARK. Blackie and Son, Limited, 16-18, William IV-street, London, W.C.2. [Price 35s. net.]

Steam Turbine Theory and Practice. By PROFESSOR WILLIAM J. KEARTON. Sixth edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 35s. net.]

Foundry Practice. By WILLIAM H. SALMON and ERIC N. SIMONS. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 30s. net.]

The Wonderful Story of British Industry. Ward, Lock and Company, Limited, 6, Chancery-lane, London, W.C.2. [Price 15s. net.]

East Coast Route. By GEORGE DOW. The Locomotive Publishing Company, Limited, 88, Horseferry-road, London, S.W.1. [Price 7s. 6d.]

The First Hundred Road Motors. By R. W. KIDNER. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 9s. net.]

Grenzschicht-Theorie. By PROFESSOR HERMANN SCHLICHTING. Verlag G. Braun, Karl-Friedrich-Strasse 14, Karlsruhe, Germany. [Price 42·80 D.M. in cardboard covers, 45 D.M. cloth bound.]

Strassenbautechnik der Gegenwart. By PROFESSOR DANIEL BOUTET. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 66 Swiss francs.]

Ministry of Civil Aviation. Civil Aircraft Accident. Report of the Court Investigation on the Accident to Dakota G-AGIW on 17th October, 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 3d. net.]

United States National Bureau of Standards. Applied Mathematics Series 7. *Tables to Facilitate Sequential t-Tests.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. U.S.A. [Price 45 cents.]

The Colliery Year Book and Coal Trades Directory, 1951. The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30s. net.]

Die-Casting Dies. Part Three. *Examples of Safety Devices—Core Operating Mechanisms—The Use of Collapsible Cores.* Machinery's Yellow Back Series No. 4E. The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1. [Price 3s. 6d.]

Cofferdams. By LAZARUS WHITE and EDMUND ASTLEY PRENTIS. Second revised and enlarged edition. Columbia University Press, Morningside Heights, New York 27, U.S.A. [Price 10 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 63s. net.]

Alkali, &c., Works Regulation Act, 1906, *and Alkali &c., Works Orders*, 1928-1950. *Eighty-Seventh Annual Report on Alkali, &c., Works, by the Chief Inspectors. Proceedings During the Year* 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 9d. net.]

Engineering College Research Council of the American Society for Engineering Education. University Research Potential. A Survey of the Resources for Scientific and Engineering Research in American Colleges and Universities. The Secretary of the Engineering College Research Council, 77, Massachusetts-avenue, Cambridge 39, Massachusetts, U.S.A.