THE GLEN AFFRIC SCHEME OF THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

(*Continued from page 460.*)

BEINN A MHEADHOIN DAM.

PHOTOGRAPHS of the Beinn a Mheadhoin dam which forms part of the Glen Affric scheme, are reproduced in Figs. 17 to 19, on this page and on page 490, and its construction can be followed from the elevation, plan, and sections, Figs. 23 to 26, on Plate XLII. As will be seen, it is of the straight gravity type, being 582 ft. long and having a maximum height of 125 ft. It incorporates a spill weir 456 ft. long, the crest of which is at 735 O.D. This spill weir, which extends the whole length of the dam except for the gatehouse, is surmounted by a road bridge 8 ft. wide, the latter being carried upon reinforced-concrete piers at a level of 746 O.D. control the flow to a stilling pool at 647 O.D. This pool is provided with two longitudinal weirs and a transverse weir also shown in Figs. 23 to 26. The dam incorporates a scour pipe 6 ft. in diameter, for emptying the reservoir. This pipe is provided with a screen and an electrically-operated free rolling emergency gate at its upstream end and with a 72 in. to 60 in. hand-operated needle valve and jet disperser at its downstream end. An automatically-controlled valve with a diameter of 18 in., and fitted with an indicator and recorder, has been installed to pass compensation water; and the needle valve will enable additional compensation water to be supplied up to a maximum quantity of 2,000 million gallons per annum. All this equipment is of Messrs. Glenfield and Kennedy's manufacture.

CONSTRUCTIONAL DETAILS.

At the beginning of the construction of this dam a diversion channel was driven through which the river was caused to flow. At a later stage, the river was allowed to pass through three wedge-shaped openings in the dam itself; two in one block, which took the normal flow, and the third for the flood water. To prevent weakness in the finished structure for this reason, tubes were inserted through which grouting was forced after the concreting had been completed.

Owing to the presence of a zone of weathered and fractured rock on the south side, extensive grouting was also necessary in the foundation. This was carried out in three stages, holes 10 ft. deep being first drilled at 10-ft. centres at the bottom of the cut-out trench, the depth of which ranged from 5 ft. to 10 ft., and grout was pumped into them at a pressure of 10 lb. per square inch to fill the open fissures. After the bottom lifts of concrete for the dam had been poured into the trench, holes up to 50 ft. long were drilled at maximum intervals of 10 ft. and grouted at a pressure of from 40 lb. to 75 lb. per square inch. Finally, inclined holes 100 ft. deep were drilled in the river bed, and in the shattered zone on the south bank from the upstream step of the cut-off trench and were grouted at pressures up to 120 lb. per square inch.

The dam was divided into 14 blocks, nine being 45 ft. long and the others ranging from 20ft. to 51 ft. Generally, the system of construction was the same as that previously described for the Mullardoch dam, the northern half being carried up first, as it was clear of the river and stood on satisfactory ground. To enable the three blocks which spanned the river to be begun, a diversion channel was formed in an adjacent block and three temporary openings were left. After the scour culvert had been set, the river was diverted through the openings and the diversion channels were closed. One of the openings was later filled in the dry, the others being sealed with temporary gates while they were being completed. Low-heat Portland cement was used for building the north side of the dam and ordinary Portland cement for the south side. After a period of 4 to 15 hours for the Portland cement and from 6 to 24 hours for the low-heat cement, the surface was scoured with high-pressure hoses and brushed until the exposed aggregate was cleared of cement. A $\frac{1}{2}$-in. layer of cement mortar was then laid over the surface before the next lift was placed, a procedure which has been justified by the fact that there has been no sign of seepage. Aggregate for the 7-to-1 hearting used in the dam was obtained from the spoil, while that for the 4-to-1 facing concrete was drawn from a gravel pit near the power station. The concrete was mixed in two 1-cubic yard mixers and transported to the site on Bailey bridges. It was unloaded by derricks in a manner similar to that previously described for the Mullardoch dam.

The reservoir formed by this dam covers 1,069 acres and 1,016 acres at top water level and crest level, respectively, and has capacities of 1,159 million and 970 million cubic feet at these two levels.

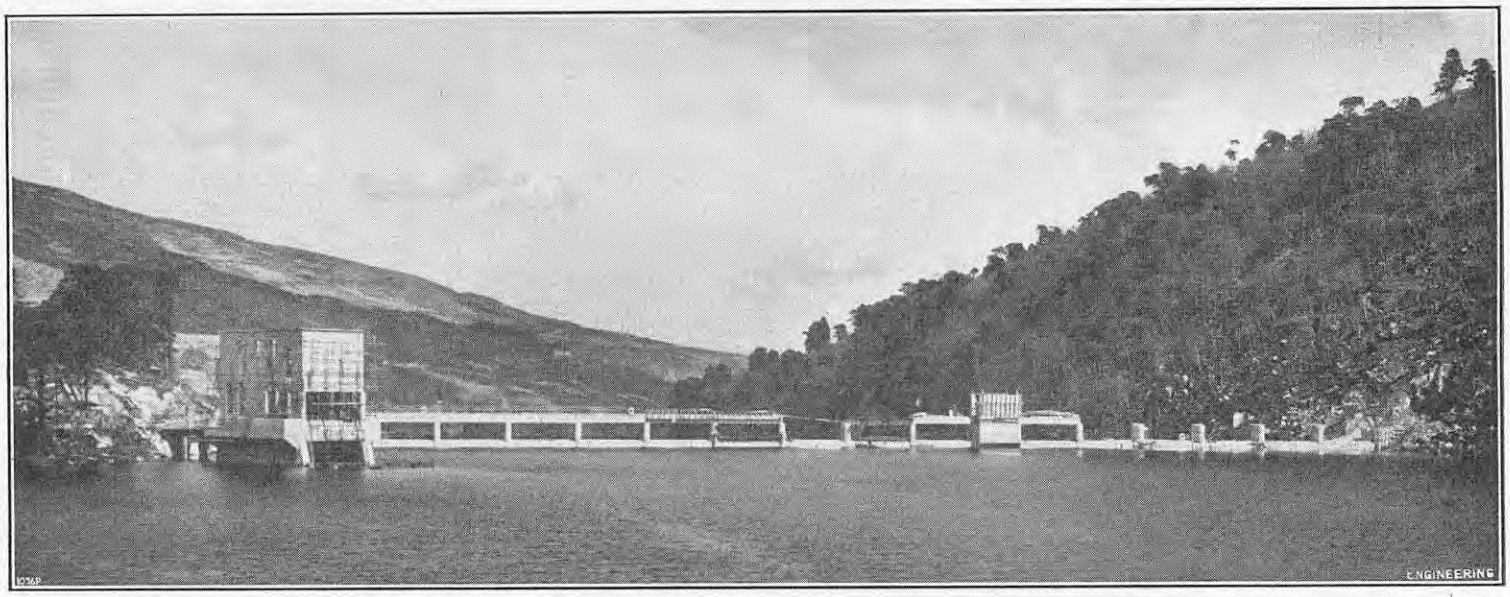


FIG. 17. BEINN A MHEADHOIN DAM, LOOKING DOWNSTREAM.

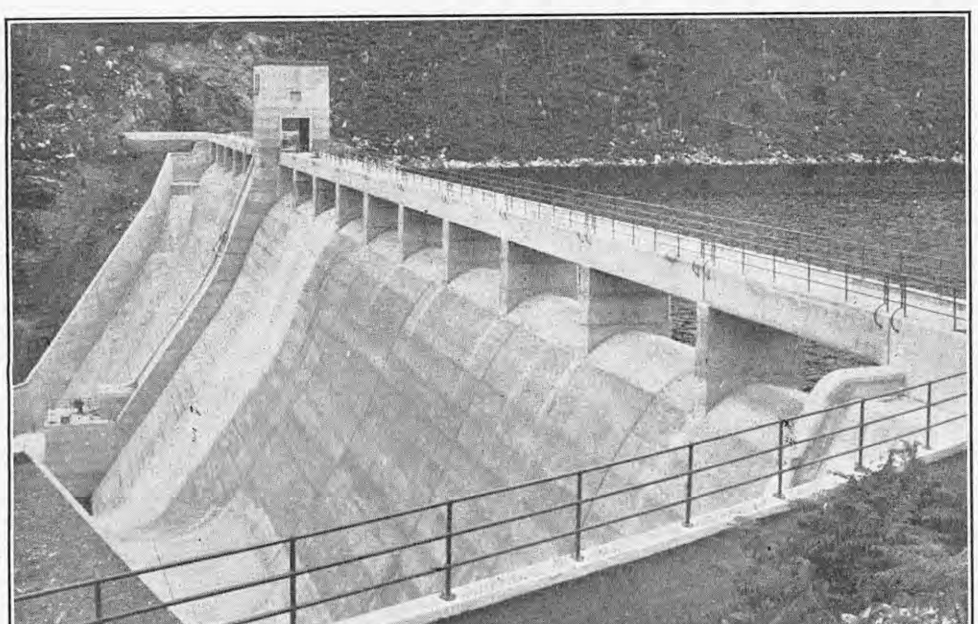


FIG. 18. BEINN A MHEADHOIN SPILLWAYS.

The design of the spill weir, which is not provided with gates, was based on tests carried out on hydraulic models at Aberdeen University. It has a capacity of 13,800 cusecs with a reservoir level of 739·5 O.D., and delivers into two channels which run across the downstream face of the dam. These channels incorporate a number of steps which

The extent of its catchment area, in which the average annual rainfall is 98·3 in., is 46,272 acres.

Beinn a Mheadhoin-Fasnakyle Intake.

The intake to the Beinn a Mheadhoin-Fasnakyle tunnel, illustrated in Fig. 20, opposite, is on the north bank of the reservoir a short distance upstream of the dam. It consists of a reinforced-concrete structure, which is 86 ft. high to the floor of the gatehouse and about 23 ft. wide. Its toe is protected by a silt wall and at its opening is a coarse screen, measuring 80 ft. by 21 ft. and consisting of 4½-in. by ¾-in. bars placed at intervals of 5¼ in. Downstream of this screen is a fine screen, measuring 75 ft. by 20 ft. made up of 3½-in. by ½-in. bars placed at intervals of 1½ in. Both screens are provided with plough rakes, which are operated by 8-h.p. motors, and can be raised at a speed of 10 ft. per minute. The rakes can be lowered by gravity at double this speed. Downstream of the screens is a free roller control gate with a span of 12 ft. and 15 ft. deep, which weighs 11 tons and is provided with a 10½-ton steel-plate counterbalance. This is operated under a maximum head of 72 ft. at a speed of 4 ft. per minute by a 5-h.p. motor which is controlled by "stop," "open" and "close" push-buttons in the gatehouse. When the "open" button is pressed the gate is raised 12 in. above the sill, in which position it is arrested by a "crack open" switch. It remains in this position until the tunnel has filled and the water reaches "No-Flote" electrodes. Further pressure on the "open" button then allows the gate to be fully opened, its position at any time being indicated by coloured lights.

The emergency gate, which is installed upstream of the control gate, is of the free rolling type and weighs 21 tons, while its top water load is 23 tons and its friction load 4½ tons. To crack it open, a load of 48·5 tons is necessary. It is operated by a 20-h.p. motor which is controlled from the intake structure to give a hoisting speed of 4 ft. per minute. It is lowered by gravity at a speed of 12 ft. per minute, its motion being controlled by automatic centrifugal and hand brakes. Both gates were manufactured by Messrs. Glenfield and Kennedy, Limited, Kilmarnock.

Low-Pressure Tunnel.

From the intake, the water flows into a low-pressure tunnel, which extends a distance of 12,340 ft. to the surge shaft as shown in Figs. 27 and 28, on Plate XLII. As shown in Fig. 30, page 492, this tunnel is of horse-shoe section with an equivalent diameter of 14 ft. 6 in. after lining with 1-to-4 concrete. The minimum thickness to flats is 5 in., and the capacity is 1,850 cusecs. Driving was effected by Messrs. John Cochrane and Sons, Limited, from the intake and from two adits 5,126 ft. and 9,582 ft. farther downstream, as shown in Fig. 28, thus providing four working faces. These adits have now been closed by concrete plugs containing access pipes which will be normally blanked off. At two of them, arrangements were made for the installation of apparatus to enable the flow to be measured by the salt-velocity method during the turbine-efficiency tests. The arrangements adopted for drilling, loading, firing, and removing the spoil were the same as those described previously for the Mullardoch tunnel, except that drifters were employed throughout. Pumps were also provided for the removal of the water. Lining was carried out by a steel travelling shutter 85 ft. long, which was driven eastwards from the intake portal to the east adit and then westwards from the surge shaft. This shutter, assembled at the tunnel intake, is illustrated in Fig. 21, opposite. Material for making the concrete was first taken in through the western and later through the eastern adits, the constituents being batched midway between

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

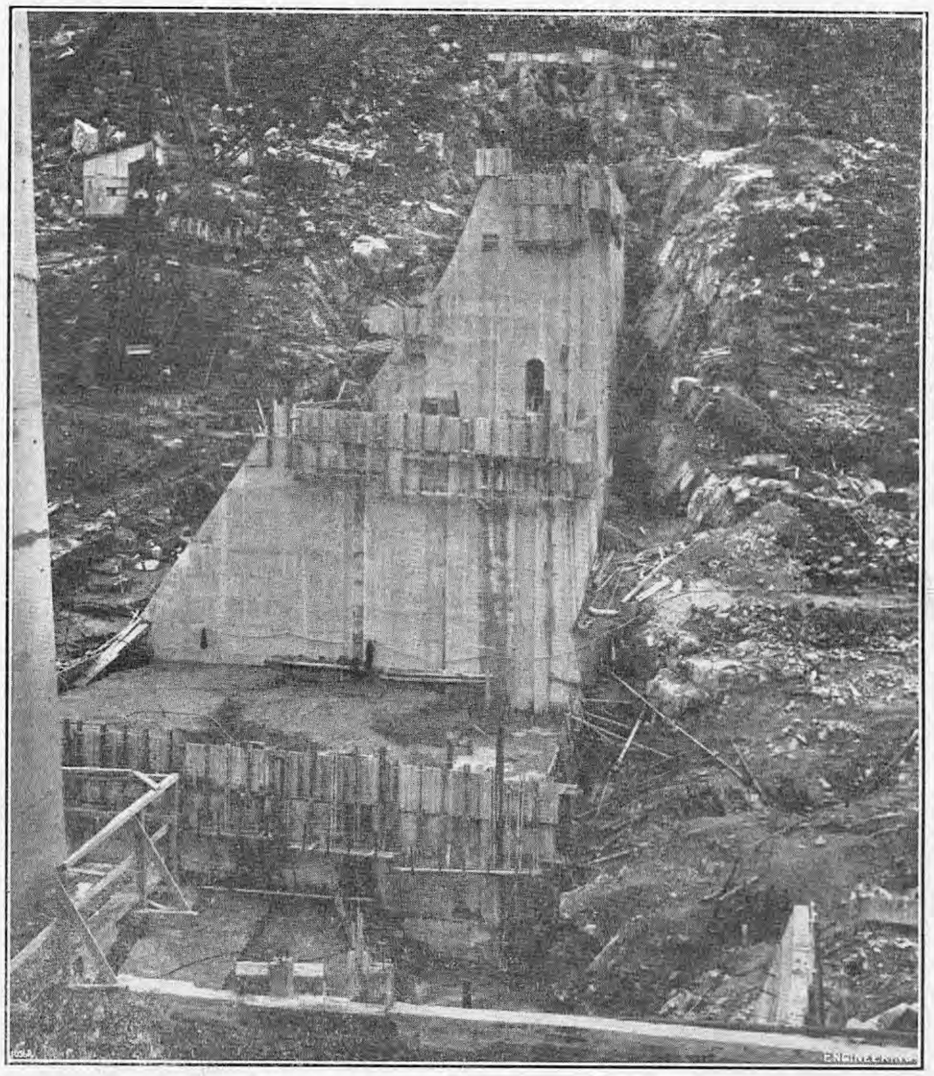


Fig. 19. Beinn a Mheadhoin Dam Under Construction.

the two portals. At this point, a crusher plant was installed to deal with the psmammitic schist spoil and was used for supplying materials for the Beinn a Mheadhoin dam and also for the road works in the neighbourhood. The sand was obtained from Fasnakyle.

The lining of the tunnel was carried out simultaneously in stages, the invert being first cleaned by hand and a rough layer of concrete being laid to carry the sleepers of the travelling steel shutter. The 4 to 1 mixed aggregate and cement for the roof and side wall concrete was run into the tunnel and tipped on to a conveyor from which an electrically-driven mixer with a capacity of one cubic yard was fed. This mixer discharged into a Pressweld pneumatic placer, which emptied its contents through a 6-in. steel pipe inserted over the crown of the shutter and was arranged so that the concrete took its natural slope. The concrete was also lightly vibrated to cause it to flow off the crown and then punned through hatches in the side wall until the shutter was full. The mixer and placer were moved back in steps as the concreting proceeded, the invert itself being placed after the shutter had passed.

Surge Shaft.

As will be seen from Fig. 27, the low-pressure tunnel terminates in a surge shaft, the construction of which is illustrated in Fig. 29, on page 492. This shaft is 150 ft. deep and 45 ft. in diameter and was constructed by enlargement from a pilot shaft 9 ft. square. The concrete lining was placed in timber shuttering with 4-ft. lifts. The surge shaft has been designed to accommodate a maximum surge of 55 ft. when a load of 66 MW is suddenly switched off at Fasnakyle, and so that a minimum surge level of 673 O.D. will be reached when the load on that station is suddenly increased from 44 to 66 MW. It discharges into a high-pressure shaft 14 ft. 6 in. in diameter, as also shown in Fig. 27, across the mouth of which a fixed bar screen has been constructed. This high-pressure shaft was excavated by a combination of sinking and stoping, and the concrete lining was placed with six sets of 4 ft. high steel shuttering. The bottom set of this shuttering was lifted and placed on top of the remainder, so that the concreting was continuous. The concrete used for both shafts was batched at the plant in the low-pressure tunnel, mixed at the foot of the surge shaft and hoisted or lowered into position.

High-Pressure Tunnel.

The high-pressure tunnel, which extends from the bottom of the shaft to the trifurcation at the beginning of the pipe line, as shown in Fig. 27, is about 4,500 ft. long and is of circular section 14 ft. 6 in. in diameter, as shown in Fig. 32, page 492. It was driven from the trifurcation point, the arrangements for excavation being the same as those already described. It is lined with concrete to a minimum thickness of 10 in., for which purpose the following procedure was employed. Working upstream, the sides of the tunnel were cleaned and curb walls placed in position. The central portion of the invert was then cleaned and concreted to 34 deg. on each side of the vertical centre line, working downwards from the high-pressure shaft. This work was carried out in steps of 150 ft., utilising

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

(*For Description, see Page* 489.)

Fig. 23. ELEVATION OF DOWNSTREAM FACE OF DAM.

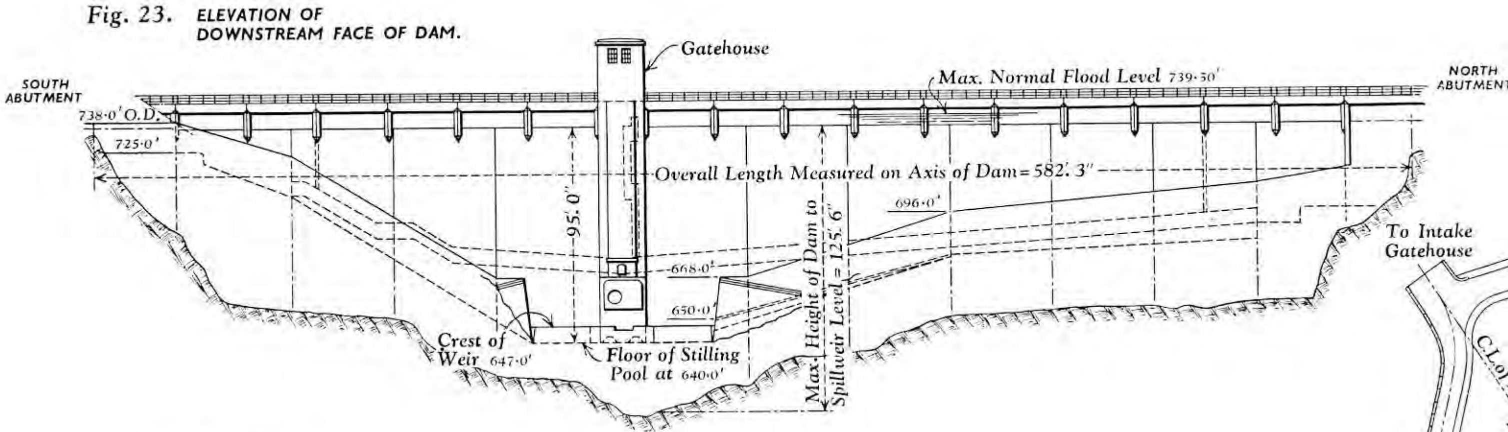


Fig. 24. PLAN.

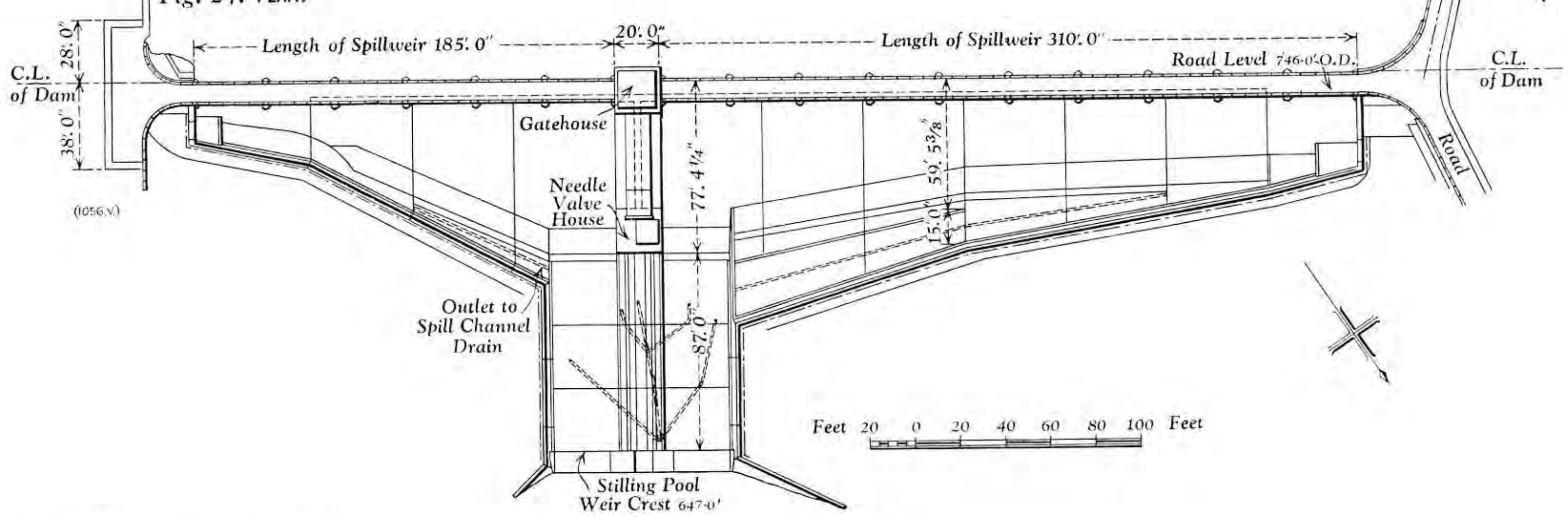


Fig. 25.

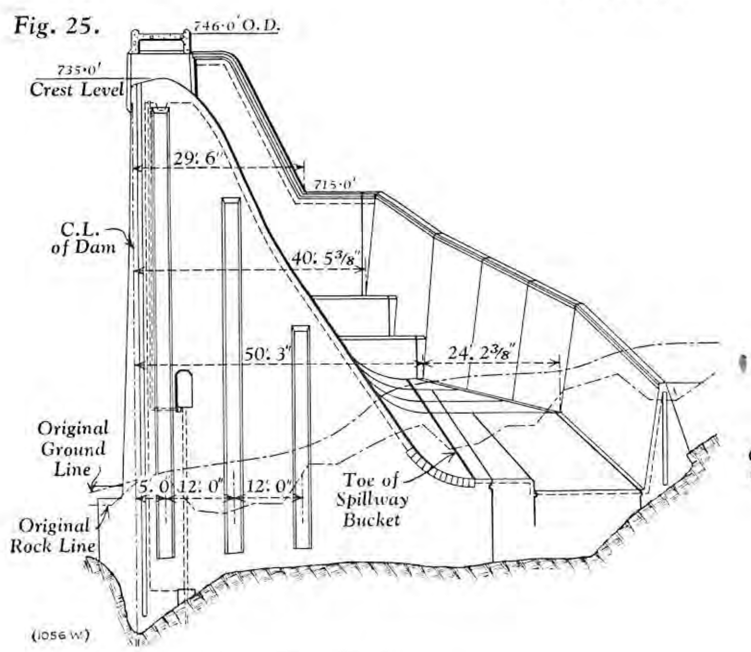


Fig. 26.

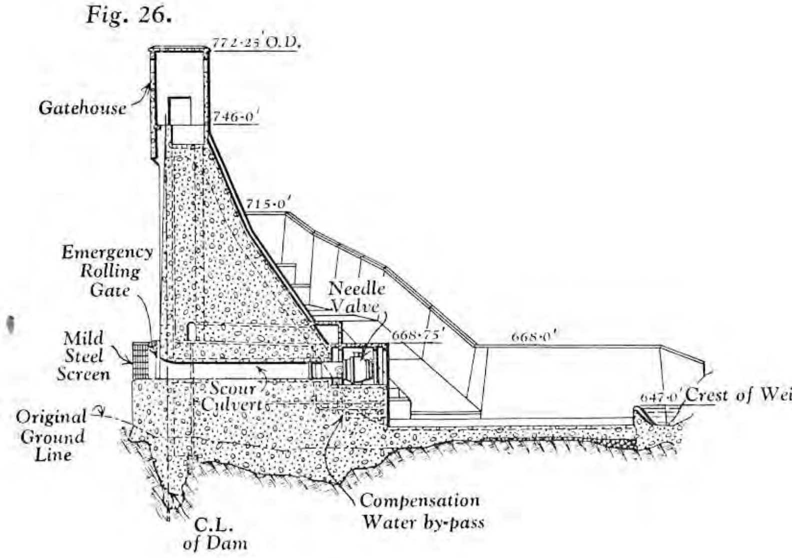


Fig. 27. LONGITUDINAL SECTION.

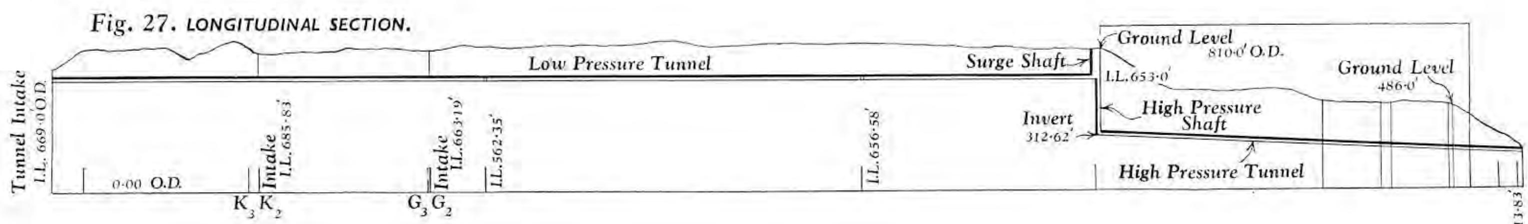
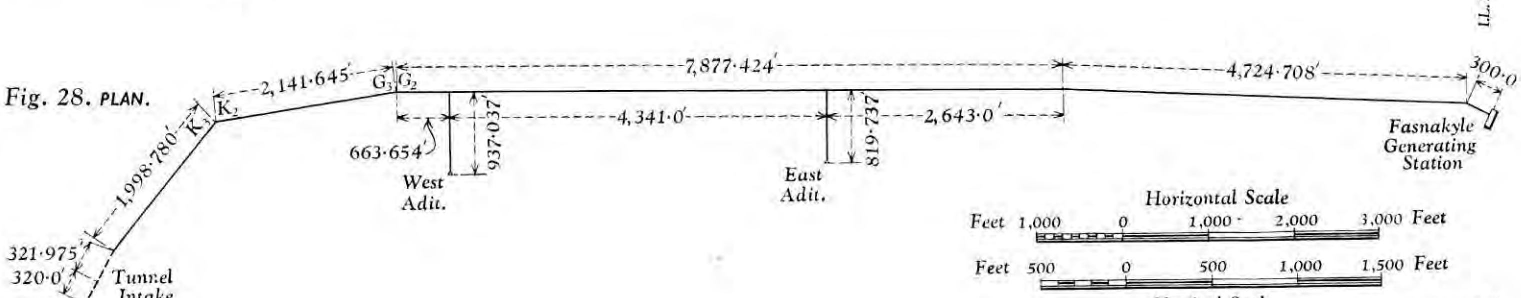


Fig. 28. PLAN.



(*To face page* 490.)

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

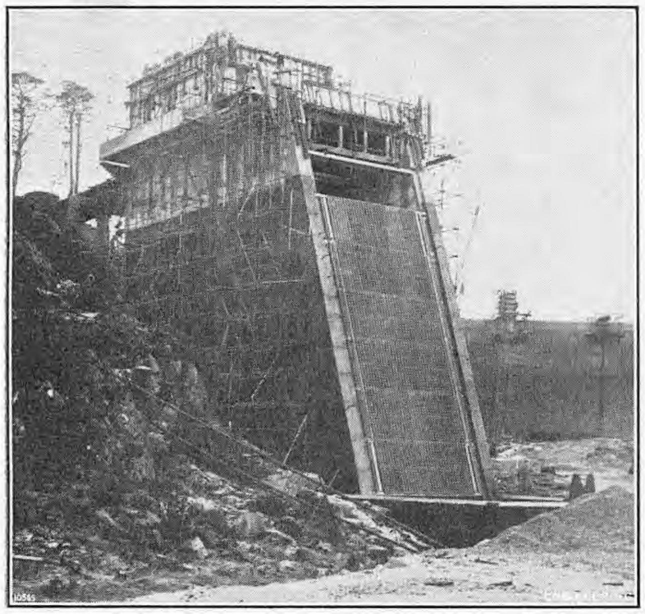


Fig. 20. Fasnakyle Tunnel Intake.

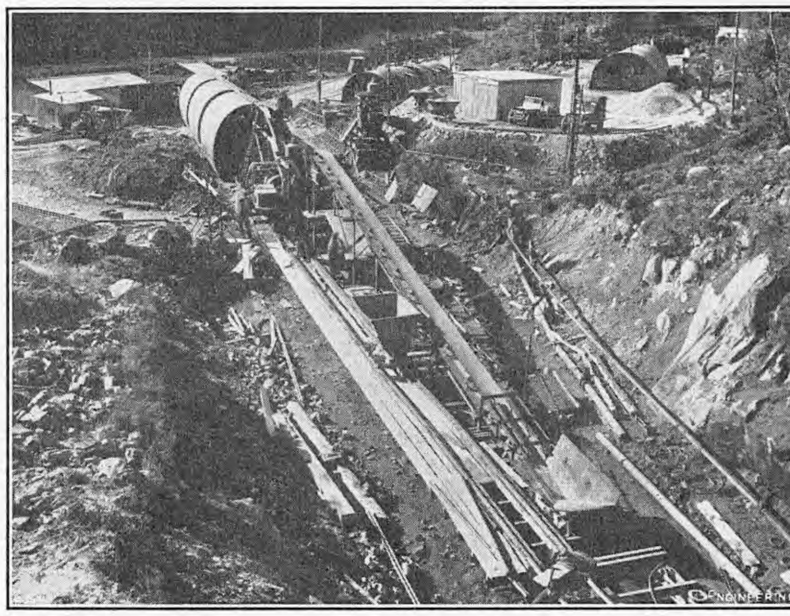


Fig. 21. Travelling Shutter at Tunnel Intake.

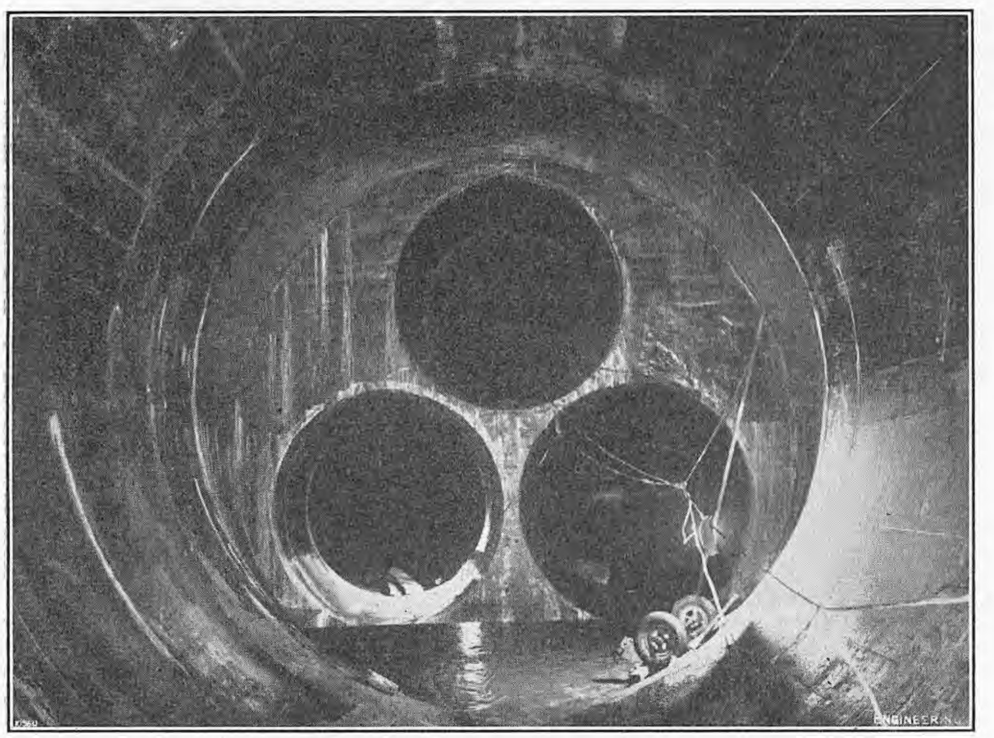


Fig. 22. Trifurcation Chamber, Fasnakyle Tunnel.

a movable bridge of the same length on which a double track was mounted for placing the concrete. The surface of the concrete was next shaped by a drag screed 5 ft. long, which ran on the side forms, and then floated. A steel travelling shutter 60 ft. long was erected for concreting the side walls and roof, these operations being carried out downstream from the high-pressure shaft. Finally, such holes as were necessary were drilled and grouted in two steps, at pressures up to 300 lbs. per square inch, by the Cementation Company, Limited, Doncaster. For this purpose eight steel pipes 12 in. long and $2\frac{1}{2}$ in. in diameter were placed in the concrete at longitudinal intervals of 5 ft. The roof was cavity grouted immediately on completion and alternate grouting tubes were drilled to a depth of 10 ft. and left to bleed for one month. They were then grouted at 100 lb. per square inch. The remaining holes were drilled to a depth of 14 ft. and three months after the concrete had been placed were grouted at 300 lb. per square inch.

The concrete for this section of the tunnel was mixed in the open air, the aggregate, the maximum size of which was $1\frac{1}{2}$ in., being volume batched and the cement being added in bag units. It may be added that tunnelling was carried out at an average rate of 88 ft. a week, the maximum rate being 132 ft., and the lining was placed at an average rate of 252 ft. a week with a maximum of about 425 ft. To form the low-pressure tunnel it was necessary to excavate 90,200 cubic yards of rock and to employ 15,600 cubic yards of concrete. The construction of the surge and high-pressure shafts necessitated the removal of 20,000 cubic yards of rock and the placing of 1,500 cubic yards of concrete, while for the high-pressure tunnel, 58,400 cubic yards of rock were removed and 20,900 cubic yards of concrete were employed for its lining.

Side Stream Intakes.

As can be seen in Fig. 27, the water from Loch Beinn a Mheadhoin is supplemented by that of three streams. The flow of two of these is led into the low-pressure tunnel, while the third discharges into the surge shaft. The design of these intakes, which is shown in Figs. 35 and 36, on page 493, was based on experiments carried out by Professor J. Allen at Aberdeen University. As will be seen, a small dam was constructed across the stream and the water led off through a screen to an off-take chamber. This chamber contains a siphon which transfers the water through a feed pipe to a vortex chamber immediately above the tunnel. A loop is incorporated in the feed pipe near the siphon to assist priming. The water is introduced tangentially into the chamber so that it forms a vortex, with the result that any air is removed before it enters the tunnel. A vent pipe is taken from the roof of the chamber to the surface and an aperture in the centre of the floor discharges the water to the tunnel.

Pipe Line.

The pressure tunnel opens out into a trifurcation 24 ft. in diameter, the construction of which is shown in Figs. 31, 33 and 34, on page 492, while a photograph of it is reproduced in Fig. 22. From this trifurcation the mouths of three pipe lines, each 8 ft. 4 in. in diameter, are brought out on 120-deg. axes and are run for a distance of 809 ft. to the power station, where they are connected through a control valve to the spiral casings of the turbines. A gully was formed in the floor of the bell mouth which leads to three 12-in. scour pipes. The 8-ft. 4-in. diameter pipes, which are entirely buried, were made by Messrs. P. and W. MacLellan, Limited, Glasgow, in 9 ft. lengths, with one longitudinal riveted joint. The circumferential joints were partly welded. As these pipes are $1\frac{1}{8}$ in. thick, a circumferential weld to the full depth would have been expensive, so a butt strap was used and the gaps between the lengths were filled with asbestos compound. Pairs of pipes were connected outside the tunnel by a joint with an external butt strap, and each pair was hauled into position in the tunnel. After laying and jointing, the pipes were tested by admitting water under pressure through a tapped hole, so that it filled the small annular space enclosed by the welds, the cover strap and the ends of the pipe, the pressure being recorded at the opposite end of the cover strap. After the joint had been proved in this way to be satisfactory, the hole was closed by a plug and sealed by further welding. The remaining joints were then made from inside the pipe. Nearer the power station, where the pipes were laid in a trench, they were joined with a full circumferential butt weld to take the weight of the valve.

After the pipes had been tested, concrete was pumped round them and the crown of the tunnel was grouted through $1\frac{1}{2}$ in. holes. These holes were then plugged and the plugs sealed by welding. The pipes were shot-blasted and sprayed with 0·003 in. of zinc followed by 0·003 in. of aluminium; and were finally painted with three coats of bituminous paint.

Turbine Inlet Valves.

The downstream end of each pipe line is connected to a taper, the diameter of which decreases from 8 ft. 4 in. to 5 ft. 5 in. These tapers pass through the turbine room walls and are connected directly to the main valves of the machines. These valves, which were manufactured by the English Electric Company, Limited, Kingsway, London, W.C.2, are the first of the straight-flow type to be installed by the firm for commercial service in Great Britain. They consist essentially of a roughly hemispherical cast-steel door, one half of which is solid and acts as the closing member, while the other half is bored out to the diameter of the pipe and forms the follower ring. They have been designed so as to ensure that the water is cleanly cut through without diverting the jet, and to give compactness with low frictional resistance. They thus combine the advantages of spectacle-eye sluices and rotary valves. The body was fabricated in halves and carries gunmetal-lined trunnion bearings. Water leakage through the valve, when shut, is prevented by a rubber seal, which is forced by the pressure in the pipe line on to a stainless-steel seating face which is welded on to the door. A dismantling joint made up of tapered segments is provided to allow the valve to be removed for maintenance and, to enable this to be done without emptying the tunnel, an emergency seal is provided upstream of the service seal.

The valves are opened and closed by separate hydraulic servo-motors, which are constructed of "Colclad" plate and are operated by the pipe-line water pressure. Opening is effected by energising a solenoid, which is either remotely controlled from the turbine panel or locally. When this solenoid is energised it moves a control valve and this valve, in turn, admits water to the by-pass and distributing valves on the main valve. The distributing valve is arranged so that the water pressure is either transmitted from the upstream side of the inlet valve to the closing side of the servo-motor, or from the downstream to the opening side of the servo-motor. When it is operated on opening therefore, its seals are de-pressurised and the main valve opens as soon as the pressure in the turbine has built up. The closing impulse trips the control valve, so that it returns to its "off" position, thus causing the distributing valve to transfer the water pressure to the closing side of the servo-motor. During the final closing movement, the speed of travel is progressively checked by a control screw of the same design as that used by the makers on their cylindrical balanced valves. The smooth performance of the valve, even when closing under unbalanced conditions, is thus ensured. When the valve is fully closed pressure is automatically applied to the seals.

(*To be continued.*)

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

Fig. 29. SURGE CHAMBER.

Fig. 30. TYPICAL SECTION OF 14' 6" DIA. TUNNEL.

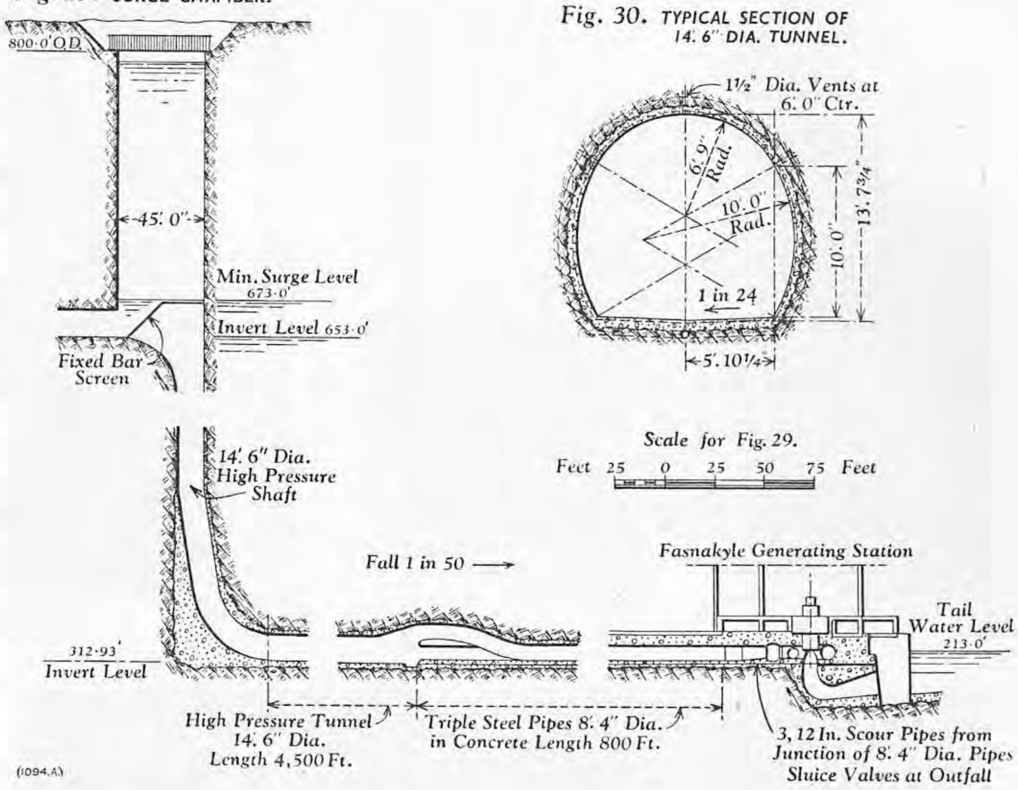


Fig. 31. PLAN OF TUNNEL AND PIPE JUNCTION.

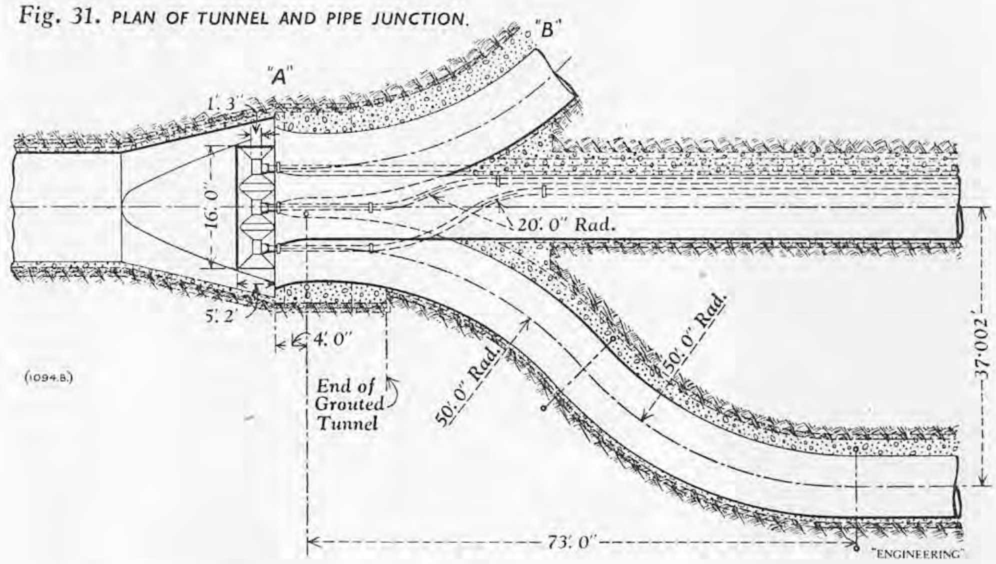


Fig. 32. TYPE B TUNNEL.

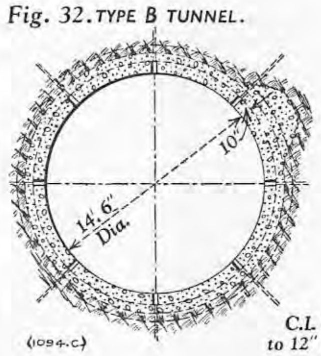


Fig. 33. VERTICAL SECTION AT "A" (FIG. 31.)

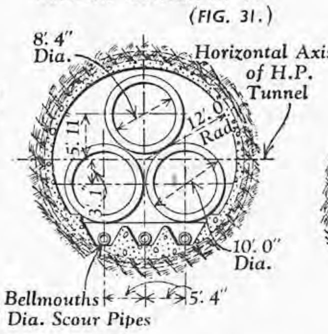
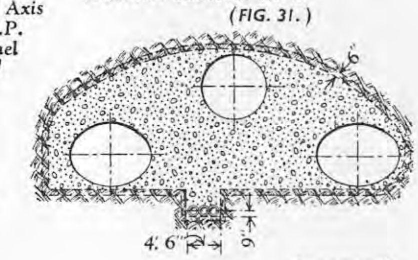


Fig. 34. VERTICAL SECTION AT "B" (FIG. 31.)



Institute of Marine Engineers' Examinations.—The next examinations for admission to student membership of the Institute of Marine Engineers will be held from April 14 to 17 and from October 6 to 9, 1953. For graduateship, the examination will be held from April 27 to May 20, 1953, and for associate membership from April 27 to May 21, 1953. Syllabuses of these examinations and particulars of exempting qualifications may be obtained on application to the secretary of the Institute, at 85, Minories, London, E.C.3.

Committee on Prevention of Pollution of the Sea by Oil.—The Ministry of Transport have announced the composition of a committee set up to consider what practical measures can be taken to prevent oil pollution of the sea. The committee is to consist of a chairman, secretary and 20 members. The chairman is to be Mr. P. Faulkner, C.B., of the Ministry of Transport. Representatives have been nominated by the General Council of British Shipping, the oil companies, the Dock and Harbour Authorities' Association, the British Transport Commission, the Dry Dock Owners and Repairers Central Council, the Admiralty, the Ministry of Agriculture and Fisheries, the Ministry of Fuel and Power, the Department of the Government Chemist, the Department of Scientific and Industrial Research, and the Ministry of Transport. The secretary is Mr. S. G. Griffin, of the Ministry of Transport. The committee's terms of reference are: To consider what practical measures can be taken to prevent pollution by oil of the waters around the coasts of the United Kingdom, and to draw up a report on the subject.

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

(*For Description, see Opposite Page.*)

Fig. 35. GENERAL PLAN.

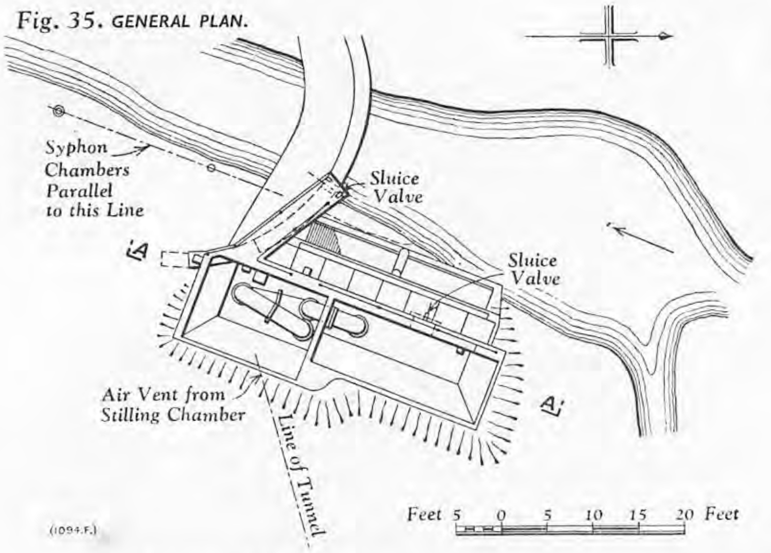
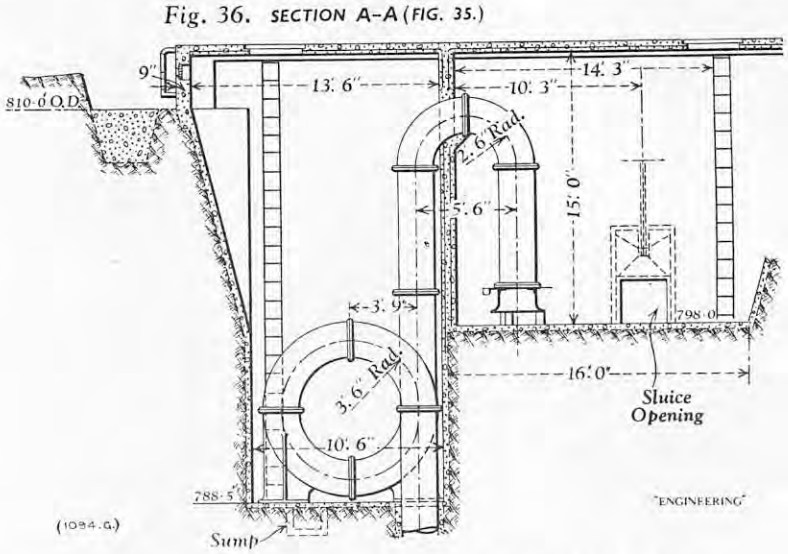


Fig. 36. SECTION A-A (FIG. 35.)



LITERATURE.

Geodesy.

By BRIGADIER G. BOMFORD, O.B.E., M.A. Oxford University Press (Geoffrey Cumberledge), Amen House, Warwick-square, London, E.C.4. [Price 50s. net.]

THE student of geodesy attains a point of vantage once he realises the interrelations between the fundamental operations of geodetic surveying, and how, in this branch of engineering, the validity of a long chain of inferences is challenged by the weakness of any one of the links. Brigadier Bomford succeeds in presenting this point of view in his first four chapters, by a systematic discussion of the initial group of operations, namely, primary triangulation, and the potentialities of radar as a substitute; the control of azimuth by Laplace stations, and of scale by base measurements, and the substitution of primary traverse for triangulation; and the measurement of height above sea-level by primary triangulation or spirit-levelling. Thus, the utility of recent developments finds a place in the general setting, as, for example, the value of radar in the measurements of long lines across the sea, and in the process of covering a large virgin area with a triangulation involving sides of from 300 to 400 miles as a principal framework. Likewise, in a later chapter, the reader's attention is drawn to the need for improvement of radar technique, and the investigation of the speed and route of radar transmission, to enable geodetic lines to be measured correctly to 1 in 200,000 across 500-mile gaps.

Evidently, the ramifications of the subject are numerous. The reason is that triangulation cannot be computed without a knowledge of the figure of the earth, and from early times geodesy has included astronomical observations of latitude and longitude, not only to locate detached survey systems, but to obtain from triangulation the length of the degree of latitude or longitude in different parts of the earth, and so to determine the earth's figure. Study of the variation of gravity between equator and pole, as measured by timing the swing of a pendulum, affords an alternative approach to the same problem, as is shown in Chapters V and VI, respectively. Moreover, consideration of these two operations alone, the measurement of the direction and the intensity of gravity, have led to more than the determination of the axes of a spheroidal earth; they have disclosed the presence of irregularities in the earth's figure and gravitation which constitute one of the few available guides to its internal constitution. While geodetic surveying thus touches upon certain aspects of geophysical investigation, it is well to remember that the ultimate aim of scientific geodesy is to ascertain the size and shape of the geoid, as may be done directly from measures of the deviation of the vertical, or indirectly from measures of the intensity of gravity, whence Stokes's theorem enables the form of the geoid to be computed. That geodesists should desire to proceed further and speculate about the physical causes of these irregularities is perhaps inevitable, but such speculations must be based on knowledge derived from the kindred sciences of astronomy, geology and geophysics. It is therefore gratifying to find, in Chapter VII, a discriminating choice of topics under the principal heading of "The Earth's Figure and Crustal Structure" where the direction is towards an understanding of the geophysical deductions which can be made from the operations already mentioned. At appropriate places in this chapter, reference is made to allied subjects of likely value to geodesists, as, for instance, magnetic survey, tidal analysis, latitude variation, and seismic methods of geophysical prospecting.

In the text, and the appendices and bibliography which occupy the final 40 pages of the book, the author explains the field work and the various methods of correlating the resulting data, as well as the systems of thought originating in more theoretical considerations, with a breadth of outlook and simplicity of language that will make the book of practical value to those who are in any way interested in the subject with which it deals. Restrictions of space account for the exclusion of certain topics, but not the essential parts of the chief purely geodetic theorems, and it is difficult to see how the general balance of this up-to-date treatment could have been improved.

ELECTRIC LAMP WITH INTEGRAL FUSE.—The lead-in wires of the general-lighting service lamps from 40 to 300 watt single-coil and from 40 to 100 watt coiled-coil, manufactured by the General Electric Co., Ltd., Kingsway, London, W.C.2, now incorporate short lengths of fuse wire sealed in glass tubes. The object of this development is to minimise the risk of circuit fuses blowing.

SHELL ROOFS.—The current issue of *Concrete Quarterly* (No. 14) is devoted entirely to descriptions of concrete shell roofs that have been built both in this country and elsewhere. Published by the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1 (price 2s.) it supplements the symposium on "Shell Roofs" organised by the Association and held in London, from July 2 to 4, and reported in ENGINEERING on pages 55, 75, 104 and 186, *ante*.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING.

(*Concluded from page* 429.)

WE conclude our report of the work of the 4th Congress of the International Association for Bridge and Structural Engineering, held at Cambridge during August last, with a review of the papers submitted to the fifth and sixth working sessions, and the discussions that followed. Both sessions were concerned with concrete structures, the fifth being devoted to fundamental principles of the properties of concrete and the sixth and last session to current problems of plain, reinforced and prestressed concrete.

FUNDAMENTAL PRINCIPLES AND THE PROPERTIES OF CONCRETE.

The papers presented for discussion at the fifth working session may be considered in two groups: those concerned with the composition and manufacture of concrete and those which were concerned with the destruction and deterioration of concrete by either the application of repeated stresses or corrosion of the concrete and the reinforcement.

Of the papers in the first group, that by Mr. D. A. Stewart (London) was substantially similar to that reproduced in ENGINEERING recently (pages 313 and 354, *ante*); in the paper, the author set out in detail the advantages and economies that could be obtained if full and correct consideration were given to the choice of materials, particularly in the effect on workability and placing with vibrators. The rational proportioning of concrete was also dealt with in the paper by Mr. K. F. Antia (Bombay), who discussed the factors involved in producing a concrete of a required strength at the lowest possible cost. Results of published experimental work were given, which related the resultant strength of concrete to the many factors that might be varied when manufacturing concrete, and a procedure for the rational proportioning of concrete of a given 28-day strength was suggested. The author admitted that it was not possible to include all the variables, but pointed out the vast saving involved in capital cost if only a small percentage saving in cement was achieved by the proposed procedure. The third paper, by Mr. Albert Joisel (Paris), entitled "The Composition of Concrete," described in detail the experiments and results of an investigation into the effect of aggregate size on the resulting strength of the concrete; note was also made of the need to limit aggregate size so as to obtain adequate workability and durability. To illustrate the value of vibration in placing concretes made from properly chosen material, Mr. Stewart showed a short film which indicated the high immediate strength that could be achieved thereby, thus permitting the shuttering to be struck without delay.

Three papers, each in French, were presented on the various aspects of corrosion and deterioration of concrete. In the first of these papers, Professor F. Campus (Liége) dealt principally with the difficulties experienced from atmospheric attack on concretes. Reference was also made to the thermal movements within concrete—shrinkage and reversible wetting movements—particularly where associated with the restraining effects of the imbedded reinforcement, and to frost attack and the corrosion of the reinforcement. To all these causes of breakdown of the concrete, Professor Campus suggested that the necessary resistance could be obtained by effective compaction of a sufficiently thick concrete cover to the reinforcement. Dr. Marcel Prot (Paris) described a piece of apparatus designed to investigate the corrosion of concrete by various fluids, particularly salt water, acid and salt-bearing ground waters, etc. The apparatus consisted essentially of a bath in which a large number of small-dimensioned specimens, each similarly supported, were subjected to the action of the liquid, which was kept circulating briskly and maintained at a constant temperature. Such treatment produced a greatly accelerated corrosion failure of the concrete, and the large number of specimens, 300 or more, permitted a fair comparison to be made between different samples and to obtain a measure of the scattering of the recorded results. Failure of the specimens was recognised precisely by their own rupture; the specimens consisted of either short cantilevers stressed under their own weight, or U-shaped specimens held by one arm, with the other loaded by a weighted bell-crank lever. During the discussion, Dr. Prot reported that difficulties were being experienced due to the smallness, and the unequal rate of corrosion of the moulded and trowelled surfaces of the specimens. He indicated that alternative forms of specimen were being examined in an attempt to overcome the difficulties.

The last paper of the session, by Mr. L. Séméac and Mr. N. Boutron (Marseilles) was entitled "The Corrosion of Reinforced Concrete in Bridges and Structures on Railways" and described the experiences of the French Railways who have been heavily committed to the use of reinforced concrete since the beginning of the century. In the early days it had been thought that the new material would need very little maintenance although, of course, later experience had shown that smoke-gases attacked concretes most vigorously. Nevertheless it had been found in practice that the damage could be much reduced by avoiding elements of small cross-sectional dimensions, providing adequate cover, avoiding smoke traps and providing sufficient ventilation to take the smoke away. In the event of damage by corrosion, the reconstruction work consisted of patching the corroded point with cement mortar, preferably with a cement gun, after cleaning away the deteriorated concrete by sand-blasting. It was thought that full protection could be achieved by insisting on sufficient control during the manufacture and placing of all concrete work, but meanwhile, and as a temporary measure, improved protection of concrete surfaces had been obtained by the application of suitable paints.

To conclude the work of the fifth session three films were shown; the one on vibrated concrete has already been mentioned. The second film showed the erection of some large concrete hangars near Marseilles, and the third showed some bridges, of steel as well as of reinforced concrete, that have been constructed in Portugal.

Current Problems in Plain, Reinforced and Prestressed Concrete.

Two groups of papers were submitted to the last working session; the first group contained five papers, related to plain and reinforced concrete, and the second group, of three papers, dealt with some current problems in prestressed concrete. Dr. F. G. Thomas (London) in a general report on the session, noted the trend of modern design methods towards considerations of a load factor with respect to the ultimate strength of the members. He continued by commenting that it was probable that a sufficiently accurate assessment of the ultimate strength of single reinforced concrete beams could be obtained from any one of the several methods that had been advanced already, and he suggested that emphasis should now be placed on the development of design methods and considerations of the ultimate strength of continuous systems. Even if the basis of design was taken as the ultimate strength it was still necessary to ensure that distortions and cracking were kept within reasonable limits. The increasing use of "high quality" materials was bringing its own problems, since the high quality only applied to some properties of the materials, the other properties remaining unchanged from those possessed by materials of ordinary quality. Dr. Thomas concluded by observing that the trend toward prefabrication was likely to continue because of its suitability to both ordinary reinforced and prestressed concrete.

The first paper presented in the work of this session was submitted by Mr. L. P. Brice (Paris) who described a theoretical and experimental investigation into the cracking of reinforced concrete. He stated in his paper that the bond between the steel reinforcement and the surrounding concrete had elastic properties capable of sustaining only the slightest of deformations and that, for very great changes of shape, such as nearly always occur in the neighbourhood of cracks, the bond displayed all the properties of a frictional force acting so as to oppose the relative displacements. He maintained that the investigation had succeeded in clarifying a number of points. Firstly, that the apparent elongation of the concrete was accounted for by the formation of relatively unstrained blocks between the cracks and by the slip of the reinforcement. Secondly, that the width of the crack was in inverse ratio to the total adhesion of the steel bars, but that the sum of all the widths of all the cracks remained a constant; an improvement, therefore, in the adhesion only served to increase the number of the cracks. Finally, the author gave a theory for estimating the spacing of the cracks in a beam subjected to bending, which took into account the geometric properties of the cross-section, the adhesion between steel and concrete and the tensile strength of the concrete.

In the following paper, by Mr. N. Esquillan (Paris), a description was given of a number of modern examples of large works in reinforced concrete. The author noted that the difficulty of finding qualified workmen and the high price of shuttering and scaffolding had led to the wide adoption of prefabricated units of various sizes, erected by movable scaffolding, by launching or by lifting. During post-war years, many structures had been erected by the systematic application of mechanisation; the most recent French example, most impressive by virtue of the size of the project, was the hangar at Marignane, near Marseilles, where the roof structure of two bays was cast on the floor and then jacked up at the rate of $3\frac{1}{2}$ ft. a day until the final height of 62·4 ft. had been reached.

Professor H. Nylander (Stockholm), submitted a paper entitled "Non-Uniform Shrinkage of Concrete Due to Segregation of the Coarse Aggregate," wherein he described some tests on vibrated reinforced concrete beams that showed the counteractive effect of the reinforcement on shrinkage to be of minor importance in comparison with the effect produced by the non-uniformly distributed shrinkage caused by the segregation of the coarse aggregate. Tests with unreinforced beams showed the influence of varying consistency and time of vibration on the non-uniform shrinkage of concrete. In the case of slabs, it was found that the moments and deformations induced by the non-uniform shrinkage could be as great in magnitude as those imposed by the allowable loading. In an effort to minimise non-uniform shrinkage, an additional layer of coarse aggregate was spread on the surface of the concrete after placing and the layer vibrated until the aggregate had been absorbed into the freshly-poured concrete below. Experiments showed that this method was of value in reducing non-uniform shrinkage.

In a paper concerned with the ultimate strength of concrete members when subjected to either pure compression or compound compression and bending, Professor E. Torroja and Mr. A. Paez (Madrid) investigated the ultimate stress distribution in concrete columns by examination of experimental stress-strain diagrams taken near the point of failure. In developing their theory the authors took account of creep effects under protracted loading in order that they could deal with prestressed members. The problem of the ultimate strength of reinforced-concrete members in combined bending and torsion was the subject of a paper by Dr. Henry J. Cowan and Mr. S. Armstrong (Sheffield). After briefly reviewing earlier work on the problem, the authors put forward a theory for the torsional strength of reinforced concrete beams, both in the elastic range and at failure, based upon the maximum principal stress theory and the internal friction criterion of Coulomb, the two theories being operative for different percentages of torsion and bending. A description was also given of the authors' machine, developed to test full-size sections in combined bending and torsion. The results of tests showed, surprisingly, that the addition of a small percentage of bending increased the torsional resistance of a reinforced section; this was in contrast to the result found for plain materials, including concrete, where the addition of bending reduced the torsional strength. The authors concluded with their recommendations for the design of beams subjected to combined bending and torsion. During the discussion, Dr. Cowan showed some slides that illustrated experimental results obtained in some similar tests on prestressed-concrete beams; these tests showed that very large increases in the torsional strength of concrete were possible with the aid of prestressing.

Dr. P. W. Abeles (London), in a paper entitled "The Use of High-Strength Steel in Ordinary Reinforced and Prestressed Concrete Beams," drew upon the published work of himself and many other investigators on the Continent and in the United States. Problems associated with cracking, resilience of prestressed concrete and fatigue were discussed in the paper, which, like the previous papers, had as its main objective the assessment of the ultimate strength of the beams, for which the author presented a theory based on a rectangular distribution of the maximum compressive stress to one-half the depth of the beam. It was claimed that the high-strength properties of both the steel and the concrete could be exploited, both in ordinary and prestressed reinforced concrete, provided that an efficient bond was developed.

In contrast to the earlier papers the next paper, by Mr. H. Lossier and Mr. M. Bonnet (Paris), described design and construction—of the Villeneuve-Saint-Georges bridge across the River Seine. The bridge had three spans; the longer central span consisted of a slung girder between the arms cantilevered from the shore anchor spans. Prestressed longitudinally by flexible cables working over rocker bearings, the loss of tension, due to shrinkage and creep of the concrete and the plastic deformation of the cables, could be compensated by the adjustment of the cable anchors at any future time. The positioning and the tensioning of the cables were so arranged that the various sections of the roadway were subjected only to slight bending stresses under permanent dead loads and that no tensile stress occurred in the concrete even under the most unfavourable distribution of the live loads. Before the bridge was built advantage was taken of the opportunity to test the carrying capacity of the cables, their anchorages, the position of welds and the reinforced-concrete anchor plates.

The final paper of the session, and, indeed, of the Congress, entitled "Continuity in Prestressed Concrete," was submitted by Professor G. Magnel (Ghent). Professor Magnel began his paper by pointing out that, if maximum use was to be made of prestressing, continuity was unavoidable. He then outlined the problems to be considered when contemplating the prestressing of continuous structures, in particular, the generation of secondary moments by the load in the prestressing cables, and the methods that could be adopted to alleviate the difficulties. The description and illustration of several buildings and of the Sclayn-bridge demonstrated the success so far achieved in the construc-

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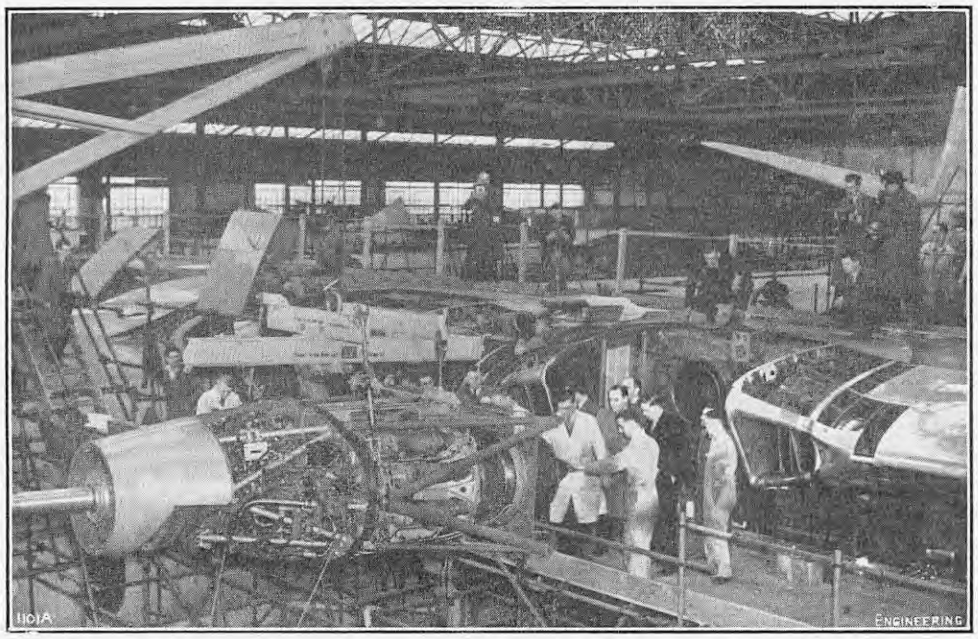

Fig. 29. Coupled "Proteus" Power Plant Being Installed.

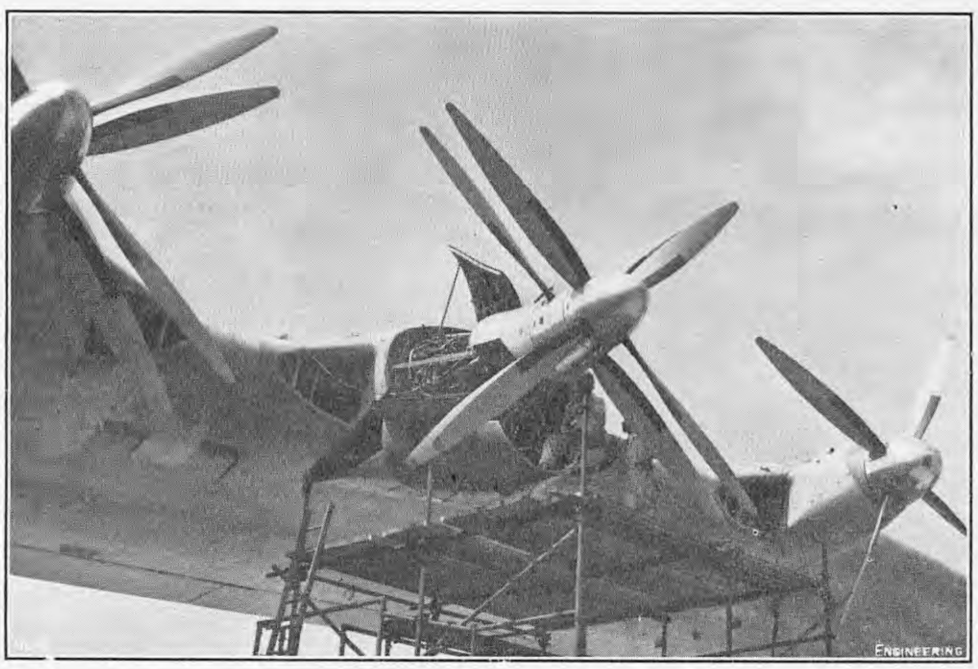

Fig. 30. De Havilland Propellers Installed; Engine Cowlings Open for Inspection.

tion of continuous prestressed structures. The paper was concluded by some results of experimental measurements of the loss of stress in the cables due to friction when the prestress was being applied. The advantages to be obtained by the development of partially prestressed structures, where individually pre-cast prestressed members were used in the erection of framed structures, were expressed by Dr. A. M. Hass (The Hague) during the course of the discussion. In particular, he pointed out that such methods avoided the excessive costs of the full prestressing of complete structures.

Closing Session.

In a final closing session held at the Engineering Laboratories, Professor J. F. Baker, M.I.C.E., chairman of the Cambridge Reception Committee, thanked the Association for having chosen Cambridge as the location for the 4th Congress and expressed the hope that members had profited from their labours of the previous week. Professor F. Stüssi, the President of the Association, briefly outlined the scope of the problems tackled at the meetings and ended by thanking Professor Baker and his assistants for the arrangements that had been made to receive the Association.

The members of the Congress travelled to London on Saturday, August 30, for the official reception by the Government, for the Banquet at Guildhall in the City of London, as reported in Engineering (page 307, *ante*) and for a further week of visits and tours to places of general and engineering interest.

Parsons Memorial Lecture.—Mr. Claude Seippel will deliver the Parsons Memorial Lecture of the North East Coast Institution of Engineers and Shipbuilders in the lecture theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne, on Friday, October 31, commencing at 6.15 p.m. The title of the lecture will be "From Stodola to Modern Turbine Engineering."

New Jet Engine Factory in Canada.—On Monday, September 29, a new factory, built for A. V. Roe (Canada) Ltd., Malton, Ontario, Canada, was opened by the Rt. Hon. C. D. Howe, Minister of Defence Production. Production of the Avro Canada Orenda axial-flow turbo jet, which was designed specifically for the CF100 all-weather fighter constructed by the company, and which will also power F.86 Sabre fighter aircraft built under licence by Canadair Ltd., will take place in the new factory.

THE "PRINCESS" FLYING BOAT.

(*Continued from page* 431.)

In this article the whole of the power-plant installations of the "Princess" flying boat are described. Previous articles on the Princess appeared on page 289 of our issue of September 5, in which the structural features were described; on page 371 of our issue of September 19, which dealt with the powered flying controls; and on page 429 of our October 3 issue, which covered the services for water operation, and the electrical system.

Power Plants.

A description of the Bristol Proteus II propeller-turbine engine, of the same type as the single outboard engines fitted in the first Princess, was given on page 269 of our 168th volume (1949), and it may be recalled briefly that it employs two independent turbines, one driving the propeller and one driving the compressor, with no mechanical interconnection between them. The centre and inboard power units in each wing comprise coupled Proteus II engines, arranged with their axes parallel, and driving a common central shaft through a coupling gearbox which provides part of the speed reduction between the turbines and the propeller. The common shaft from the coupling gearbox drives, through a second reduction gearbox, two coaxial contra-rotating propeller-drive shafts. The engines are started individually by Rotax electric starter motors, supplied by the 120-volt direct-current system and controlled by the 24-volt supply through a time-controlled three-stage starting circuit.

When taking off in rough weather, quantities of water may be thrown up to the level of the leading-edge air intakes. To prevent any interference with correct engine functioning, therefore, the compressor air intakes are provided with controllable shutters, which are closed during take-off. The resulting depression within the engine cowling opens a number of inwardly-hinged spring-loaded doors in the bottom cowling panel. The intake air then turns through approximately 120 deg., effectively separating the water spray.

As already noted, the engine tailpipes pass through holes in the spars and emerge through the top skin aft of the rear spar, above the trailing edge. Each tailpipe is surrounded by a cooling shroud through which cooling air, entering through one of the main-intake passages (the layout of which was described on page 293, *ante*) is led. Aft of the rear spar, the shroud expands into a "snail," from which branch pipes are taken to the air-conditioning system (in the case of the inboard engines) and to the outer-wing anti-icing system (in the case of the single power units and the outer units of the centre coupled engines.

Fig. 29, herewith, shows the first of the coupled power plants, in its welded tubular-steel engine mounting, being installed in the aircraft. The engine mountings of both the coupled and single engine units are attached to four pick-up brackets on the forward face of the front spar by single high-tensile steel tapered bolts and expanding sleeves. For facilitating engine changes, all the attachment brackets are provided with a second hole for aligning the joints during re-assembly. Great care has been devoted to the design of the engine cowlings, which are constructed in sections arranged to rotate about hinges, or to slide on rollers, to give easy access for servicing the engines. The entire lower cowling panels can be winch-lowered, and portions of it can be folded outwards to form servicing platforms, as shown in Fig. 30. It should also be mentioned that special engine-changing fixtures, for erecting on the wing and nacelle structure, and equipped with winches, have been designed to

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Fig. 31. LAYOUT OF FIRE EXTINGUISHING SYSTEM, PORT SIDE.

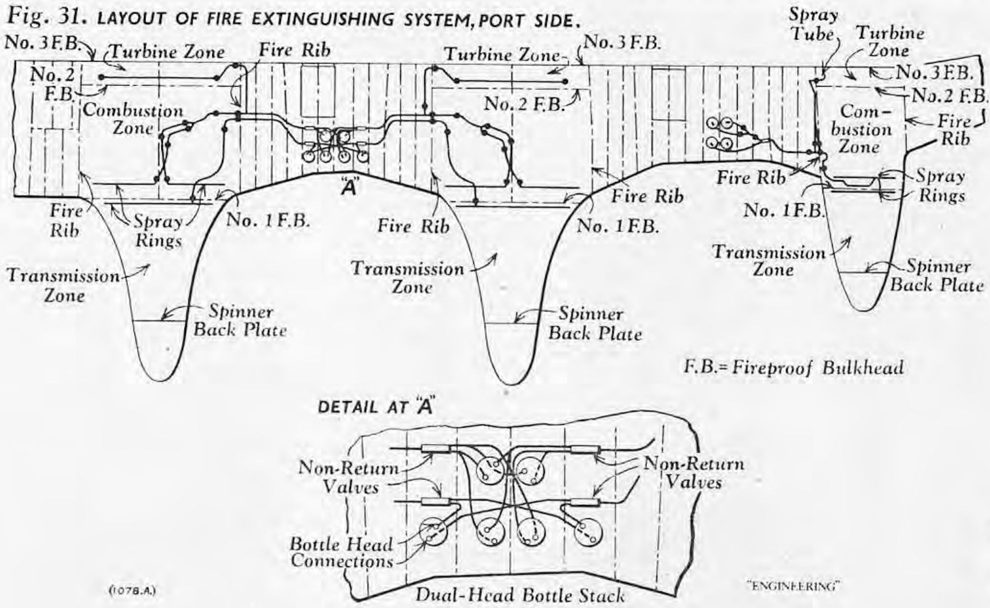
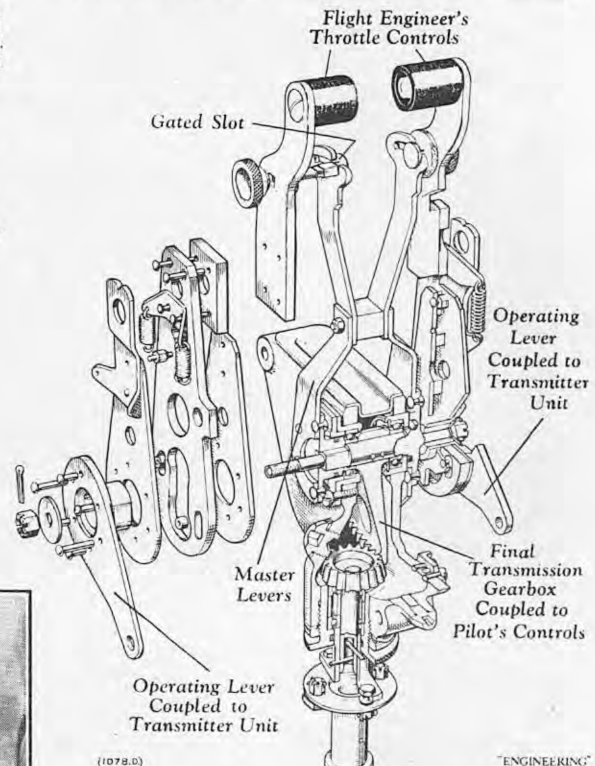


Fig. 32. FLIGHT ENGINEER'S COUPLED-UNIT THROTTLE CONTROLS.



facilitate engine-changes when the aircraft is on the water.

The drives for the aircraft accessories are taken from the coupled engines only. A shaft extending from the rear of each coupling gearbox drives an accessory gearbox mounted on the forward face of the front spar. Each inboard accessory gearbox drives the air-conditioning plant and one of the 39-kW generators. The other two 39-kW generators are driven by the centre-unit accessory gearboxes, which also drive the 6-kW generators supplying the 24-volt electrical system.

The coupled units are provided with separate oil systems for the transmission and for each engine. This layout was adopted so that, in the event of a failure in any portion of the unit, the remaining sections would be unaffected by the circulation of metal particles; and also in order that an oil embodying film-strength additives could be used for the transmission gears. In fact, however, it has been found satisfactory to adopt oil of the same specification for engine and transmission systems, which simplifies operation and maintenance.

Engine Fire-Extinguishing System.—To check the spread of a fire starting in one of the power plants, each of the engine bays and nacelles is divided into three zones by stainless-steel firewalls, as indicated in Fig. 31—the transmission zone, extending from the propeller spinner back plate to No. 1 fireproof bulkhead; the combustion zone, bounded by the fire ribs and Nos. 1 and 2 fireproof bulkheads, and, in the case of the coupled engines, subdivided by a longitudinal fire-wall so that the combustion chambers of each engine are completely isolated; and the turbine zone, also bounded by the fire ribs, and by No. 2 fireproof bulkhead and the front spar, and also divided by a longitudinal firewall in the coupled bays. The turbine zone forms a plenum chamber for the tail-pipe cooling-air supply. In each compartment enclosed by the fire-walls are fitted spray rings or spray tubes for spraying fire-extinguishing liquid in the event of an engine catching fire. The extinguishing fluid is directed to all three fire zones; it is not possible to confine the flow to any one spray tube.

It will be seen from Fig. 31 that, in each wing, the outboard single engines are served by four Graviner methyl-bromide extinguisher bottles, and the two coupled power units are served by six extinguisher bottles, in this case fitted with dual heads; one outlet of each bottle is connected to the inner coupled unit and the other outlet to the outer

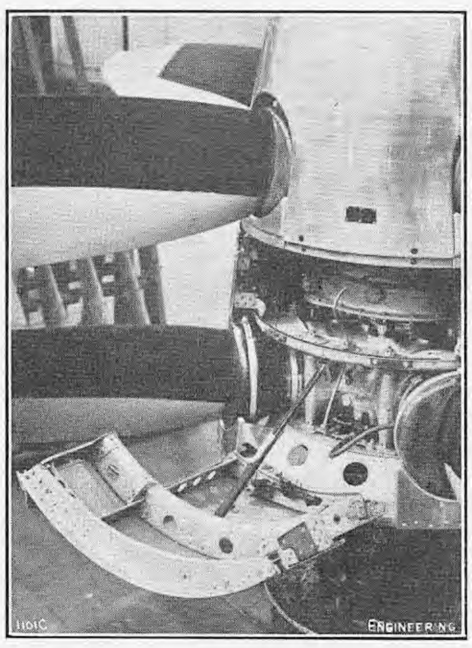


FIG. 33. OPENED REAR SPINNER OF DE HAVILLAND PROPELLER.

coupled unit. The fluid is released electrically either by the pilot or, in the event of a crash, by two inertia switches, mounted in the hull on the centre-section front spar, which operate under an acceleration exceeding $3g$; in the latter case, all the bottles are discharged simultaneously, flooding all the engines with methyl bromide, and, in addition, the high-pressure fuel cocks and the tail de-icer fuel-supply cock are shut off, and the electrical circuits controlling propeller feathering, the thermal de-icing system, and the engine starters are broken. Two manual over-ride switches are also provided for the crash circuit for use if one of the inertia switches should fail to operate; both must close in order to complete the circuit.

All the relevant pilot's controls for each engine are grouped, in six vertical columns, on a "fire panel" in the cockpit: the fire warning lamp, mounted on the centre of the appropriate feathering button; the air-intake shutter switch, the fuel and oil cocks, and their associated position indicators; and the "first shot" and "second shot" fire-extinguisher buttons. In a coupled engine, the "first shot" button releases all the methyl bromide from three of the bottles to that power unit; the remaining three bottles are then available either for a "second shot" to the same power unit, or for the other coupled unit by operating its first-shot button. In the single outboard engine, each fire-extinguisher button releases the contents of two of the four bottles.

The fire warning lamps, which are duplicated at the flight engineer's station, are actuated by Graviner resetting detector switches mounted around each end of the combustion chambers and around the transmission gearboxes. Non-return valves are fitted where necessary to prevent released methyl bromide from flowing back into bottles that have already been emptied.

Engine Controls.—Electric throttle-control equipment has been supplied by Ultra Electric, Limited, Western-avenue, London, W.3, similar to that adopted in the Bristol Britannia air liner and described on page 258, *ante*. It provides for remotely operating the engine throttle valves to correspond with the pilot's (or flight engineer's) throttle-lever movements, but independently of the rate at which the throttle levers are operated. Should the jet-pipe temperature of any engine exceed a predetermined value, a temperature over-ride system closes the throttle, and re-opens it as soon as safe conditions are re-established. The control is also designed to provide a measure of compressor-speed governing. The throttle valves are actuated through duplicated rotary actuators, one of which forms an emergency standby. They drive through a differential gearbox.

The pilot is provided with six throttle levers only—i.e., he can only control the coupled engines as a single unit. The flight engineer, however, has separate throttle levers for each of the ten engines, which he can close independently of the pilot's levers. These levers are connected by push-pull rods with the Ultra transmitter units, which are housed on the engineer's console. The flight engineer cannot open the throttle levers (apart from a very small range of movement to allow for synchronising the coupled engines). It will be apprecia-ted, therefore, that the mechanical linkages between

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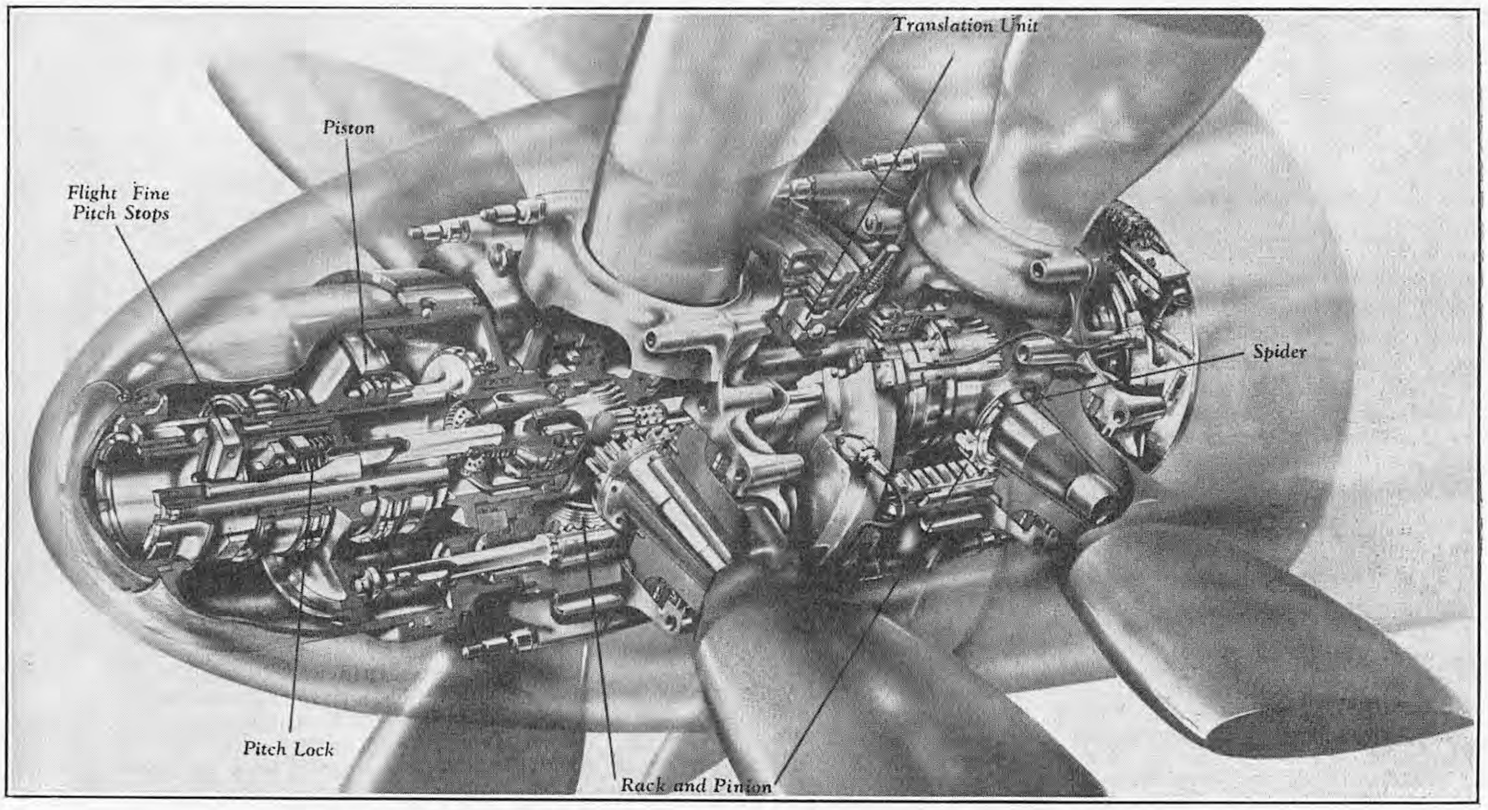


FIG. 34. SECTIONED VIEW OF PROPELLER MECHANISMS.

the pilot's and flight engineer's throttle levers are somewhat complex.

The outboard single engines drive reversing propellers and, after releasing a locking lever, the pilot's outboard throttle levers can be shifted through a gate into a reversing quadrant, so that further rearward movement of the levers progressively opens the throttles with the propellers in reverse pitch. This motion is carried out by means of an auxiliary lever which is brought into engagement when the pilot's lever is raised against spring pressure, to go through the gate. This action also operates micro-switches energising the propeller reverse-pitch control circuits. The flight engineer's levers, however, have no reversing motion.

Movements of the pilot's throttle levers are transmitted, by sprockets and chains, through a system of shafts and bevel gearboxes to the throttle lever assemblies, illustrated in Fig. 32, on the flight engineer's console. In the case of the coupled engines, the spindle of the final throttle-lever transmission gearbox carries two ganged master levers which reproduce the movements of the pilot's levers. Each of the two individual throttle levers controlled by the flight engineer is linked with the master levers by a knurled nut engaging in a gated slot in the upper end of the master levers. The flight engineer's levers are freely mounted on the spindle and are attached at their lower end to levers coupled with the Ultra transmitter units. By loosening the knurled nut, the flight engineer's levers can be adjusted relatively to the master levers by an amount limited by the length of the slot. Each of the flight engineer's levers comprises a built-up assembly which can be extended against a spring load so that the lever can be lifted through the gate in the slot and thereby disconnected from the master levers, thus allowing the flight engineer's lever to close the throttle independently of the position of the pilot's controls. The other engine of the pair remains under the pilot's control. The flight engineer's lever cannot, however, be raised sufficiently to allow forward movement independently of the pilot. The interconnection between the pilot's and flight engineer's controls for the outboard engines is broadly similar in principle, but there is no provision for advancing the flight engineer's lever relative to the master lever.

Propellers.—The propellers of the Princess, the largest turbine propellers yet built, with a diameter of 16 ft. 6 in., were designed specially for the aircraft by de Havilland Propellers, Limited, Hatfield. They are well shown in Fig. 30, on page 495. More than 7,000 hours of bench-testing of the propeller, fitted to a Proteus engine, have been completed, and 500 hours' flight-testing has been carried out on the Bristol company's Proteus Lincoln flying test-bed. The four inner coupled Proteus units are fitted with contra-rotating Duralumin propellers of the rack-operated constant-speed feathering type. The single outer Proteus units drive single four-blade propellers of the standard Hydromatic feathering and reversible-pitch type. They are similar to those of the Britannia, described on page 258, *ante*, except that, at present, they have Duralumin blades whereas those of the Britannia have hollow-steel blades. It is probable that steel-bladed units will be fitted at an early stage in the flying trials of the Princess.

In the contra-rotating propellers, the spinners comprise two assemblies, one for the front propeller and one for the rear. The shell of the rear spinner consists of four hinged panels, which open to give access for inspection, as illustrated in Fig. 33. A sectioned view of the pitch-changing mechanism is reproduced in Fig. 34. The central member of each half-propeller assembly is a spider, splined to the driving shaft. The four blades, of the conventional de Havilland hollow-shank design, are retained on the spider against centrifugal loads by a lipped barrel, formed in two halves and bolted together. Each blade root carries a pinion engaging with a fore-and-aft rack passing through the barrel. The pitch-changing mechanism comprises a double-faced piston, moving in a cylinder fixed to the hub. The piston slides on a tubular extension of the engine shaft, which forms an oil passage-way to the front of the piston. The engine shaft extension houses the flight fine-pitch stops limiting the movement of the piston in the fine pitch direction; it also contains the hydraulic pitch lock—a mechanism for locking the blades in the angle at which they are set should there be a failure of the hydraulic supply. The blades are thus prevented from returning to the flight fine-pitch stop, and resulting in high "windmilling" r.p.m. of the turbine. For ground operation, the flight fine-pitch stops can be retracted to enable a high propeller speed to be obtained at moderate engine power. The piston incorporates four lugs, to which are attached the four front-propeller blade-operating racks. At the rear end, the forward racks are connected to the inner race of a translation unit which imparts the motions of the pitch-changing piston to the blade-operating racks of the rear propeller. The translation unit consists of a sliding sleeve and two races with a ball bearing designed to carry thrust and journal loads. It is enclosed in an oil bath specially designed to ensure that every moving part is adequately lubricated and that oil is not flung out of the unit by centrifugal force.

Two oil-transfer tubes in the hollow driving shaft provide for the passage of oil from the constant-speed unit, which controls the pitch angle of the blades to maintain a predetermined propeller speed setting, to the front and rear of the piston in the propeller. A de Havilland "double-acting" constant-speed unit, controlling both high-pressure and low-pressure oil supplies to the propeller, is employed. It consists of a gear-type pump, and a spring-loaded centrifugal governor driven by the engine. The pump receives oil from the engine lubrication system, and boosts up its pressure. A control valve, moving in the bore of the gear-pump driving shaft in response to the opposing forces of the governor spring and centrifugal weights, determines the delivery of oil to the propeller at either high pressure to move the blades to coarse pitch, or low pressure to move the blades to fine pitch. The latter movement is assisted by the centrifugal twisting moment on the blades.

The setting of each constant-speed unit is controlled by a rotary electric actuator, set in operation by the flight engineer either for individual speed selection or to synchronise all the propellers with a "master" propeller. The regulation of the propeller speeds is carried out entirely by the flight engineer. The only propeller controls provided for the pilot, other than the feathering switches, are a single emergency switch for over-riding the flight engineer's controls, to give maximum revolutions on all the propellers.

In order to provide sufficiently high rates of pitch change to cope with the sudden increases in power and speed of such large turbines, the de Havilland company have designed an electric over-riding control for the constant-speed units, similar in principle to that of the Britannia, as described on page 259, *ante*. In brief, it consists of an automatic pitch-coarsening mechanism to guard against over-speeding with, additionally, an acceleration-sensitive arrangement to detect high accelerations of the turbines and thereby preventing overspeeding.

(*To be continued.*)

THE INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING.

(*Continued from page* 466.)

CONTINUING the discussion on Mr. Turnbull's paper, Dr. Ing. A. Nicastro remarked that many ships, chiefly tankers, lost during the first world war, were easily salvaged, though heavily damaged by torpedoes. He recalled also the disastrous case of the S.S. Cuma, which sank in 1930; only six men, who were on the weather deck, were saved, all the men below deck being lost. He attributed the losses, and much damage suffered at sea, to excessive lightness as well as to localised structural weakness. In connection with the author's diagram showing maximum wave heights for various wave lengths, he thought it advisable to show the heights of the breaking waves in a high sea separately from those of the unbroken waves; this would give a curve lower than that in the diagram, and probably would be more useful. He did not believe that rivet slip could occur because, if it did, the riveting would soon weaken, which did not occur in practice. The failures that occurred at discontinuities in welded ships were due, he thought, to the weakness of the joints and of the overlaps or seams; both these elements provided a mass of stiff material which did not transmit the stress away from the points of discontinuity and thereby lessen the stress concentration at those points. The differences found by the author between the calculated strains and those determined by the bending tests were justified, he considered, because the shell plating behaved more like a wire in tension than a rigid plate. It was right to put the longitudinal stiffening at the bottom and in the strength deck.

Other points to which he personally gave attention were the increase of stress in the shell plating of the double bottom, which he believed to be caused by the deformation of the transverse structure, and the effect of the water pressure in displacing the neutral axis from that determined theoretically. It was desirable, in his view, to determine the "lines of influence" of the ship in passing over waves, and to study the strength scientifically by calculations based on the longitudinal deformation as well as at the points of discontinuity. The calculations took a long time, and were difficult and delicate, but he suggested that, by making them, it should be possible to reduce the losses of ships and of men.

Professor E. V. Telfer said that, while Mr. Turnbull had made a very interesting limited assessment of the stress due to thrust in ships, his remarks were a little ambiguous when he said that the stress in those particular cases did not exceed half a ton per square inch. That suggested that the stress was actually of the order of half a ton per square inch, but a rough calculation that he (Dr. Telfer) had made indicated that the stress due to thrust was quite negligible—something of the order of one-hundredth of a ton per square inch. He asked, therefore, whether the author would give his reasoning in placing the limit at half a ton.

From Mr. Turnbull's illustration comparing the distribution of longitudinal stresses for bottom shell plating near amidships, the inference was that the welded ship was much inferior to the riveted; but might not the inferiority of the welded ship be due to the absence of longitudinal seams in the bottom shell plating? A ship could be entirely welded except for the seams at the bottom, which could be either riveted or welded, and it could be accepted then that the excellent development of the riveted ship through the years would be carried on in the welded ship without having to adopt the longitudinal system of framing. He was glad that Mr. Turnbull had indicated the possible future policy of Lloyd's Register in the treatment of the longitudinal strength of ships, and thought it excellent that, probably, there would be a greater concentration on the investigation of the still-water bending moment and the correlation of experience for the amount of fluctuation of stress caused by the action of waves. In his paper, Mr. Turnbull had remarked that some years ago, the sagging stresses were the more important, whereas now it was the hogging stresses, which suggested that, with a little co-operation with the designers and the classification societies, it should be possible to have a zero still-water bending moment, and that could be made one of the conditions of design for all important ships.

Dr. Ing. Gino Soldà said that, as the purpose of ship calculations was to guarantee safety, it must be remembered that, with the use of welding, it was necessary to improve the quality of steel, particularly if automatic welding were to be more widely adopted. No doubt, the steelmakers would collaborate with the naval architects to produce materials which would satisfy all future requirements. Regarding the author's statement that the standard longitudinal bending-moment calculation was likely to be superseded by a simplified still-water bending-moment calculation, he thought that some reservations should be made in order to avoid possible misunderstanding regarding this simplification.

Mr. Turnbull, replying to the discussion, noted Mr. Steel's opinion that fatigue was an important factor in the behaviour of ships at sea. He had himself thought that not long ago, but recent tests had caused him to think that he was wrong. He believed that very high stress concentration was also an important factor. Dr. Fusini had mentioned that finer ships had a smaller bending moment than full ships, and thought that was a good thing. It was very doubtful, however, whether in fact a fine ship did have a lower bending moment at sea than a full one. Mr. Murray had asked whether the same dynamic factor could be used for the ballast draught as for the load draught. In his own opinion, to do so would be as near to the truth as it was possible to get at the moment. In considering longitudinal bending, he thought that there was something to be said for having the machinery aft and the holds forward, as suggested by Dr. Fusini, provided that there were good ballast tanks amidships. This was necessary, because a ship in the ballast condition had a very appreciable longitudinal bending moment.

Mr. Murray had suggested that tests should be carried out with statistical strain gauges on a number of types of ships. That had been contemplated, though no definite action had yet been taken; in the not too distant future, however, that excellent suggestion would probably be put into operation. In reply to Professor Telfer's remark concerning the stress due to thrust: the figure of half a ton per square inch was provided by the scientists, who had worked it out from the measurement of the actual forces on the ship in a certain condition. It was very important, as Dr. Ing. Soldà had said, that the classification societies should take steps to ensure that good steel was supplied for welded ships; but it was still necessary to pay attention to design.

(*To be continued.*)

INTERNATIONAL COMMERCIAL MOTOR SHOW.

(*Concluded from page* 468.)

THERE is little doubt that the International Commercial Motor Show, which closed at Earl's Court on Saturday, October 4, was successful, preliminary reports from several of the exhibitors indicating that the volume of business transacted surpassed even the most optimistic forecasts. As mentioned in our earlier reports on the exhibition, there were several new vehicles on show, most of which were of advanced design. Some of these were described on pages 412, 436 and 467 of our issues for September 26 and October 3 and 10, respectively, and we conclude below our account of the exhibition.

LOAD CARRIER WITH UNDER-FLOOR ENGINE.

Although most of the under-floor engined chassis on view were developed for passenger-carrying purposes, it must not be assumed that such chassis are limited to this field. Karrier Motors, Limited, Luton, for example, were showing a new under-floor engined chassis which they have introduced to take the place of their CK3 3 to 4-tonner. The new vehicle, which is known as the Gamecock, is illustrated in Fig. 19, on page 500, which shows the chassis and cab assembly. It has the same load-carrying capacity as the CK3 and is available with wheelbases of 9 ft. 7 in. or 11 ft. 9 in. As will be seen from the illustration, the power unit is situated below the floor of the cab, a position that enables full forward-control to be employed with its consequent advantages of greater load-carrying space and balanced distribution of the load without the usual disadvantages of the normal forward-control vehicle in which, as a rule, the engine is located in the cab alongside the driver. In this case, the engine is not arranged horizontally but is set at an angle of 66 deg. to the vertical with those components likely to require routine servicing, such as the starter motor, distributor, fuel pump and carburettor, arranged at the top of the engine, access to them being gained through trap doors in the cab floor. It is a petrol unit having a bore and stroke of $3\frac{3}{4}$ in. and $4\frac{3}{8}$ in., respectively, developing 85 brake horse-power at 2,600 r.p.m. and a maximum torque of 216 lb. ft. at 1,200 r.p.m. Notable features of the design are the employment of chromium-plated cylinder bores, push-rod operated overhead valves, a seven-bearing balanced crankshaft, pressure-lubrication of the gudgeon-pin bearings, renewable valve guides and a four-bearing camshaft.

Apart from the design and position of the engine, the vehicle follows standard practice. The engine and clutch form a single unit with the gearbox, the latter being arranged to provide four forward speeds and a single reverse speed. On the long-wheelbase model, two tubular propeller shafts are used to transmit the drive to the rear axle, the shafts being supported by a centre bearing located in a spherical rubber-encased housing. A single shaft without the centre bearing is used on the short-wheelbase model and in both cases the shafts are fitted with Hardy-Spicer needle-roller bearing universal joints. The final drive consists of a spiral-bevel crown-wheel and pinion assembly with straddle-mounting of the pinion. The assembly is provided with a four-pin bevel-type differential and is supported by two opposed taper-roller bearings. A pressed-steel axle casing is employed and fully-floating flanged half-shafts transmit the drive to the hubs which are fitted with taper-roller bearings. An I-section front axle is used and both axles are connected to the chassis through semi-elliptical springs, those at the front being 48 in. long and those at the rear, 46 in. long. The frame side members have a maximum section 8 in. deep with top and bottom flanges of $2\frac{3}{16}$ in. and 3 in., respectively. Hydraulically-operated servo-assisted brakes are fitted to all four wheels, the brake shoes having a total lining area of 305 sq. in.

HORIZONTAL DIESEL ENGINE.

To meet the increasing demand for underfloor Diesel engines, F. Perkins, Limited, Queen-street, Peterborough, have introduced and were showing at Earl's Court, a horizontal version of their well-tried P4V engine. This unit, which is illustrated in Fig. 21, on page 501, has four cylinders with the same bore and stroke as the vertical unit, namely, $3\frac{1}{2}$ in. and 5 in., respectively; it develops 52 brake horse-power at 2,400 r.p.m. and a maximum torque of 133 lb. ft. It is, of course, fitted with a re-designed sump and a new filler column and dipstick, but in most respects is similar to its vertical counterpart. A wire-gauze strainer is installed in the new sump and the lubricating-oil pump has a new bottom plate which incorporates a weir to facilitate priming of the pump when the engine is started. Modifications have been made also to the camshaft and the breathing system, the former having been lengthened so that it can drive the fuel pump through a coupling and the latter altered so that a partial vacuum is maintained in the crankcase thus ensuring effective drainage of the valve chamber underneath the cylinder-head cover. Provision has been made also for the fitting of an exhauster when required and minor modifications have been made to the layout of the fuel and lubricating-oil pipes and the location of the filters. The engine is supported at the front through a special stub pin which passes through the timing case and is connected through Silentbloc mountings to any convenient chassis cross member. At the rear, it is supported by means of mountings on a special bell housing fitted to a backplate at the rear of the engine. The height of the complete power unit is 1 ft. $6\frac{3}{4}$ in., the length 3 ft. 3 in., and the width 3 ft. $6\frac{5}{8}$ in., the design being such that no part extends more than $8\frac{1}{2}$ in. below the centre-line of the crankshaft.

THREE-TON DELIVERY CHASSIS WITH UNDERFLOOR ENGINE.

One of the first vehicle manufacturers to take advantage of the introduction of the Perkins flat-four engine were Dennis Brothers, Limited, Guildford, who were showing a three-ton load-carrying chassis powered by such a unit. This chassis, which has been designated the Stork, is illustrated in Fig. 22, on Plate XLIII, from which it will be seen that the driving controls are located on a dropped forward extension of the chassis. This arrangement gives an exceptionally low driving platform, which is an important consideration on delivery vans where the driver is continually stepping into, and out of, the cab. The chassis shown in the illustration has a straight rear extension but a dropped extension, similar to that used at the front, can be fitted, thereby rendering the chassis suitable for use in connection with the travelling-shop type of body with the entrance for customers at the rear. The engine is situated a short distance behind the front axle and the radiator is located just in front of the axle, an extension shaft from the engine driving the fan.

Apart from the engine and its location, the design of the chassis follows established Dennis practice. The clutch, clutch housing and gearbox form a single unit with the engine, the gearbox being designed to give four forward speeds and a single reverse speed and employing the long-addendum tooth form to give quiet running associated with a long life. A fully-floating hypoid rear axle is employed, hypoid gears having been chosen on account of their quietness and the greater tooth-contact area they provide. Channel-section side members and cross members are used for the frame, the side members having a depth of 6 in., a width of flange of $2\frac{1}{2}$ in. and a thickness of $\frac{3}{16}$ in. Semi-elliptical springs are used both at the front and rear, the front springs being 40 in. long by $2\frac{1}{2}$ in. wide and the rear springs 50 in. long and $2\frac{1}{2}$ in. wide. Both the front and rear brakes are of the Girling pattern, the front brakes having a diameter of 14 in. and a width of $2\frac{1}{2}$ in.; the rear brakes are of the same diameter but have a width of $3\frac{1}{2}$ in. The brakes, together with the clutch and accelerator, are operated by hydraulic means. The chassis is available with wheelbases of 11 ft. 8 in. or 10 ft. 6 in., the distance from the front dash to the end of the frame being 17 ft. 10 in. for the former and 16 ft. 1 in. for the latter model. The total overall lengths are 22 ft. $5\frac{1}{2}$ in. and 20 ft. $8\frac{1}{2}$ in., respectively, and the width is 6 ft. $4\frac{1}{2}$ in. in both cases.

THREE-CYLINDER DIESEL ENGINE.

F. Perkins, Limited, were also showing, for the first time, a new three-cylinder Diesel engine suitable for use in light vans. This unit, which is known as the P3V, is illustrated in Fig. 20, on page 501, where it is shown equipped with a proprietary gearbox. It has a bore and stroke of $3\frac{1}{2}$ in. and 5 in., respectively, and is capable of developing up to 34 brake horse-power at 2,200 r.p.m., which is the maximum governed speed. Apart from the number of cylinders, the P3V engine is, in most respects, similar to the P4V engine referred to above. The cylinder block and crankcase are a single iron casting and the cylinder bores are fitted with renewable dry-type liners. Overhead valves are, of course, employed and these are operated by push rods and rocking levers in the normal manner. Spherical combustion chambers are fitted, each chamber being formed in the cylinder head. The crankshaft is machined from a solid nickel-chromium-molybdenum steel forging and has a large flange formed integrally at the rear to accept the flywheel. It is dynamically balanced and is supported by four main bearings of the steel-backed copper-lead lined type. Nickel-chromium-molybdenum steel is also used for the connecting rods, which are machined from light H-section stampings. The pistons are made from an aluminium alloy and are provided with three compression rings and two scraper rings, the latter being located one above and one below the gudgeon pin. A pneumatic governor is fitted to the fuel pump, a standard C.A.V. unit being used, but the atomisers have two sprays one of which is directed into the combustion chamber and the other into the cylinder itself.

FOUR-WHEEL DRIVE LOAD CARRIER.

The vehicles being shown by Transport Equipment (Thornycroft) Limited, Thornycroft House, Smith-square, London, S.W.1, included a four-wheel drive chassis expressly designed for cross-country work. This chassis, which is known as the Nubian, is illustrated in Figs. 23 and 24, on Plate XLIII. It was designed originally to Ministry of Supply requirements but has since been adopted commercially for many applications where four-wheel drive is essential. Rural fire-fighting services, for example, have found such vehicles invaluable for dealing with forest and heath fires, and Fig. 25, on Plate XLIII, shows a Nubian chassis fitted out as a water tender. The chassis exhibited was fitted with the Thornycroft CR6 six-cylinder Diesel engine, which develops a maximum of 78 h.p. at 1,900 r.p.m., but for increased performance either the Thornycroft four-cylinder petrol engine or the Rolls-Royce B80 eight-cylinder petrol engine can be fitted. The transmission group consists of a 14-in. diameter single-plate dry-type clutch, a four-speed gearbox giving ratios of 5·28 to 1, 2·62 to 1, 1·58 to 1 and 1 to 1, and a transfer gearbox. The four-speed gearbox forms a single unit with the clutch and engine but the transfer gearbox is mounted centrally between the two axles. Its function is to distribute the drive to the front and rear axles as required, the design being such that there are two ratios, namely, a high gear of 1 to 1 and a low gear of 2·26 to 1. In high gear, the drive to the front axle is disconnected so that only the rear-axle drive is used for normal roadwork. Selection of the lower ratio, however, automatically brings the four-wheel drive into play.

Transmission of the drive to the transfer box and from the transfer box to the two axles is by open-type propeller shafts fitted with needle-roller bearing universal joints. The front axle is of the fully-floating type, the casing, which is machined from a drop forging, being fitted with a bevel drive and differential. Trunnion pins on the axle casing support the stub axles through taper-roller bearings and the hubs, which run on ball and roller bearings, contain epicyclic reduction-gear units driven from the axle shafts through double universal joints designed to give constant velocity at all angles of steering lock. The combined reduction of the bevel drive and epicyclic gear is 7·48 to 1 and by adopting this design it has been possible to obtain a ground clearance of 13 in. when laden. The rear axle is of substantially the same design as the front axle but there is, of course, no need to fit constant-velocity universal joints in this case. Semi-elliptical springs are employed for both axles, those at the front being 47 in. long and those at the rear 55 in. long. Rebound leaves are fitted at the front and rear and springing is assisted by hydraulic shock absorbers.

The frame side members and cross members are made from pressed-steel channel sections, the maximum frame depth being $8\frac{3}{16}$ in. All four wheels are fitted with wedge-actuated hydraulic brakes of the internal-expanding type and brake application is assisted by a vacuum servo unit. The brake drums are $16\frac{1}{2}$ in. in diameter and the brake linings 3 in. wide, the design being such that the drums can be removed without disturbing the hubs. A cam-and-roller steering box is fitted and the turning circle diameter is 55 ft. approximately. In running order, the chassis weighs 9,352 lb. and the maximum permissible gross laden weight on good roads is 20,720 lb., this figure being reduced to 19,600 lb. for cross-country use. The wheelbase is 12 ft. and the overall length of the chassis, 19 ft. 11 in. It should be added, however, that these figures refer to the oil-engined chassis only.

SIX-WHEEL HEAVY-LOAD CARRIER.

Transport Equipment (Thornycroft), Limited, were also showing a six-wheel four-wheel drive chassis designed specially for operation under arduous tropical conditions and special attention has, therefore, been paid to the cooling arrangements. This chassis, which is known as the Trusty SAR/KRN6, is illustrated in Figs. 27, 28 and 29, on Plate XLIV, Fig. 27 giving a general view, Fig. 28 showing the spare-wheel hoist, and Fig. 29 the air reservoirs for the brakes and the fuel tanks. The letters KRN6 of the type designation refer to the motive unit. This is illustrated separately in Fig. 30, on Plate XLIV, from which it will be seen that it is of exceptionally heavy construction. There are six cylinders with a bore and stroke of $4\frac{3}{4}$ in. and $6\frac{1}{2}$ in., respectively, and the maximum output is 155 brake horse-power at 1,900 r.p.m. It is of monobloc construction, but the cylinder head is in two parts, each of which covers three bores. Overhead valves are employed and these are operated by push rods and rocking levers from a single camshaft driven from the crankshaft through a triple roller chain. A nitride-hardened crankshaft is used; this is supported by seven main bearings of the steel-backed copper-lead lined type, and to ensure freedom from torsional vibration, it is fitted with a viscous torsional-vibration damper. Forced-feed lubrication is, of course, employed, and the lubrication system embodies an oil cooler, cooling of the oil being further assisted by a specially designed sump. A hollow camshaft is employed to convey the oil to the camshaft bearings, the camshaft tunnel being designed so that excess oil forms small reservoirs into which the cam lobes dip.

The transmission assembly comprises an 18-in. diameter single dry-plate clutch, a four-speed main gearbox and an auxiliary gearbox. The main gearbox forms an integral unit with the engine and provides ratios of 6·07 to 1, 3·2 to 1, 1·69 to 1 and 1 to 1. The auxiliary gearbox is separate from the main box and is designed to give an overdrive ratio of 0·735 to 1, direct drive and a reduction ratio of 1·728 to 1. These three ratios can be used in conjunction with all the gears in the main gearbox and the driver has, as a consequence, a choice of twelve different ratios. Both axles at the rear of the vehicle transmit the drive, each being equipped with a worm and worm-wheel final-drive and differential assembly, the design of which permits their removal without disturbing the road wheels. Semi-elliptical springs are used at the front and rear, those at the front being $3\frac{1}{2}$ in. wide and 3 ft. 10 in. long, and those at the rear 5 in. wide and 4 ft. 6 in. long. Actually, two inverted springs are used each side at the rear, each set being pivoted at the centre to a bracket on the chassis frame and the ends being attached to the axle casings through ball trunnions, a design that prevents torsional loads from being placed on the springs.

An air-pressure braking system is installed, the brakes operating on all six wheels in such a way that the braking effect is even, irrespective of the state of adjustment of the individual brake shoes.

Compressed air is supplied by a two-cylinder compressor mounted on the engine and is delivered through an unloading valve to two reservoirs installed on the chassis side member. The compressor can be seen in Fig. 30, and the two reservoirs in Fig. 29. The total effective braking area is 2,074 sq. in., the brake-drum diameter being 16½ in. throughout and the lining width 4 in. at the front and 6 in. at the rear. The frame is of pressed-steel construction, the side members having a depth of 11 in. Two spare-wheel carriers are fitted, one at each side, and in view of the heaviness of the tyre and wheel equipment, each carrier is provided with a hand-operated lifting and lowering device. One of the carriers is shown in Fig. 28, on Plate XLIV. Two lengths of chassis are available, one with a mean wheelbase of 18 ft. 4 in. and the other with a mean wheelbase of 21 ft. 9 in. In the former case, the weight of the chassis in full working order is 17,500 lb., and in the latter case 17,800 lb. The maximum permissible gross laden weight when operating solo is 47,040 lb., and when operating with a trailer, 78,400 lb.

Extra-Heavy-Duty Tractor.

The most impressive vehicle on the Thornycroft stand, however, was the extra-heavy-duty tractor, illustrated in Fig. 33, on Plate XLV. This is a four-wheel version of the Mighty Antar 6 by 4 tractor described in ENGINEERING, vol. 169, page 341 (1950), and has been designed for operation with a trailer having a combined gross laden weight of 140,000 lb. It is particularly suitable, therefore, for semi-trailer operations, such as logging and the transportation of pipes. The main details of this chassis are similar to the 6 by 4 version already referred to; the engine, clutch and gearbox, for example, are exactly the same. The front axle is also identical and although only one rear axle is used, the design is generally similar to those on the 6 by 4 tractor. Instead of employing rear springs, however, the axle is bolted directly to the chassis frame, as shown in Fig. 34, on Plate XLV, the road shocks being absorbed by large 20-ply 21·00 in.-24-in. pneumatic tyres; the 6 by 4 version, it will be recalled, employed leaf springs at the rear and twin tyres. Air-pressure brakes are fitted to all four wheels and provision is made for connecting the system to the trailer. There is also a hand-operated control which can be used to apply the rear brakes individually, thus enabling skid turns to be made. Although the illustration shows the vehicle equipped with an open cab, an enclosed cab can be installed and, if required, a heavy-duty winch can be fitted behind the cab. Any type of trailer connection can be used according to requirements, and, if necessary, air-pressure connections can be provided to operate equipment, such as hopper doors, on the trailer. The weight of the tractor depends, naturally, on the equipment fitted, varying between 11 tons and 13 tons, but the maximum permissible axle weights are 9 tons at the front and 12 tons at the rear.

Tanker for the Bulk Transport of Liquids.

Scammell Lorries, Limited, Watford, have long specialised in the construction of heavy vehicles and it was only to be expected that some of the largest vehicles in the Show would have been on their stand. One of these, namely, an articulated tanker for the transportation of liquids in bulk, is illustrated in Fig. 26, on Plate XLIII. The tractor portion is fitted with a Meadows 6.DC.630 oil engine, which develops 125 h.p. at 1,750 r.p.m., and a torque of 420 lb.-ft. at 1,000 r.p.m. A Gardner 6LWK engine can be installed as an alternative, however, this unit developing 112 h.p. at 1,700 r.p.m. and a torque of 350 lb.-ft. at 1,300 r.p.m. The gearbox is an independent unit and provides six speeds, all gears being in constant mesh and being selected by sliding dogs; top gear is a 1·5 to 1 over-drive. The rear axle, like the gearbox, is of Scammell design and construction, and employs a double-reduction final drive, secondary reduction being obtained through epicyclic gearing. Reduction ratios down to 11·28 to 1 can be obtained by this means. To give smooth riding, three-stage progressive springs are employed at the rear, the springing

EXHIBIT AT COMMERCIAL MOTOR SHOW.

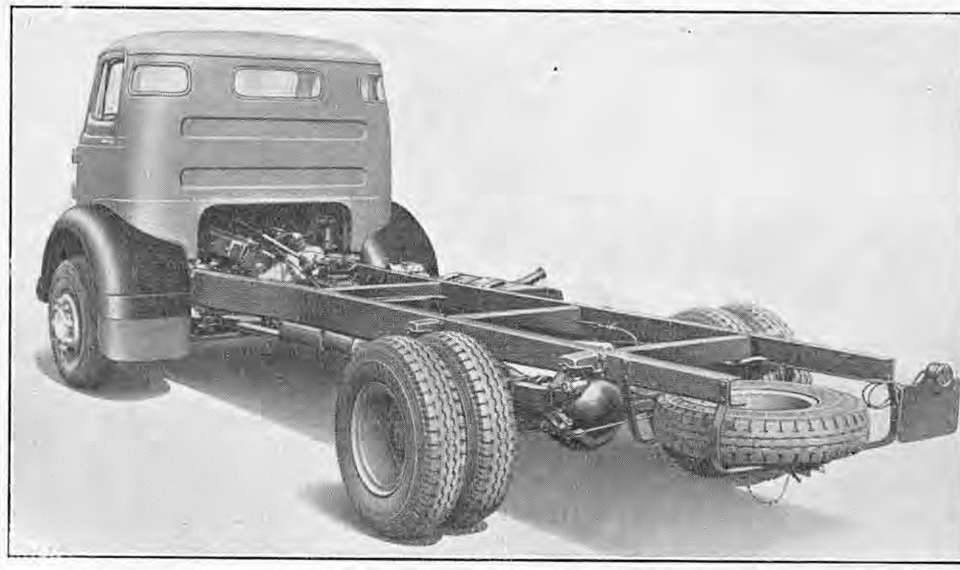


FIG. 19. LOAD CARRIER WITH UNDERFLOOR ENGINE; KARRIER MOTORS, LTD.

being controlled by directly-acting shock absorbers. The brakes are applied by compressed air, a twin reaction valve giving good balance between the tractor and trailer. The semi-trailer, or tank, is of frameless construction and has six compartments the total capacity being 4,300 American gallons.

Six-Wheel Drive Heavy Tractor.

The really outstanding vehicle shown by Scammell Lorries, however, was the six-wheel six-wheel drive heavy tractor illustrated in Figs. 35 and 36, on Plate XLV. This vehicle is fitted with a Rolls-Royce C.6.N.F.L. six-cylinder direct-injection oil engine having a bore and stroke of 5⅛ in. and 6 in., respectively, and developing 160 brake horse-power at 1,800 r.p.m., which is the maximum governed speed. This engine, however, was described at length in ENGINEERING, vol. 172, page 44 (1951). A single dry-plate Borg and Beck clutch is used to transmit the drive to the gearbox. The clutch plate has a diameter of 18 in. and is provided with special thick linings to give a longer life than usual. The gearbox is a separate unit connected to the chassis at three points through rubber bushes so as to eliminate distortion due to chassis flexure. It provides six speeds all of which, with the exception of first ratio, are in constant mesh, selection being made by sliding dogs. All gears run on ball or roller bearings and a comparatively light oil is circulated through the box by a gear-type pump. Behind the main gearbox, and attached directly to it, is a further gearbox known as the transposing box. As its name suggests, the function of this gearbox is to transmit the drive to the three axles. It has three separate output flanges, one for each propeller shaft to the front, middle and rear axles, respectively, the drive from the main gearbox output shaft being transferred to each flange through spur gearing. The transposing gearbox also incorporates the auxiliary gearbox the function of which is to give two speeds and a neutral position for each of the ratios in the main gearbox.

The front axle incorporates double-reduction gearing, secondary reduction being obtained by means of epicyclic gears. The hubs are driven through constant-velocity universal joints, the stub axles being supported by adjustable taper-roller bearings. Location of the axle is by means of a triangulated structure formed by the axle itself and two pressed-steel radius arms, the latter extending rearwards and terminating in a ball-and-socket anchorage on the second cross member. The front suspension consists of a single transverse leaf-type spring pivoted about its centre which, acting in conjunction with the radius arms, permits a considerable transverse articulation without frame distortion. The two rear axles are similar to the front axle many of the parts being interchangeable. They are also located in much the same manner, torque arms extending forwards to form triangulated structures which terminate, in each case, in ball-type anchorages fitted to the chassis cross members.

The rear bogie is sprung through two large laminated springs pivoted at their centres and terminating in ball pivots which slide on lubricated surfaces on the axle casing. Separate propeller shafts are used to transmit the drive from the transposing gearbox to the axles, that for the rear axle being supported by a rubber-mounted steady bearing attached to one of the cross members. Ransome and Marles cam and double-roller steering gear is employed, steering being power assisted. Compressed air is used for this purpose, the linkage and servo controls being designed so that the road wheels follow exactly the requirements of the driver without his having to exert much effort. Air-operated brakes are fitted to all six wheels, compressed air for this service being supplied by a compressor driven from the engine. A secondary, or trailer, reservoir is provided and compressed air for operating the steering is taken from this. Couplings for operating trailer brakes are fitted to the rear of the tractor and provision is made for their installation at the front if required, so that two tractors can be used together. A manually-operated Neate's type brake is also provided, and this acts on the four rear wheels only.

Three different types of chassis are available, namely, a 15-ft. 9-in. wheelbase motive unit for semi-trailer operation, a 15-ft. 9-in. wheelbase tractor for towing full trailers, and a 21-ft. 9-in. wheelbase load carrier with oilfield or special bodies. The maximum permissible gross vehicle weight is 67,200 lb., and the maximum gross train weight 224,000 lb. The overall length with a 15-ft. 9-in. wheelbase is 24 ft. 5⅝ in., and the overall width, 8 ft. 7½ in., the latter dimension referring to all three types of chassis. The height to the top of the cab is 9 ft. 4½ in., and the height to the top of frame when fitted with 12·00-24 in. tyres, 3 ft. 11½ in., both dimensions referring to a laden vehicle.

Passenger Chassis with Underfloor Engine.

Seddon Motors, Limited, Oldham, Lancashire, were showing an underfloor-engined passenger chassis with the difference that the engine, instead of being a horizontal unit, is disposed vertically between the chassis side members. They claim that this arrangement gives several advantages; the design of the engine, for example, is one which has proved itself over many years and normal servicing can be carried out without recourse to an inspection pit. This has been achieved by providing large access panels in the floor of the saloon, and at the side of the body, thus enabling the mechanic to stand beside the engine in a protected position with the floor of the 'bus available as a workbench. The disposition of the engine in relation to the rest of the chassis will be clear from Figs. 37 and 38, on Plate XLVI. A Perkins P6 Diesel engine is fitted, minor modifications having been made to give a floor height of 41 in. laden

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

(*For Description, see Page* 498.)

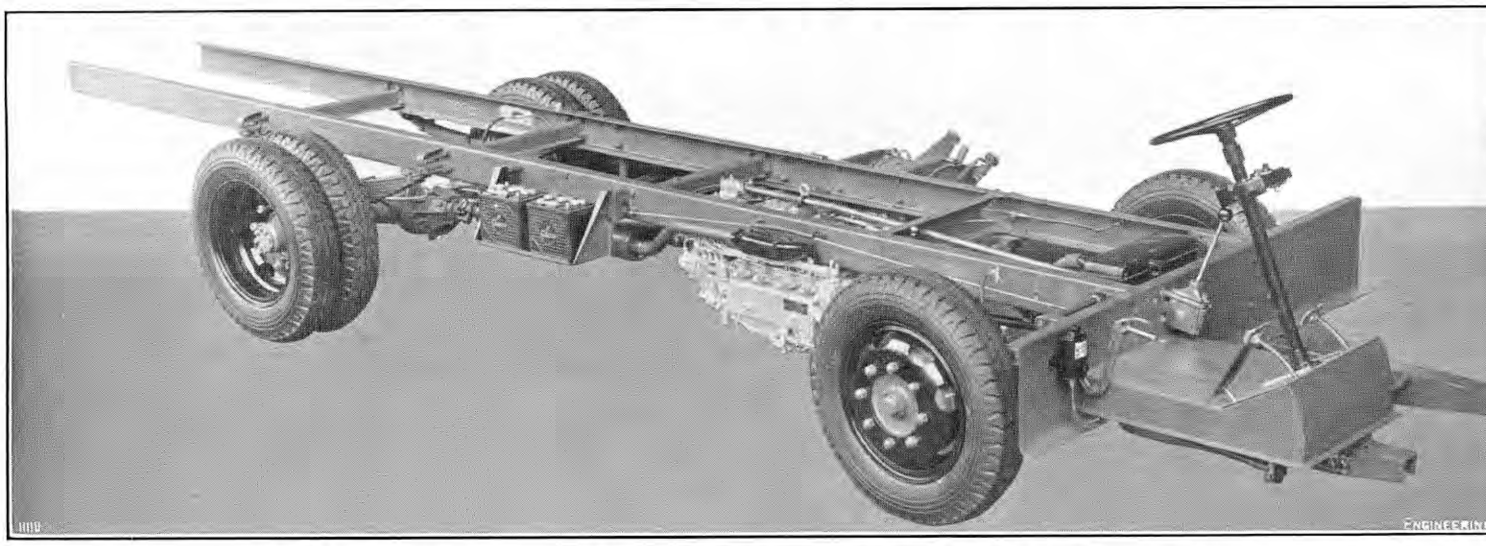
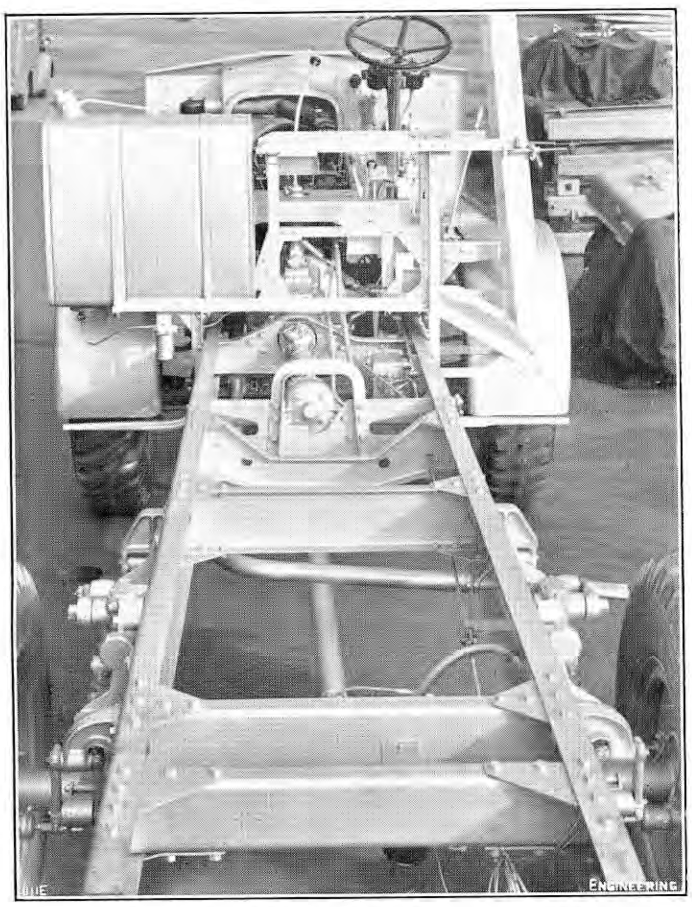


Fig. 22. Three-Ton Delivery Chassis with Underfloor Engine; Dennis Brothers, Ltd.



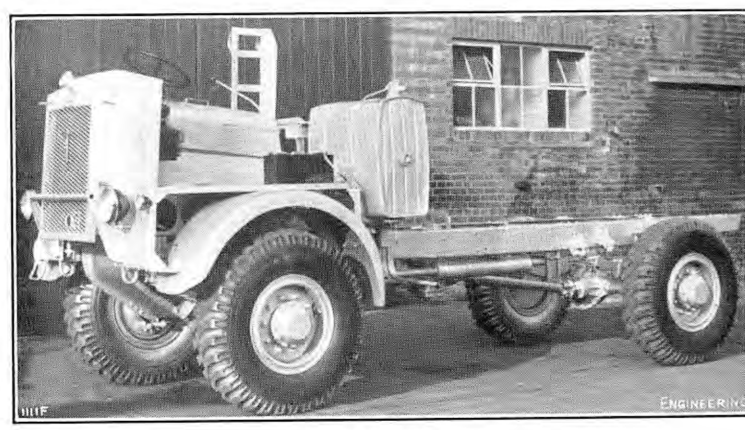
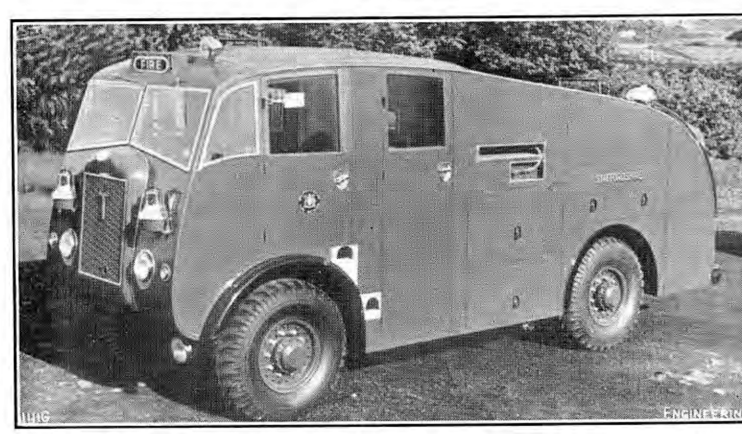


Fig. 24.



Figs. 23 and 24. "Nubian" Four-Wheel Drive Chassis; Transport Equipment (Thornycroft), Ltd.

Fig. 25. "Nubian" Water Tender; Transport Equipment (Thornycroft), Ltd.

Fig. 26. Tractor and Semi-Trailer for Bulk Transport of Liquids; Scammell Lorries, Ltd.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

(*For Description, see Page* 498.)

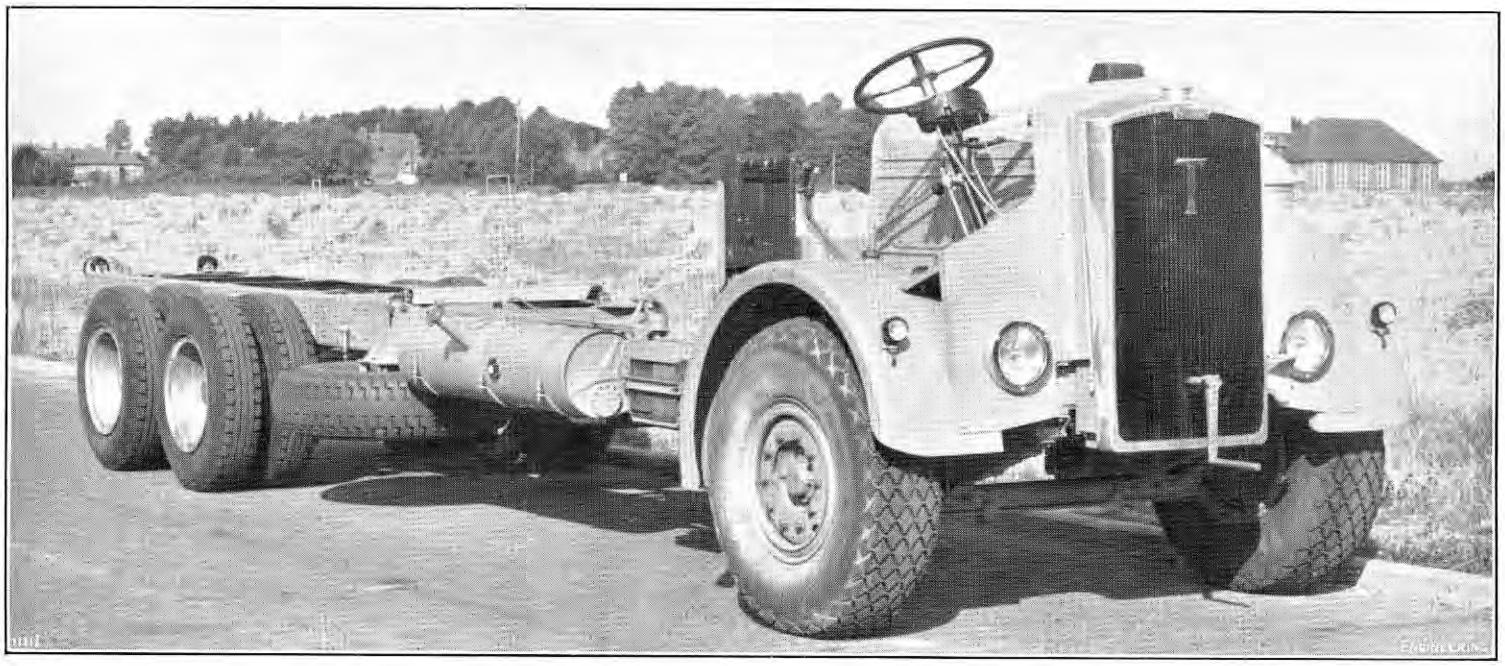


Fig. 27. "Trusty" Six-Wheel Chassis for Heavy Loads; Transport Equipment (Thornycroft), Ltd.

Fig. 28. Spare-Wheel Hoist on "Trusty" Chassis.

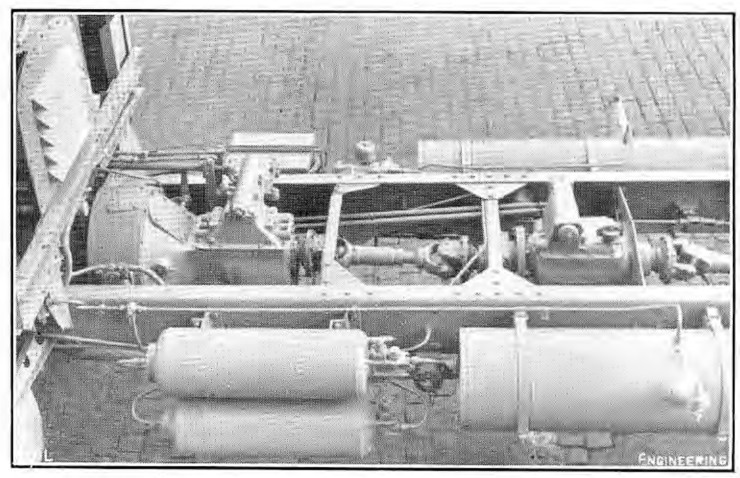


Fig. 29. Fuel Tanks and Air Reservoirs; "Trusty" Chassis.

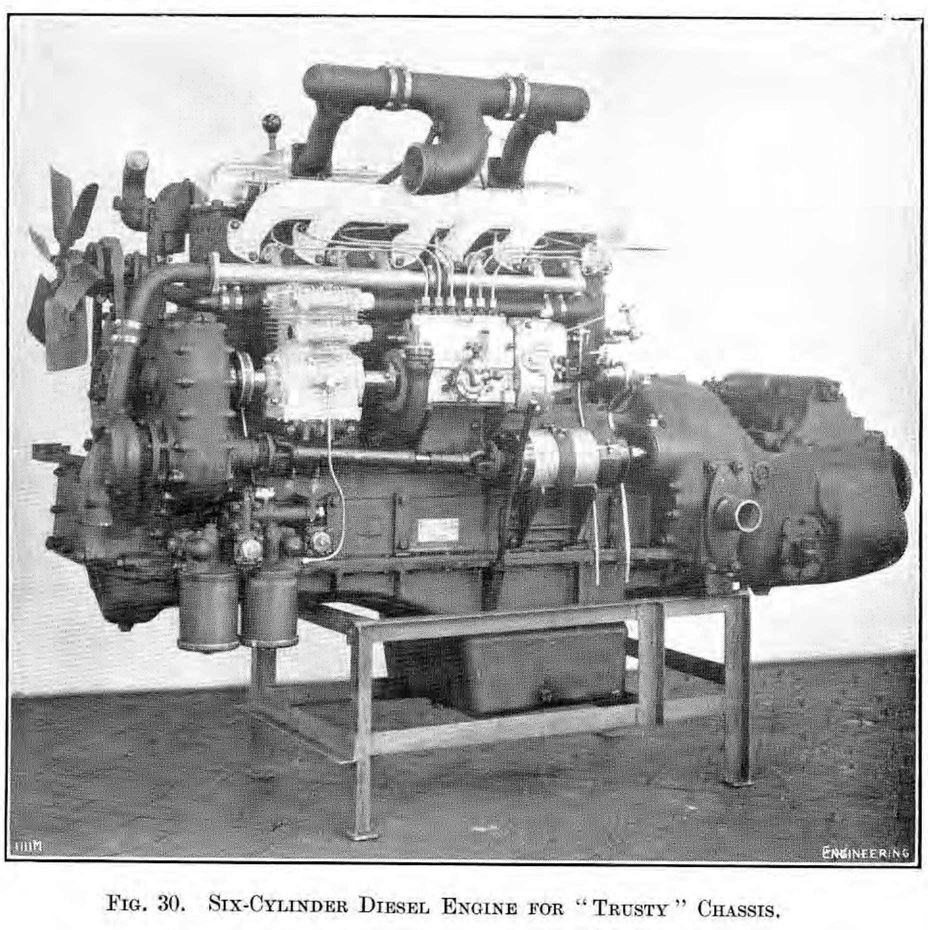


Fig. 30. Six-Cylinder Diesel Engine for "Trusty" Chassis.

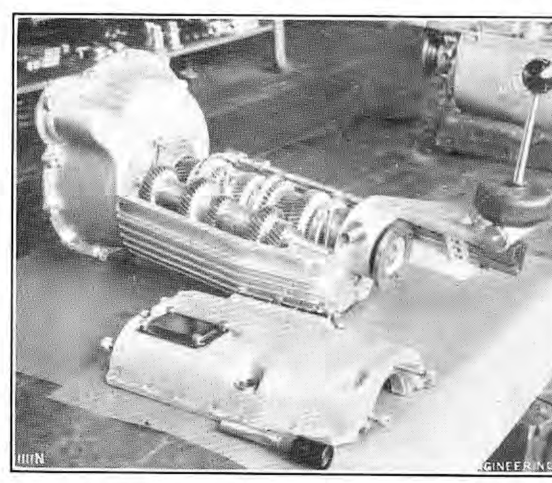


Fig. 31. Five-Speed Gearbox; David Brown and Sons (Huddersfield), Ltd.

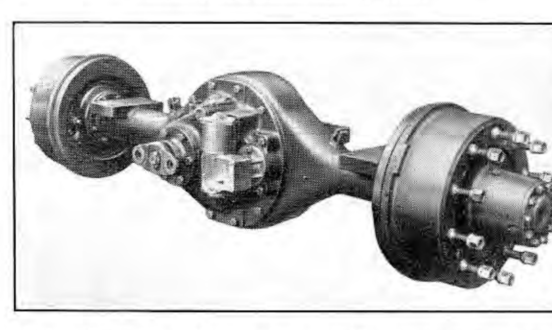


Fig. 32. Two-Speed Axle; Eaton Axles, Ltd.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

(*For Description, see Page* 498.)

FIG. 33. HEAVY-DUTY TRACTOR; TRANSPORT EQUIPMENT (THORNYCROFT), LTD.

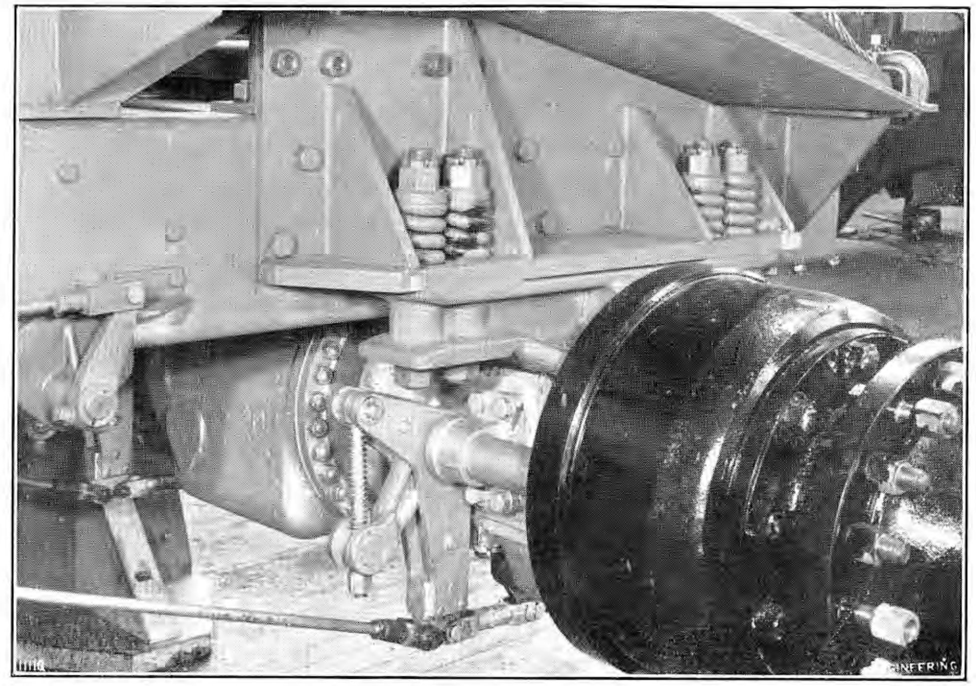


FIG. 34. TRACTOR REAR AXLE; TRANSPORT EQUIPMENT (THORNYCROFT), LTD.

FIG. 35.

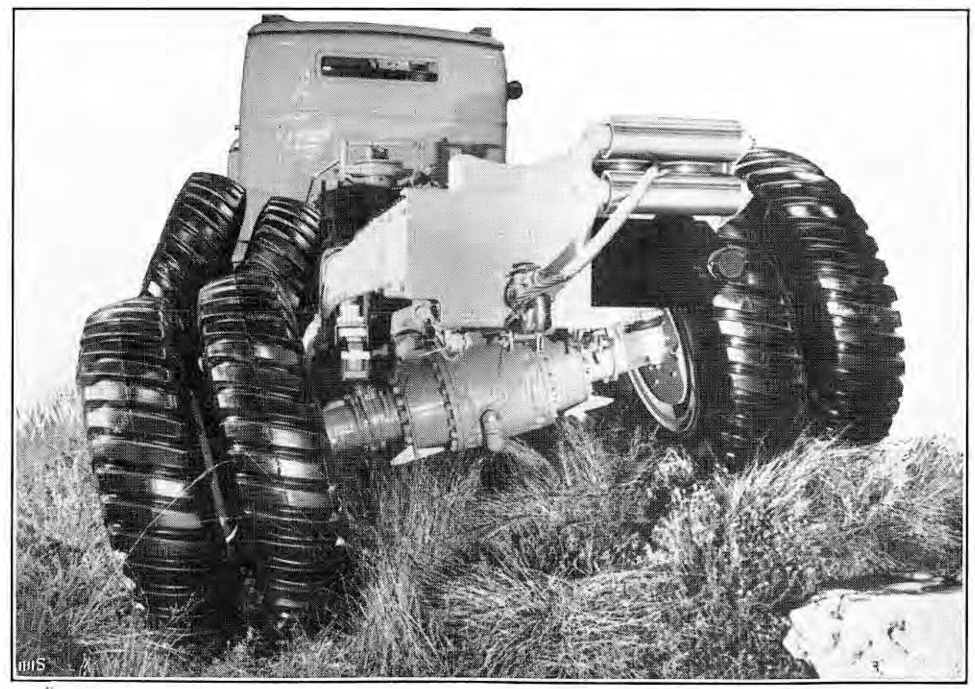


FIG. 36.

FIGS. 35 AND 36. SIX-WHEEL DRIVE HEAVY-DUTY TRACTOR; SCAMMELL LORRIES, LTD.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

(*For Description, see Page* 498.)

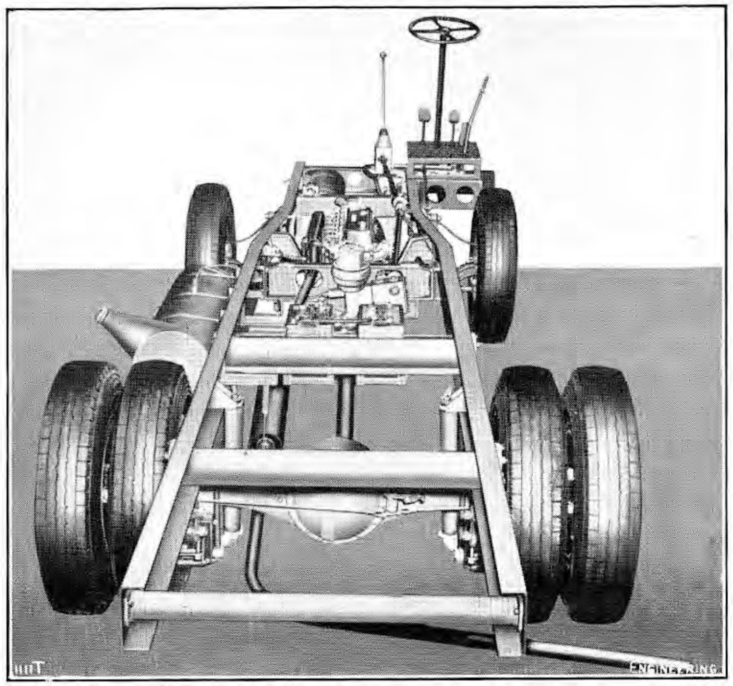


Fig. 37.

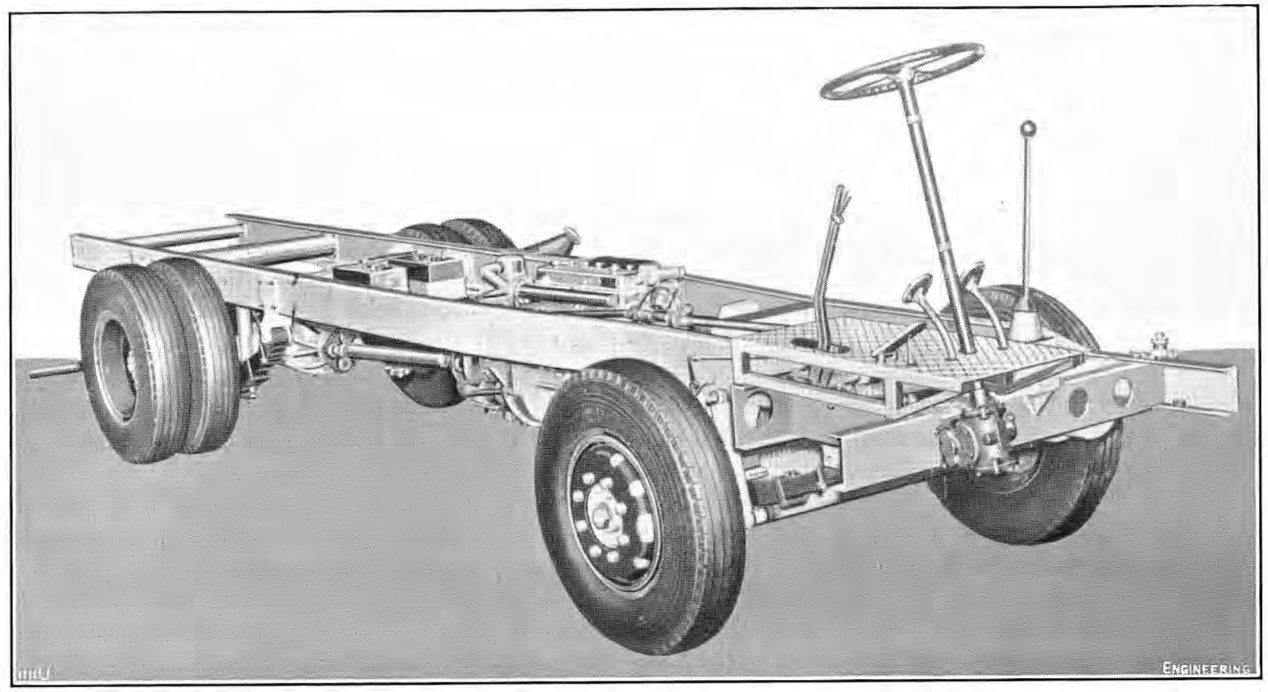


Fig. 38.

Figs. 37 and 38. Underfloor-Engined Passenger Chassis; Seddon Motors, Limited.

Fig. 39. 50-Seat Half-Deck Coach; Mann Egerton & Co., Ltd.

Fig. 40. 41-Seat Commer-Harrington Integral Coach; Thomas Harrington, Ltd.

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EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

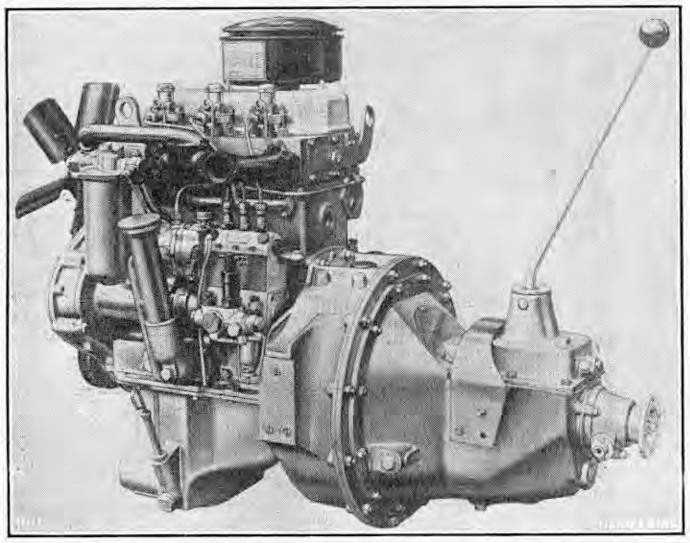

Fig. 20. Three-Cylinder Diesel Engine; F. Perkins, Limited.

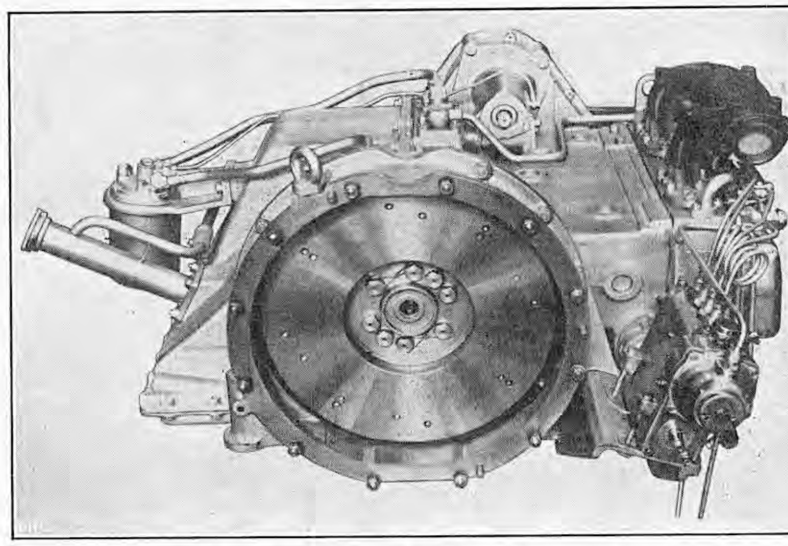

Fig. 21. Four-Cylinder Horizontal Diesel Engine; F. Perkins, Limited.

and a ground clearance of 11 in. The Perkins P6 engine is a six-cylinder vertical unit having a bore and stroke of 3 in. and 5 in., respectively, and developing 79 brake horse-power at 2,400 r.p.m. The cylinder block and crankcase are a single casting and the cylinder bores are fitted with dry liners. Overhead valves are employed, the camshaft being chain-driven from the front end of the crankshaft and operating the valves through short push rods and rocking levers. The crankcase skirt is extended well below the crankshaft centre line and the crankshaft is supported by seven main bearings, the end thrust being taken at the rear main bearing. The combustion chambers are incorporated in the cylinder head and the injection equipment is of C.A.V. manufacture, comprising a monobloc injection pump with pneumatic governor and injectors designed to give two sprays, one into the combustion chamber and the other into the cylinder.

Apart from the disposition of the engine, the design of the chassis follows well-established principles. The transmission group comprises a 12-in. single dry-plate clutch, a five-speed gearbox and a fully-floating hypoid rear axle. All shafts in the gearbox are mounted on either ball or roller bearings and the casing is designed so that it forms two sections when dismantled, being split along the centre lines for the layshaft and main shaft. The rear axle has a ratio of 6·166 to 1 but an alternative two-speed axle, in which the selection of the ratios is made by a vacuum-shift mechanism, can be fitted. A single propeller shaft, 3 in. in diameter, is used to transmit the drive from the gearbox to the rear axle, the shaft being fitted with Layrub joints and a splined joint to accommodate relative movements of the axle and shaft. Semi-elliptical springs are employed all round, those at the front being 3½ in. wide and 43 in. long and those at the rear 3½ in. wide and 58 in. long. The channel-section side members of the frame are 8¼ in. deep with 2¾-in. flanges, and they are joined together by seven cross members. Hydraulically-operated brakes are fitted to all four wheels, those at the rear being of the two leading-shoe type. Brake application is assisted by a vacuum servo unit and the rear brakes are arranged so that they can be applied by hand. The wheelbase is 13 ft. 11 in. and the overall length of the complete chassis, 25 ft. 5 in.

Aluminium Coach of Chassisless Construction.

The exhibits in the coachbuilding section were of an exceptionally high order and covered a wide field ranging from straightforward load carriers to luxury touring coaches. Although, in general, the methods employed in their construction followed traditional lines, there were certain notable exceptions. Messrs. Thomas Harrington, Limited, Old Shoreham-road, Hove, Sussex, for example, were showing the 41-seat coach illustrated in Fig. 40, on Plate XLVI, which not only is built from aluminium alloys throughout, but is of chassisless, or integral, construction. It was developed in co-operation with the British Aluminium Company, Limited, who supplied the various aluminium-alloy sections and panels used in its construction. The mechanical components were supplied by Commer Cars, Limited, the power unit being this firm's 109 brake horse-power horizontal petrol engine. This is mounted ahead of the front axle and the forward end of the coach is designed so that the complete engine can be withdrawn from the front of the vehicle, thus facilitating overhaul procedures. The design of the bodywork is such that the sides, roof, underframe and ends form a hollow beam. The main strength, however, lies in the beams formed by the body sides between the floor and waist. These beams are extended beyond the wheel arches, taking in the wheelboxes as structural members and are suitably reinforced in way of the doors. There are no continuous longitudinal members in the underframe which consists, mainly, of strong transverse beams of varying depths placed at the pillar stations, short longitudinal beams being inserted between adjacent transverse members to carry the engine, suspension units, etc. Where convenient, the transverse and longitudinal members extend from the floor to the skirt to form large underfloor lockers. All main members are fabricated from 14 s.w.g. sheet stiffened all round with extruded angle to form deep I-section beams. To give stability to the underframe, a 2-in. deep corrugated section pressed from 18 s.w.g. sheet is used and this is further reinforced by plywood flooring fixed to the corrugations by Araldite cold-setting adhesive. The roof, of course, carries a considerable amount of stress, and it incorporates, therefore, a longitudinal centre spine 2 in. deep made from two extruded channel sections set back to back. The approximate unladen weight of the complete vehicle is 4 tons 15 cwt., a figure that compares favourably with the bare chassis weight of a standard vehicle.

50-Seat Half-Deck Coach.

The exhibits on the stand of Messrs. Mann, Egerton and Company, Limited, Norwich, included the latest version of their half-deck coach. This vehicle, which is illustrated in Fig. 39, on Plate XLVI, is capable of carrying 50 passengers, but only uses a single-deck chassis. The seats are arranged in groups of four, and at two different levels, on each side of a central gangway. The seats are arranged in facing pairs and each group of four forms a small saloon to which access is gained by steps, either up or down according to the position of the saloon. The space below the feet of the upper-saloon passengers is used to accommodate the luggage, suitable doors being incorporated in the body sides. The entrance door is at the front and an emergency door can be installed in almost any position according to requirements. A luggage compartment is also formed under the rear seats, extending, in this case, the full width of the body. The body is of composite construction incorporating steel transverse sections and a special light-alloy roof. Special attention has been paid to ventilation and fresh air inlets at the front of the vehicle are connected by ducting to each compartment.

Transmission Units.

An extensive selection from their range of transmission units, including complete gearboxes, was being exhibited by Messrs. David Brown and Sons (Huddersfield), Limited, Park Works, Huddersfield. A typical David-Brown gearbox is illustrated in Fig. 31, on Plate XLIV. Those on show included their 557 five-speed unit. This has a maximum input torque capacity of 4,200 lb.-in., the standard gear ratios being 7·92 to 1, 4·68 to 1, 2·74 to 1, 1·565 to 1 and 1 to 1. Either unit or separate mounting can be used with forward or central control as required, two universal couplings incorporated in the control rod of the former unit giving latitude in layout and assembly. A lighter model on show, the 542 gearbox, is designed for use with vehicles up to 9½ tons maximum laden weight and is capable of transmitting engine torques up to 2,210 lb.-in. This also gives five different ratios and either a direct drive or overspeed top gear can be incorporated; direct drive, however, is recommended for heavy-duty work. A third gearbox on show, namely, the 437 unit, is intended for use with vehicles up to 5½ tons maximum loaded weight, but, like the 542 gearbox, will transmit an engine torque of 2,210 lb.-in.

Two-Speed Rear Axle.

Two-speed rear axles are gaining rapidly in popularity as they provide a convenient means of improving the versatility of almost any type of vehicle. Eaton Axles, Limited, Victoria-road, Warrington, Lancashire, have specialised in the production of these units for a number of years now and the exhibits on their stand included a selection of two-speed rear axles, the largest of which is suitable for use on goods and passenger vehicles of up to 8 tons. The Eaton axle incorporates a robust epicyclic-type secondary reduction gear which can be brought into use at will merely by pressing a button fitted to the normal gear-shift lever. Thus the driver can use two complete speed ranges, either of which is instantly available as the need arises and with a four-speed gearbox has eight different ratios at his disposal. A typical Eaton two-speed rear axle is illustrated in Fig. 32, on Plate XLIV. This unit is fitted with an electrically-operated shifting device, the great advantage of which is its independence of vacuum power or air pressure, a valuable feature so far as Diesel-engined vehicles are concerned.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Steel and Iron Production.—Scottish steel output declined slightly during September as compared with the previous month, but pig-iron production improved. The output of steel ingots and castings in September was at an annual rate of 2,214,600 tons, against 2,276,500 tons in August. The corresponding figure for September, 1951, was 2,114,700 tons. Pig iron produced last month was equivalent to 890,700 tons per annum, compared with 856,500 tons in August and 852,900 tons in September, last year.

Air-Conditioning Plant for United States.—A specially-constructed air-washing tank and high-efficiency main ventilating fan, the first consignment of equipment for an air-conditioning plant which is to be supplied and installed by Thermotank Inc., in the administrative offices of a large new technical centre under construction in Detroit, U.S.A., will be shipped from the Clyde this week. The contract for the complete installation is valued at over 500,000 dols. Much of the specially-designed equipment is being manufactured by the parent company, Thermotank Ltd., at their three Glasgow factories.

Locomotives for Scottish Region, British Railways.—Engine No. 80,000, the first of ten British Railways mixed-traffic 2-6-4 Class 4 standard tank locomotives, to be built at Derby for use in the Scottish Region, has been allocated to the Corkerhill motive-power depot and is now working between Glasgow and stations in Ayrshire and Renfrewshire.

The Late Sir James Barr.—Sir James Barr, Scottish surveyor and head of the firm of James Barr and Son, chartered surveyors, Glasgow, died on October 6 in a Glasgow nursing home. He was 68. Sir James was prominent as an adviser to various shipbuilding concerns, including the National Shipbuilders Security, Ltd., the Shipbuilding Corporation, and the Shipbuilding Conference. He was also associated with the National Association of Marine Enginebuilders, the Association of Ship Repairers and Drydock Owners, and the British Iron and Steel Federation.

New Shower Baths at Arbroath Works.—New shower baths and cloakrooms were opened on September 25 at the Arbroath works and foundry of Keith Blackman, Ltd., manufacturers of fan-engineering and industrial-gas equipment. Miss A. S. Mollison, chief clerk of the Arbroath works, who has direct family connection with the works dating back to last century, declared the baths open. The proceedings were presided over by Mr. W. G. Calder, resident director and works manager. The baths, which incorporate an employees' cloakroom, undressing and dressing rooms, wash-ups and toilets for workpeople and staff, ambulance room, office, boiler house, and laboratory, together with a new entrance corridor, form part of the general reconstruction scheme which has been in progress during the past three years.

CLEVELAND AND THE NORTHERN COUNTIES.

Filling of Worked-Out Collieries.—A pneumatic stowing machine which is capable of handling 30 tons of waste material an hour is being used at Crookhall Colliery, Consett, County Durham, for the filling of worked-out underground galleries. At present, the machine is working at about 150 ft. below the surface. For the time being, workings under farm buildings which might otherwise be threatened by subsidence are being filled.

Electricity Supply on N.E. Coast.—The annual report of the North-Eastern Electricity Board shows that, last year, there was a loss of 162,247*l*., compared with a surplus of 90,184*l*. the year before. Mr. H. H. Mullens, chairman of the Board, at a Press conference, referred to circumstances bringing about the loss. He pointed out that petrol costs had increased by 43 per cent., jointing compound used in cable assembly by 34 per cent., and copper by 50*l*. a ton to 280*l*. Moreover, wages and salaries had increased by 16 per cent. in two years. At the same time, the Board were concerned at the falling off in sales, especially last winter. The report states that it was probable that an upward adjustment of tariffs could not be long delayed, but Mr. Mullens expressed the opinion that no steps would be taken in this direction until the end of the present financial year.

Tees Traffic Statistics.—At the meeting of the Tees Conservancy Commission, held at Middlesbrough, on October 6, the announcement was made that imports to the Tees, during August, had reached the record total of 407,464 tons, and that the net registered tonnage of ships dealt with in the river in September had attained 389,055, the highest figure since August, 1939, when the record total of 395,976 tons was reported. August total imports, namely, 407,464 tons, amounted to 50,270 tons more than the previous highest total, that for June, 1950. Heavy iron-ore imports were chiefly responsible for this.

The Late Mr. L. Golightly.—The death has occurred suddenly, at Darlington, of Mr. Lawrence Golightly, chief draughtsman to Robert Stephenson and Hawthorns, Ltd., the Darlington locomotive builders, since 1946. Mr. Golightly, who was 57 years of age, joined the firm in 1911.

Trade and Technical Publications Required.—Recently a serious fire occurred at the works of the Thecla Engineering Co. Ltd., Allan-street, Darlington, as a result of which the whole of their offices were gutted and most of their records, including their reference library, were destroyed. They will therefore be grateful if manufacturers and suppliers of the various commodities required to keep a factory going will send catalogues, booklets, leaflets and technical information on their products so that a new trade reference library may be built up.

THE MIDLANDS.

Leonardo da Vinci Exhibition at Birmingham.—The scientific section of the Leonardo da Vinci Quincentenary Exhibition, recently displayed in London, is now on view at the Museum of Science and Industry, Newhall-street, Birmingham, 3. Selected reproductions of drawings from Leonardo's notebooks, and a number of models made by the Science Museum, London, are used to show the great range of scientific and technical work covered by him. The exhibition will remain open until October 26, and it will then be transferred to Bristol. At a later date it will go to Edinburgh.

Reduction of Tractor Output at Coventry.—Production of tractors at the Banner-lane, Coventry, factory of the Standard Motor Co., Ltd., has been reduced from 314 a day to 207 as a result of overseas import restrictions. About 6,000 employees are affected, but so far there have been no dismissals. As an alternative to declaring about 1,000 of the employees redundant, short-time working has been introduced, and the working week has been reduced from the normal 42½ hours to 29½ hours.

Possibility of Higher Electricity Charges.—Alderman W. S. Lewis, chairman of the Midlands Electricity Board, speaking in Birmingham on October 7, said that there was a possibility that a further increase in the charges for electricity would be necessary. The Board's accounts for the year ended March 31 showed a deficit of 660,734*l*. Alderman Lewis said that several suggestions on tariffs had been examined, but the Board had not yet reached a decision. It was necessary to wait until the accounts were made up to September of this year, to obtain a full estimate of the effect of the tariffs introduced in June, 1951.

Air Transport of Boiler Tubes.—John Thompson Water Tube Boilers, Ltd., Ettingshall, Wolverhampton, have sent by air to Singapore 2,200 ft. of boiler tube for repairing an auxiliary boiler in a British ship. The repair was to have been carried out in this country, but as the tubes were not available in time, they have been sent by air to meet the ship.

Transport of 110-Ton Alternator Stator.—The completely wound stator of a 25-MW hydrogen-cooled turbo-alternator, weighing nearly 110 tons with its specially constructed fabricated steel transit skid, was recently taken by road from the Rugby works of British Thomson-Houston Co., Ltd., to Liverpool *en route* for the factory of the Ford Company of Canada, at Windsor, Ontario. Owing to the size and weight of the load, detours of over 50 miles had to be made. At Liverpool, the stator was lifted on to S.S. Arabia by a 250-ton floating crane and on arrival at Sorel on the St. Lawrence was hauled to the site by a special train.

Study of Human Relations in Industry.—The College of Technology, Birmingham, has instituted a new senior lectureship, claimed to be the first of its kind in this country. Mr. John Munro Fraser, M.A., has been appointed to this post. Its subject is the "Human Relations Aspect of Management," and it is part of the Department of Industrial Administration. It will cover the existing courses in psychology for supervision, industrial psychology, and personnel administration.

LANCASHIRE AND SOUTH YORKSHIRE.

The Late Mr. D. MacArthur.—Mr. Duncan MacArthur, director and general sales manager of the Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, died suddenly at his home in London on October 7. Mr. MacArthur had spent the whole of his business life with Metropolitan-Vickers, having joined the company (then British Westinghouse) in September, 1906. The early part of his career was spent in Glasgow, and in 1919 he became manager of the district office there. In 1935, he was transferred to London, being appointed manager of the London office. In 1943, Mr. MacArthur was elected a director of the company, and in the following year he became manager, home sales. In 1945, he was appointed general sales manager. He also joined the board of the Metropolitan-Vickers Export Company, Ltd. Mr. MacArthur was chairman of Newton Victor Ltd., and Newton & Co. Ltd., and a director of Metropolitan-Vickers South Africa (Pty.) Ltd., Metropolitan-Vickers-GRS Ltd. and Sunvic Controls Ltd.

Outlook in the Coal Trade.—For three successive weeks the Yorkshire coal output has exceeded one million tons, and in the opinion of the chairman of the North-Eastern Coal Board, Major-General Sir Noel G. Holmes, the Division has the capacity to exceed 1,000,000 tons of saleable coal in any week. The area has produced 33,115,390 tons this year, 336,436 tons more than at the same time last year. Man-power has gone up by nearly 7,000 to more than 140,000. The increased man-power, he states, is now beginning to show in output as men are up-graded to the coal face. The miners have made excellent efforts on the Saturday voluntary shift.

Trade with East Africa.—The United Kingdom Trade Commissioner for East Africa, Mr. G. T. Dow-Smith, who is on a visit to Sheffield, has stated that East Africa has almost no secondary industries and has to import practically all manufactured goods. Long delays in delivery from United Kingdom firms, however, have allowed Continental manufacturers to enter the market by selling goods at higher prices but with quicker delivery.

The Late Mr. L. Brooke.—We note with regret the death, on October 9, of Mr. L. Brooke, manager of the Leeds Branch of W. T. Henley's Telegraph Works Co., Ltd. Mr. Brooke was 59, and joined the company in November, 1926. He was appointed manager of the Sheffield sub-branch in September, 1928, and in January, 1937, was appointed manager of the Leeds branch.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Welsh Coal Trade.—A new pit-head bath built at a cost of approximately 100,000*l*. at the Lewis Merthyr Colliery, Trehafod, was opened last week by Sir Hubert Houldsworth, chairman of the National Coal Board. Performing the ceremony, he said that, this year, South Wales had increased her export production by 750,000 tons of coal over the corresponding period of last year, and, each week, 8,500 tons of coal came into South Wales from the West Midlands, thereby releasing that amount of Welsh coals for export.

Cardiff Lock Gates.—A new lock gate for the Cardiff West Dock was launched recently into the River Wye at Chepstow by the Fairfield Shipbuilding Works Ltd. It is one of a number for the South Wales ports which the firm have constructed at Chepstow. The gate is of all-welded construction.

Foremen's Conferences.—Nearly 50 foremen from ten different works in South Wales will attend residential conferences this month organised by the South Wales and Monmouthshire Area Training Committee of the British Iron and Steel Federation. The conferences, which will be held at Dunraven Castle, are designed to give foremen an insight into the wider aspects of management and an awareness of their responsibilities to those above them and to the men in their charge.

Unemployment Statistics.—There was a total of 24,961 people unemployed in Wales on September 15, according to the Ministry of Labour. This was an increase of 169 over the figure for August 11, and, of the total, 15,705 were men. There were 1,461 temporarily stopped, an increase of 327 over the previous month.

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 FUEL.—Monday, October 20, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Melchett Lecture, by Dr. D. T. A. Townend. *Midland Section:* Tuesday, October 21, 6 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address, by Mr. E. Brett Davies.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, October 20, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Institution and Current Affairs," opened by the President, Colonel B. H. Leeson. *Mersey and North Wales Centre:* Monday, October 20, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Joint Meeting with the LIVERPOOL ENGINEERING SOCIETY. "A Logical Approach to the Problems of Space Warming," by Mr. D. H. Parry. *District Meeting:* Monday, October 20, 7.30 p.m., Royal Hotel, Norwich. "Technical Colleges and Education for the Electrical Industry," by Dr. H. L. Haslegrave. *Measurements Section:* Tuesday, October 21, 5.30 p.m., Victoria-embankment, W.C.2. Chairman's Address by Mr. L. Hartshorn. *East Midland Centre:* Tuesday, October 21, 6.30 p.m., Gas Board's Showrooms, Nottingham. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers and others. *South Midland Centre:* Tuesday, October 21, 7.15 p.m., Winter Gardens Restaurant, Malvern. "The Magnetic Fluid Clutch," by Mr. E. J. R. Hardy. *Southern Centre:* Wednesday, October 22, 6.30 p.m., Technical College, Brighton. "Economics of Low-Voltage Electricity Supplies to New Housing Estates," by Mr. F. G. Copland. *London Students' Section:* Wednesday, October 22, 7 p.m., Public Library, Chelmsford. "Breakdown Stress of Air at Low, High, and Ultra-High Frequencies," by Dr. W. Jasinski. *Utilization Section:* Thursday, October 23, 5.30 p.m., Victoria-embankment, W.C.2. Chairman's Address by Dr. J. W. T. Walsh.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group:* Monday, October 20, 6 p.m., Northampton Polytechnic, St. John-street, E.C.1. (i) "Tin-Nickel Alloy and Nickel-Chromium Coatings: Corrosion Tests," by Mr. S. C. Britton and Mr. R. M. Angles. (ii) "Tin-Nickel Alloy Coatings: Thickness and Porosity Testing," by Mr. S. C. Britton and Mr. D. G. Michael.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-East Centre:* Monday, October 20, 7 p.m., Vane Arms Hotel, Stockton-on-Tees. "Foundry Practices Associated with the Motor-Vehicle Industry," by Mr. G. B. Taylor. *Institute:* Thursday, October 23, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Rear Axles," by Mr. R. H. Wilson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, October 20, 7 p.m., College of Art, Green-lane, Derby. "Precision with Production—Hydroptic Boring and Milling," by Mr. G. H. Clements. *Manchester Section:* Monday, October 20, 7.15 p.m., College of Technology, Sackville-street, Manchester, 1. "Test House and Techniques for Maintaining Quality Production," by Mr. W. N. Blacklock. *Southern Section:* Tuesday, October 21, 7 p.m., Municipal College, Portsmouth. "Developments in the Economic Use of Materials," by Mr. P. H. M. Le Vie. *Coventry Section:* Wednesday, October 22, 7 p.m., Geisha Café, Hertford-street, Coventry. "Automobile Production Methods in the United States," by Mr. D. Burgess. *South Wales and Monmouthshire Branch:* Thursday, October 23, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Developments in Machinability," by Mr. K. J. B. Wolfe. *London Section:* Thursday, October 23, 7 p.m., Old Ship Hotel, Brighton. "High Cost of Low Overheads," by Mr. C. H. Starr.

INSTITUTION OF MECHANICAL ENGINEERS.—*Scottish Automobile Centre:* Monday, October 20, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Brake Linings and Their Performance," by Mr. J. G. Remington. *Western Branch:* Tuesday, October 21, 7 p.m., Grand Hotel, Broad-street, Bristol, 1. Discussion on Anglo-American Productivity Council's Report on "Welding." *Yorkshire Branch:* Wednesday, October 22, 6 p.m., The University, St. George's-square, Sheffield. "Problems Encountered in the Manufacture of Heavy Rolling Mills," by Mr. P. A. E. Jump. *Southern Branch:* Wednesday, October 22, 7 p.m., Canteen of British Electricity Authority, High-street, Portsmouth. "Mechanical Engineering Problems Connected with Astronomical Telescopes," by Mr. G. M. Sisson. *Bedford Branch:* Wednesday, October 22, 7.15 p.m., Dujon Restaurant, High-street, Bedford. Inaugural Meeting. "Measurement and Interpretation of Machinery Noise, with Special Reference to Oil Engines," by Mr. C. H. Bradbury. *Institution (Steam Group):* Friday, October 24, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Joint Meeting with the INSTITUTION OF ELECTRICAL ENGINEERS. "Design and Operation of Dunston "B" Generating Station, with Reference to 50-MW Turbo-Alternators Unitised with Reheater Boilers," by Mr. A. Howell and Mr. J. B. Jackson.

SHEFFIELD METALLURGICAL ASSOCIATION and SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Monday, October 20, 7.30 p.m., The University, St. George's-square, Sheffield. "A Recent Visit to the United States," by Dr. E. W. Gregory.

INSTITUTION OF CIVIL ENGINEERS.—*Maritime and Waterways Engineering Division:* Tuesday, October 21, 5.30 p.m., Great George-street, S.W.1. "Designs for Flexible Fenders," by Mr. D. H. Little.

CHEMICAL ENGINEERING GROUP.—Tuesday, October 21, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Flow of Concentrated Suspensions as Related to Chemical Engineering Problems," by Mr. P. S. Williams.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 21, 6.30 p.m., 39, Elmbank-crescent, Glasgow. Discussion on "Cabin Design," opened by Sir Colin S. Anderson.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, October 21, 6.30 p.m., 2, Savoy-hill, W.C.2. Presidential Address, by Mr. C. T. Melling.

INCORPORATED PLANT ENGINEERS.—*Glasgow Branch:* Tuesday, October 21, 7 p.m., 351, Sauchiehall-street, Glasgow. "Manipulation of Corrosion and Heat-Resisting Steels," by Mr. J. A. McWilliam. *Western Branch:* Wednesday, October 22, 7.15 p.m., Grand Hotel, Bristol. "Application of the Gas Turbine to Industry," by Mr. A. W. Pope.

ASLIB.—Wednesday, October 22, 5.30 p.m., Friends House, Euston-road, N.W.1. "Psychology of Classification," by Mr. J. E. L. Farradane.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, October 22, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Development of the Oil-Fired Locomotive," by Mr. W. C. Ikeson.

INSTITUTE OF PETROLEUM.—Wednesday, October 22, 5.30 p.m., 26, Portland-place, W.1. "Distribution of Petroleum in the United Kingdom: The Changing Pattern," by Mr. T. W. Mathias.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Birmingham Branch:* Wednesday, October 22, 6.30 p.m., Imperial Hotel, Birmingham. "Engineering Equipment for the Royal Festival Hall," by Mr. R. J. Dickson.

BRITISH ASSOCIATION OF CHEMISTS.—*London Section:* Wednesday, October 22, 7 p.m., Wellcome Institute, 183, Euston-road, N.W.1. "Refining, Blending and Testing of Lubricants," by Mr. A. McAulay.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham, Coventry and West Midlands Branch:* Wednesday, October 22, 7.15 p.m., James Watt Memorial Institute, Birmingham. "Production of Spheroidal Graphite Cast Iron," by Mr. N. Croft. *Bristol and West of England Branch:* Saturday, October 25, 10.15 a.m., Grand Hotel, Bristol. "Degassing of Non-Ferrous Metals," by Mr. E. C. Mantle.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, October 23, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Large-Span Prestressed-Concrete Beams for London Airport Hangars," by Mr. A. J. Harris. *Midland Counties Branch:* Friday, October 24, 6 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address, by Mr. H. J. Morris.

INSTITUTION OF CHEMICAL ENGINEERS.—*Yorkshire Graduates' and Students' Section:* Thursday, October 23, 7 p.m., The University, Leeds. "The Associate-Membership Examination of the Institution," by Mr G. U. Hopton.

INSTITUTE OF WELDING.—*North London Branch:* Thursday, October 23, 7.30 p.m., Community Centre Hall, Slough. "Developments in Welding Research," by Dr. H. G. Taylor.

INSTITUTION OF ENGINEERING INSPECTION.—*North-West Branch:* Thursday, October 23, 7.30 p.m., Engineers' Club, Albert-square, Manchester. "Interpretation of Mechanical Tests for Metals," by Dr. K. Entwistle.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, October 24, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Influence of Aluminium and of Heat Treatments on Creep Properties of Low-Carbon Steel Superheater Tubes," by Mr. D. C. Herbert and Mr. E. A. Jenkinson.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 24, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Coin Manufacture," by Mr. G. H. Thompson.

INSTITUTE OF ECONOMIC ENGINEERING.—*Manchester Branch:* Friday, October 24, 7 p.m., Engineers' Club, Manchester. "Personnel Management," by Mr. A. Cunliffe. *Liverpool Branch:* Friday, October 24, 7.30 p.m., Radiant House, Bold-street, Liverpool. Film: "Punched Cards for Production Control." *Glasgow Branch:* Saturday, November 1, 10.30 a.m. 70, Bothwell-street, Glasgow. "Time Study," by Mr. J. Jones.

PERSONAL.

SIR TRISTRAM EDWARDS, joint managing director of Smith's Dock Co. Ltd., is retiring from that position but will continue as chairman. LT.-COL. T. EUSTACE SMITH is to be sole managing director.

MR. MAURICE PLATT, M.Eng., M.I.Mech.E., executive engineer of Vauxhall Motors Ltd., Luton, Bedfordshire, has taken office as chairman of the Automobile Division of the Institution of Mechanical Engineers for the 1952-53 session.

DR. W. G. THOMPSON, M.I.E.E., has been appointed manager of the Witton laboratories of the General Electric Co. Ltd.

DR. D. T. A. TOWNEND, director general of the British Coal Utilisation Research Association, received the Melchett Medal for 1952 at the annual dinner of the Institute of Fuel on October 9.

PROFESSOR J. T. MACGREGOR-MORRIS has been elected to honorary membership of the Illuminating Engineering Society, 32, Victoria-street, S.W.1.

MR. W. H. PILKINGTON, chairman of Pilkington Brothers Ltd., has been elected deputy-President of the Federation of British Industries.

CAPTAIN J. C. LEA, O.B.E., has been appointed Commodore of the British Tanker Company's fleet, the shipping organisation of the Anglo-Iranian Oil Co. Ltd. The new Engineer Commodore is MR. D. A. DAVIES, and MR. A. AITKEN, M.Inst.N.A., has succeeded the late MR. H. S. HUMPHREYS as chief engineer superintendent.

MR. WILLIAM MURE, C.B.E, has been elected chairman of the Council of the Zinc Development Association, Lincoln House, Turl-street, Oxford, in succession to MR. S. C. HUNN.

MR. A. V. BUTTRESS, river superintendent to the Tees Conservancy Commission, Middlesbrough, has been installed as President of the Northern Counties branch of the Institution of Structural Engineers.

MR. R. S. CRUMP, M.I.Mech.E., technical director and chief engineer of Henry Meadows, Ltd., Fallings Park, Wolverhampton, has retired but remains on the board and will act as technical consultant. MR. J. E. ROBINSON, chief technical supervisor of Petters Ltd., has joined the firm as chief engineer. MR. G. WEDGE, sales manager, has been made technical adviser, MR. E. B. CHRISTIE, contracts manager, and MR. A. F. BROWN, sales promotion manager.

MR. K. M. FOX, A.M.I.E.E., until recently in charge of the British Thomson-Houston Co.'s district sub-office, Bristol, has been appointed manager of the firm's Swansea district office, in succession to MR. S. J. CLARKE, who will shortly take up another appointment in the company. As stated on page 339, *ante*, Mr. Fox has been succeeded at Bristol by MR. K. G. LEACH.

MR. W. H. LINDSEY, M.A., F.R.Ae.S., who has been chief engineer to Armstrong Siddeley Motors Ltd., Parkside, Coventry, since 1950, has been elected to the board of the company.

As from October 1, MR. G. W. G. CANTER, A.M.Inst. N.A., A.M.I.Mar.E., manager, marine and special contracts department, Metropolitan-Vickers Electrical Co. Ltd., is permanently stationed at the company's London office, 1-3, St. Paul's Churchyard, E.C.4. MR. J. NICHOLSON, A.M.Inst.N.A., M.I.Mar.E., A.M.I.E.E., A.M.I.Mech.E., has been appointed assistant manager of the department and is stationed at Trafford Park, Manchester, 17.

MR. R. H. MATTHEW, C.B.E., A.R.I.B.A., Architect to the London County Council, has been appointed to the Forbes Chair of Architecture of the University of Edinburgh.

MR. T. DAWSON has been appointed assistant publicity manager of Leyland Motors Ltd.

AUSTIN & LANG (SALES) LTD., Heather Park-drive, Wembley, Middlesex, announce that a new company, LUNZER DIAMOND TOOLS, LTD., has been formed. In addition to present selling arrangements, BURTON, GRIFFITHS & CO. LTD., Birmingham, have been appointed distributors for Lunzer diamond tools.

MR. C. R. URQUHART has been elected a director of Foster Yates and Thom, Ltd.

KERRY'S (GREAT BRITAIN) LTD., Warton-road, Stratford, London, E.15, have acquired a controlling interest in the business of SPARE PARTS LTD., St. Peter-street, Blackburn.

CROMPTON PARKINSON LTD. and AUTO DIESELS LTD. have concluded an agreement to engage jointly in the production of mobile dual-voltage ground power units of outputs up to 95 kW for starting the engines of commercial and service aircraft.

CAPTAIN (E) L. F. INGRAM, A.M.I.Mech.E., M.I.Mar.E., R.N., until recently Fleet Engineer Officer on the staff of the Commander-in-Chief, Home Fleet, has been appointed Fleet Engineer Officer on the staff of the Flag Officer, Submarines.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 511.)

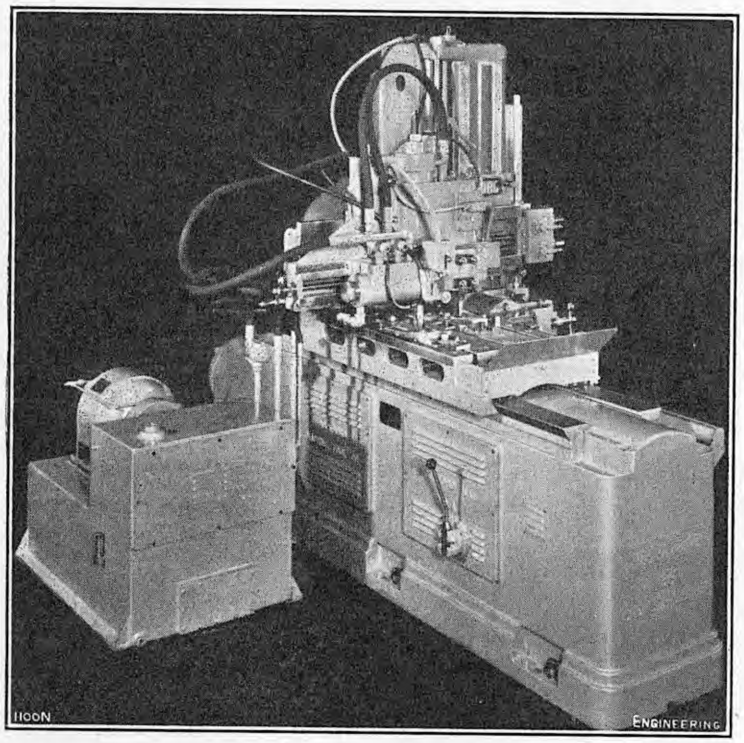

Fig. 124. Rockford Planer; Rockwell Machine Tool Co., Ltd.

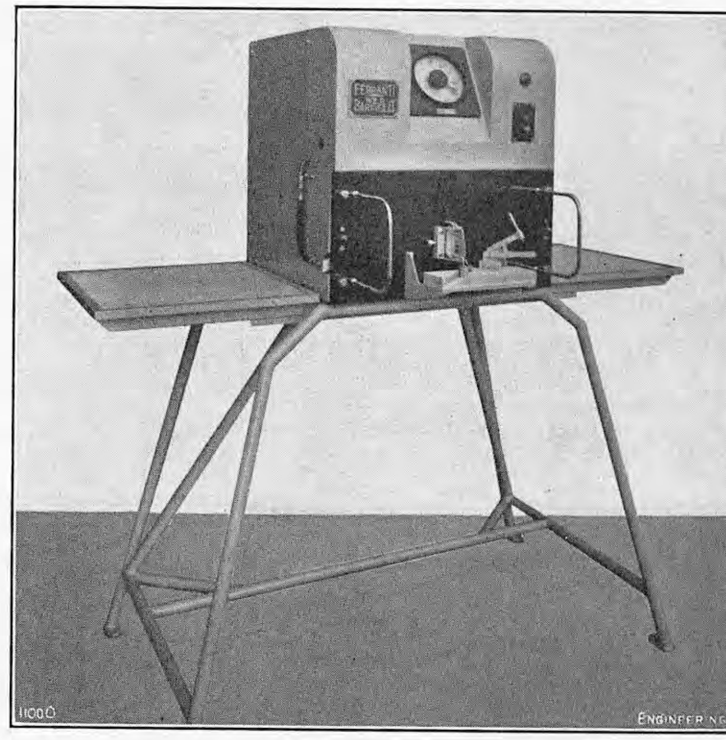

Fig. 125. Universal Workhead; Wild-Barfield Electric Furnaces, Ltd.

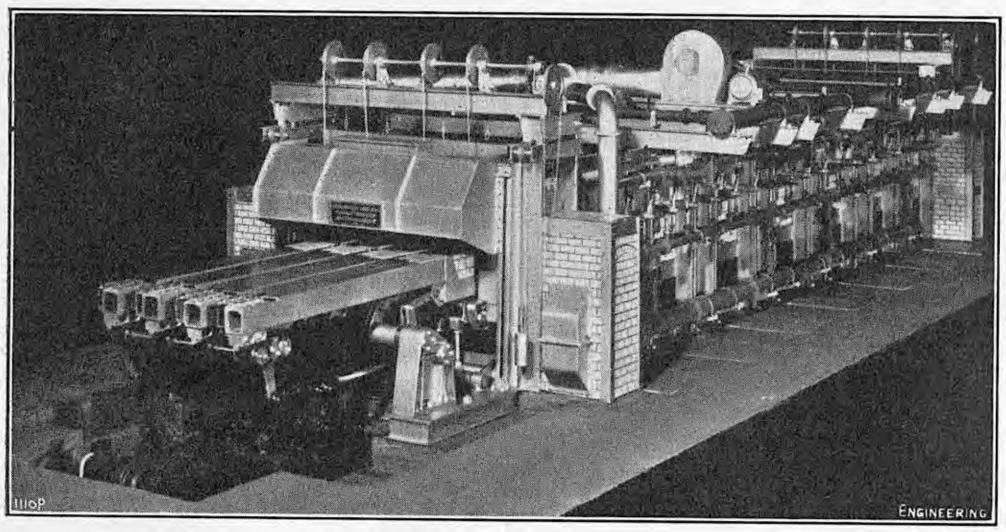

Fig. 126. Model of Balanced-Hearth Walking-Beam Furnace; Incandescent Heat Co., Ltd.

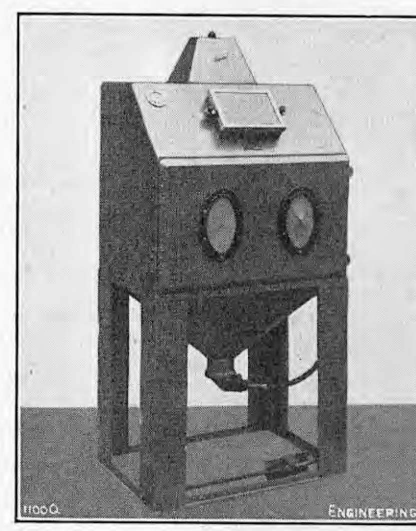

Fig. 127. Shot-blast Cabinet; Guyson Industrial Equipment, Ltd.

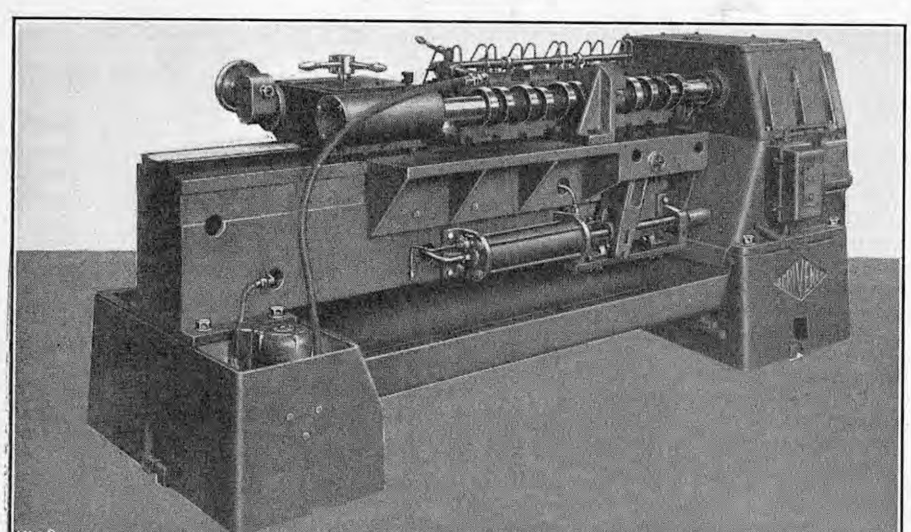

Fig. 128. Profile-Turning Lathe; Arthur Scrivener, Ltd.

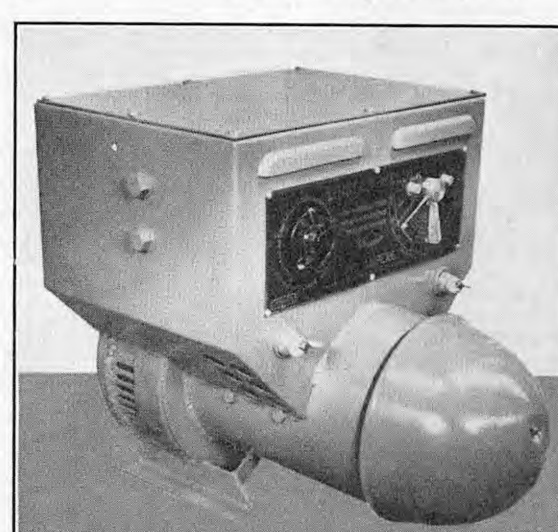

Fig. 129. Welding Generator; Lincoln Electric Co., Ltd.

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ENGINEERING

FRIDAY, OCTOBER 17, 1952.

VOL. 174. No. 4525.

ELECTRICITY AND NATIONAL AFFAIRS.

It is becoming an increasing part of the duties of journalists of all classes to attend Press conferences; but those who are not regular participants may be informed that curious things sometimes happen at these gatherings. For example, at one held recently a question was put which clearly implied that the manufacture of electrical generating plant (of which the country needs increasing quantities) ought to be restricted; and the effort thus saved applied to the development of the export trade. Although the fallacies inherent in this argument were faithfully dealt with at the time, in case its protagonist, and those who think with him, remain unconvinced we recommend a study of the presidential address which Colonel B. H. Leeson delivered to the Institution of Electrical Engineers on Thursday, October 9. This discussed the place that engineering in general and electrical engineering in particular rightly occupy in what he called the economic network of current affairs, a network in which "coal, electricity, production, mechanisation, men, hours, work, capital, and savings" are inextricably interlinked. The problem he went on, was how the related system was to be balanced and restored to a state of stability. He added that there was insufficient capacity, but too much reactance, resistance and self-inductance, the results being a low power factor and much worthless effort which, if not corrected, must lead to a deterioration in our standard of living.

Analysing the position further, Colonel Leeson pointed out, quite rightly, that the country's economic system depends upon an adequate supply of coal, a material which is indeed its major national resource. Since 1913, however, the output of this commodity has fallen catastrophically and, in particular, exports of it have dwindled to such an extent that the ability to purchase essential food and materials from abroad has been crippling. This shortage, in fact, is a main cause of the present instability. It is surprising therefore that the attempts that have been made to relieve it have been so few and so unimaginative; and that those who control our destinies appear to be unaware of the seriousness of the situation. Even to say as much is, we know, to tread on dangerous ground, and Colonel Leeson is to be congratulated upon both his courage and frankness in taking his argument thus far.

Courage and frankness also distinguish his further statement that a second major cause of our present discontents is the fall in human effort, a fall brought about, in his opinion, by shorter hours of work; the longer time spent in education and training, coupled with National Service; and the changing structure of the population. He holds, and among the thoughtful there will be many who will agree with him, that this slackening is the direct cause of our present shortages in food, homes, fuel, power, transport and production; and has had the further harmful result of forcing up wages and costs without lasting benefits to anyone, except perhaps our foreign competitors. An additional complication is that the effects of these factors are cumulative, so that cause and effect become inextricably intertwined. The position may, in fact, without exaggeration be described as desperate; and, if our standards of living are not to be further lowered, they must be countered by remedies which, though in essence simple, will require much ability and hard thinking to organise and self-denial to apply and accept.

Of the possible remedies for this situation Colonel Leeson mentioned four: more human effort; greater production of basic commodities, such as food, coal and metals; more fuel and power, both for the industry and the home; and more capital, that is, greater savings by Government, industry and individuals. All this is sound. It may also be agreed that the most important of them is greater human effort in man-hours. This greater effort must be first exerted in the basic industries, thus priming the pump of extra production so that shortages will be transformed into sufficiencies and earnings into savings and capital reserves to the betterment of all. The President added that these concepts were put forward to stimulate thought and, he hoped, action. We also trust that such will be the results, since otherwise the state of the country's industry, owing to the greater effect which is being exercised by external influences, will become more and more unsatisfactory.

The portion of the inaugural address, which we have just considered, followed an account of the development of the electrical manufacturing industry and that, in turn, was preceded by a discussion of the need for the proper education of those entering the electrical engineering profession. The arrangement was logical, since it is clear that if industry is to develop, more electric power will be required; and that if the equipment necessary for that development is to be provided efficiently all branches must be ensured of a constant supply of adequately trained recruits so that progress in research, design and production may be maintained at a high level.

That the manufacturing branch of the electrical industry is in a state from which further advances should be possible without difficulty is clear from certain figures given by Colonel Leeson. In 1907, the value of the output of the industry was some 14*l.* million, but it is estimated that in 1951 this had risen to no less than 700*l.* million. During the past

15 years, too, output has risen at an ever-increasing rate, so that electrical manufacturing is now one of the nation's leading industries. Moreover, it is third in importance in the export trade of the country and is also one of the world's two largest exporters of electrical goods. It has attained this position of strength from one of extreme weakness by adopting a policy of co-operation without restricting the liberty of individual manufacturers. In the President's words, experience has proved that such voluntary co-operation between manufacturers can not only be effective, but economical, in that it merely needs a modicum of administration to foster enterprise and thus to achieve mutual advancement. Prosperity, however, has its drawbacks and, as is well known, the Monopolies Commission has begun investigations into the electrical manufacturing branch of the engineering industry. The result, no doubt, will be the publication of much interesting, if not always relevant, information, but the arguments we have just summarised should form a good defence against any ill-informed attack.

Manufacture, of course, means the production of plant and equipment for the generation, transmission, control and utilisation of electric power. It is also becoming more and more recognised that industrial productivity, in the widest sense, is a function of the electrical horse-power available for each workman. In other words, if we are to produce more the supply of electricity must be developed. As we pointed out only last week, an acceleration of the generating plant programme is one of the necessary factors in this development, in order that the harmful, if indeterminate, effects of load spreading and shedding may disappear. To ensure this, Colonel Leeson envisages the installation of no less than 2,000 MW of new generating plant each year, a figure which incidentally exceeds the more modest demands of the British Electricity Authority. That such a statement is made does, however, indicate that the electrical manufacturing industry is in a position to meet a greater demand for new machines than is sometimes considered possible. The provision of new plant at this rate would have the further beneficial result of making it possible to replace inefficient sets more rapidly and thus to achieve an appreciable economy in coal consumption. This is, of course, primarily a financial and economic problem.

In order, however, that electricity shall make an even greater contribution to the country's well-being in the future than it has done in the past, it is necessary that all branches of the profession and industry should attract recruits whose education and training have been based on the broadest concepts of general and scientific learning. This education and training should also have aimed at providing those concerned with a general appreciation of life and at the development of their characters. To ensure this, improved facilities are imperative for all grades of personnel, not only those within the generic group of technologist or professional engineer, but also for the technician and craftsman, since the needs of these two classes are equally pressing. The Institution has in the past paid close attention to the needs of the first of these groups. As, however, an army cannot consist entirely of colonels, we are glad to learn that, within the limits imposed by its Charter, it is now studying ways and means of providing and improving facilities for technicians who outnumber the technologists in the ratio of at least five to one. This investigation has two facets, one of which is to ensure that first-class technicians are produced, and the other to make certain that men of the right aptitude in that group are not prevented from becoming professional engineers. In this connection, it may be asked whether the Institution should not take steps which would enable it to go farther than it can do at present in order to find a place for this useful body of men within its ranks.

TRAINING FOR WORK STUDY.

The term "work study" has been recommended by a sub-committee appointed by the joint committee representing the Institute of Cost and Works Accountants and the Institution of Production Engineers. The business of the joint committee is "investigating the measurement of productivity" and the sub-committee which it appointed was charged with the task of devising a "comprehensive system of training for time study." Much of the work which has been done in the past, the basic purpose of which has been to improve industrial productivity, concerned itself with the time occupied in carrying out individual operations, and the term "time study" appeared in the terms of reference of the sub-committee. The efficiency of industry, however, depends on many things other than the skill or application of the manual workers concerned, and it was considered that the term "work study" more nearly represented the range of work which a system of training would be required to cover. As the sub-committee remarks, "output depends . . . on the flow of components, their design, the quality, standard and the morale in the factory, and not simply on the individual machining or assembly operation."

In a large shell factory during the first World War, the head inspector, a Government official, in no way responsible for the running of the factory, once remarked that what was lacking in the organisation was a senior member of the staff with no specific duties who could devote his time to consideration of the complicated organisation as a whole, and the relations between the various departments, and could point out or devise methods of improving output which the overworked staff had not the time, and frequently not the training, to concern themselves with. Activities of this kind are, in broad terms, those which are carried out by the various firms of industrial consultants, but it is considered by the joint committee, and by others, that in addition to the assistance which such consultants afford in increasing the efficiency of industry, firms themselves should appoint members of their staffs to carry out the observational and measurement work on which analysis of the operations of a factory should be based.

The results of the deliberations of the sub-committee are given in a report* which has just been published. For reasons already mentioned, it used the expression "work study" in the title of its report, in place of "time study" which figured in its terms of reference. The stop-watch timing of machining or other operations is a task requiring training and experience, but, none the less, will not be carried out by senior executives. There does not appear to be an agreed title for the individual who carries out work of this kind. The report quotes a number of advertisements in which he is variously described as a "time and motion study man," a "time study engineer," a "methods engineer" and so on. In none of the advertisements is it implied that the individual appointed will be responsible for the whole productive operations of a factory, and, to quote the report, "the flow of components, their design, the quality standard and the morale" appear to be tasks for what is frequently called "top management."

There is no question at all but that these matters are the business of works managers and other higher officials, and any work-study man who tries to run the factory is not likely to hold his job. The report gives a list of personal characteristics desirable in those who are to train for work study. These include "tact," "capacity for dealing with people" and a "sense of proportion." Clearly, technical ability is essential, but unless the trainee has the necessary personal characteristics he is not likely to to be a success. The productive efficiency of a factory is determined by the higher management, but that efficiency is based on a mass of detailed operations and methods which a works manager has no time to investigate for himself. It may be presumed that the "senior member of the staff with no specific duties" who was recommended as desirable in the shell factory would not attempt to manage it; his duty would be "work study," which would presumably lead to recommendations. If his activities were to be of value in a large or complicated organisation, he would require his own staff of observers. It is with the training of such observers that the report is concerned.

The first of the "recommendations" of the sub-committee is that "every industrial manager should make it his job to study more closely the results that can be achieved from a wider application of work study." This implies that the observer would report to the manager, but in large firms no doubt a senior official would have charge of the whole section of the organisation concerned. The report states, however, that even the small firm should have at least one man to "cover the whole field of work study." As this field covers such matters as "the suitability for manufacture of different product designs" and "balancing operations to ensure an even flow of production," it is clear that the man must be highly qualified; "the slow development of work study in small firms" is attributed to the "severe shortage" of such men.

It is suggested that work-study courses should, in the first instance, be "limited to a specific college or colleges in each region of the country." The reason for this limitation is the small number of suitable tutors at present available. A full-time course would occupy three months and a part-time course would spread over two years. The syllabus would cover such matters as method and motion study, work measurement, and incentives and job evaluation. A substantial proportion of the non-tutorial time should be devoted to study work under actual operating conditions; "this should be possible through the co-operation of local firms."

In selecting men for training, considerable attention should be paid to personal characteristics, since "in work study personal qualities play a greater part than in most technological jobs." This is certainly true but it will not always be easy to assess such recommended characteristics as "team spirit," "a positive attitude," "prospective ability" and "originality." The technical status of candidates will be a more measurable quantity. It is recommended that mathematical ability should extend to the use of "decimals, fractions, percentages, simple equations, slide rule, graphs and diagrams." This is really little more than schoolboy standard, and as the report envisages that some who take the course will ultimately become managers or production consultants, it is clearly desirable that at least some men of higher technical qualifications should undergo the training. The report tacitly recognises this, as it recommends that a balanced study group should include men with a university background as well as those with technical-college training and those with mainly practical experience. As stated, "it would not be reasonable to specify that every recruit to industrial engineering should be a university graduate," but in view of the wide facilities available for technical-college education, it should be possible to recruit men of a reasonably high technical standard for work-study training, providing always that the status and emoluments attaching to work study are competitively attractive.

* *Measurement of Productivity—Work Study Application and Training.* Issued by the Joint Committee of the Institute of Cost and Works Accountants and the Institution of Production Engineers. Sole Distributors, Gee & Co. (Publishers), Ltd., 27-28, Basinghall-street, London, E.C.2. [Price 5s., post free.]

NOTES.

THE GLEN AFFRIC SCHEME OF THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

THE Glen Affric scheme of the North of Scotland Hydro-Electric Board, of which we continue our description on page 489 of this issue, was formally opened by H.R.H. the Duke of Edinburgh on Monday, October 13. The ceremony, which took place in Fasnakyle power station in the presence of about 800 people, was presided over by Mr. Thomas Johnston, the chairman of the Board. In welcoming His Royal Highness, Mr. Johnston said that it was just 5½ years since the construction of this 230-million kilowatt-hour scheme had been begun. Instead of destroying amenities, it was already bringing power and light to thousands of homes and would soon be supplying more than 2,400 farm steadings in Aberdeenshire. In addition, as the result of regulation, it should be possible to diminish flood damage to agricultural land in Strathglass. This achievement had been successfully accomplished without a penny of subsidy. In declaring the scheme open, His Royal Highness said that one of his reasons for accepting the Board's invitation had been to see whether there was any justification in the criticism that the Board was wantonly destroying the national beauty spots of the Highlands. He was now entirely relieved from anxiety on that score. To make goods, manufacturers must have abundant power, and although coal would continue to supply by far the greater proportion of that power, hydro-electricity was an alternative that should be welcomed as a means towards the recovery of prosperity. This scheme, in fact, would save 150,000 tons of coal a year. He congratulated all who had taken part in the scheme.

THE HARROW RAILWAY DISASTER.

The Ministry of Transport inquiry, conducted by Lieutenant-Colonel G. R. S. Wilson, into the railway accident which occurred at Harrow and Wealdstone station, Middlesex, on October 8, has opened at Euston station. As with all such inquiries, it is held primarily to consider the technical aspect, so that the Minister of Transport can be advised on causes and on measures that should be adopted to prevent a recurrence. The work of the Ministry's inspecting officers of railways is invariably thorough and is of considerable value to the railways; the design and development of equipment owe much to their independent advice. In the case of the Harrow accident, the driver and fireman of the Perth-Euston train, which ran into the back of the local Tring-Euston train in the station, have not lived to give evidence, and the evidence of the crew of the third train—the Euston-Liverpool express, which collided with the obstruction of the initial smash—is not relevant to the basic cause of the accident. According to information given at the inquiry, 111 lives were lost (108 passengers and three members of engine crews); 167 persons were taken to hospitals in the neighbourhood, of which eight died after admission and 69 were discharged the same day. Thirty-seven of those killed and 98 of the injured were employed by the London Midland Region; Mr. Maurice Sifton, chief of the regional research department, was among those killed.

DE HAVILLAND SERIES 3 "COMET" AIR LINER.

A statement on the Series 3 Comet, the design of which is now well advanced, has been issued by the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire. It is to be an enlarged version of the original Comet, with accommodation for up to 58 first-class or 78 tourist-class passengers. The all-up weight will be about 145,000 lb. Each of the four engines will be a civil version of the Rolls-Royce Avon jet engine, developing 9,000 lb. static thrust and giving a cruising speed of at least 500 m.p.h. It is expected that the practical stage length, allowing for fuel reserves for climb, descent, head-winds, stand-off and diversions, will be about 60 per cent. greater than that of the Series I Comet (stated in an earlier release by the de Havilland company to be 2,140 miles). The specific cost of operation will be appreciably lower than that of the Series 1, and the aircraft will, naturally, benefit from the experience gained in commercial operation of the Series 1 Comet, which has already given satisfactory and profitable service with British Overseas Airways Corporation since its introduction in May. The first Series 3 Comet is expected to fly in 1954, and the first production aircraft should appear late in 1956. In another statement issued recently, the de Havilland company have said that only 21 Series 1 Comet aircraft are being built. The nine Series 1 Comets ordered by B.O.A.C. have all been delivered. Production of the Series 2 Comet, a 44-passenger air liner with Rolls-Royce Avon engines, is progressing favourably, and deliveries to British Overseas Airways Corporation will commence in 1954. The company are in a position to expand rapidly in response to contracts placed now, and to guarantee delivery of Series 2 Comet aircraft in quantity by 1955, or of Series 3 Comets from the end of 1956, at a rate rising to about six a month in 1958.

MAIN-LINE ELECTRIFICATION ON THE FRENCH RAILWAYS.

The electrification of the main line of the former P.L.M. section of the French National Railways between Paris and Lyons on the 1,500-volt direct-current system was begun directly after the conclusion of hostilities. Operation on the new system was inaugurated between Laroche and Dijon in March, 1950, and between Paris and Laroche in October of the same year. The extension from Dijon to Lyons was completed on June 24 of the present year, thus enabling the great operating advantages of the conversion to be realised fully. In brief, the running times of the principal express trains between Lyons and Paris have been reduced by almost a third, and improvements almost as great have been made in the performance and carrying capacity of the ordinary, fast, and semi-fast services. No express on the run between Paris and Dijon now averages less than 62 miles an hour, and the 9.0 a.m. from Lyons, on which we had the opportunity to travel last week, is timed to reach Paris (Gare de Lyon) in 4 hours 36 minutes. Between Dijon and Paris, the non-stop run of 195 miles is covered at an average speed of 77 miles an hour, making this easily the fastest regular service in Europe. The maximum speed that we recorded was 95 miles an hour. The riding of the train was notably smooth throughout, a tribute to the excellent design of the coaching stock as well as to the extensive track relaying that was undertaken in preparation for the new high-speed services. A feature of particular technical interest is the method of signalling, whereby both of the tracks on the 17 miles between Dijon and Blaisy-Bas can be used for traffic in either direction. At each end of this section there are four tracks, two up and two down, but to add two additional tracks between Dijon and Blaisy-Bas would have involved heavy engineering works, which have been avoided by arranging for both of the existing tracks to be used in either direction as circumstances may require. All switching and signalling operations are directed from a single traffic-control room at Dijon which is in connection with 19 subsidiary control points. The control of electricity supply, which is obtained from the network of Electricité de France at eight points, is divided into three regions, with control stations at Paris, Dijon and Lyons, respectively. The line is now operated with 231 electric locomotives in place of 600 steam locomotives, though the volume of traffic is about 25 per cent. greater than formerly. The saving in coal is stated to be about 650,000 tons a year.

THE INSTITUTION OF PRODUCTION ENGINEERS.

The pleasure which members of institutions derive from their annual dinners, if the formal proceedings end sufficiently early for half an hour or so to be spend in renewing acquaintanceships, was evident at the dinner of the Institution of Production Engineers, held at the Dorchester Hotel, London, on October 9. Instead of an undignified rush for the exits—which is altogether too common at "late sittings"—there was a disposition among most members to take the opportunity to talk with more than the two that a seating plan normally permits. This was possible although there were three adequate and appropriate speeches, as well as the presentation of the Institution awards. Mr. F. H. Rolt, O.B.E., received an award for his paper "The Development of Engineering Metrology," the Sir Alfred Herbert paper for 1952. For the best paper presented by a non-member in the year 1950-51, Mr. J. Redshaw was awarded an Institution Medal; his paper was entitled "Building an Ocean Liner." Mr. D. C. Howard, who was not able to be present, won the Schofield Travel Scholarship for 1952, and Mr. J. Irwin, for his essay "The Automatic Production of Pressed Glassware," received the Lord Austin Prize, 1951 (for the best essay by a graduate). Mr. P. K. Eisner, author of "Tracer Controlled Machine Tools," and Mr. H. P. Jost, author of "Industrial Law and the Production Engineer," won both an Institution Medal for the best paper presented by a member during the year 1950-51, and the Hutchinson Memorial Award for the best paper presented by a graduate during the year 1950-51. Certificates of Merit were presented to Mr. R. S. Cracknell and Mr. D. Whitehead. Sir Cecil Weir, K.C.M.G., President, speaking at the dinner, referred to the establishment of a branch of the Institution in Toronto and to the great engineering opportunities in Canada. He said that the Institution membership was now over 9,000. The Hon. Norman E. Robertson, High Commissioner for Canada, who was the guest of honour, said that the value of British exports to Canada was six times greater than before the war. He reminded his audience that it was now more important than ever for goods produced in this country for export to be completely competitive in price. The chairman of Council of the Institution, Mr. Harold Burke, who had recently returned from a visit to Canada, reported that good progress was being made with the Toronto branch, and that there was a possibility of a Montreal branch being started. He had observed in Canada, however, that there was a need for post-graduate education of production engineers; at the present time, the shortage of engineers trained in that way was being met by immigrants from the United States and the United Kingdom.

ENGINEERING INDUSTRIES ASSOCIATION.

The London Region of the Engineering Industries' Association held their 5th annual display at the Royal Horticultural Society's New Hall, Greycoat-street, S.W.1, on Tuesday and Wednesday, October 14 and 15. The display, although open to all members of the Association based in the south-east area of England, is organised particularly to give an opportunity for the smaller member-firms, who could not afford the high expense of a stand at one of the national exhibitions, to display their products at a show. Of the 1,200 member-firms in the region, 134 exhibited at this year's display; limitation of space prevented more firms from having stands, though many of these firms have had, or will be having, stands elsewhere. The object of the display is several-fold. Buyers from both home and abroad—representatives from the Continent, the Americas, as well as the Commonwealth, attended this year's display—have an opportunity of discovering new sources of supply. London buyers may find products or components that they had hitherto thought to be the prerogatives of a Midland or Northern firm, are manufactured locally, so that the cost of transport can be substantially reduced. This year, as at the 4th display last year, the region staged an exhibition of blue prints and samples of work which larger concerns wished to place out to sub-contract. This was designed as a service both to those concerns who wished to locate suitable sub-contractors and to member-firms who, having the capacity available, were prepared to undertake such work. Complete units in the display included electric motors, machine tools, pumps of all descriptions and heating and ventilating equipment.

BRITISH EUROPEAN AIRWAYS.

In contrast to British Overseas Airways Corporation, the annual report of which was summarised on page 410, *ante*, British European Airways suffered an increased deficit over the previous year, it is recorded in their *Report and Accounts for the Year Ended 31st March*, 1952, on sale at H.M. Stationery Office, price 3*s*. 6*d*. net. Although they are able to report an increase in the traffic carried of more than 20 per cent., compared with the previous year, the increase in expenditure exceeded the increase in revenue, largely owing to delays in the delivery of new aircraft, coupled with the steep rise in wages and prices, the necessity for flying increased sector distances to conform with air-traffic control regulations, and the effects of an industrial dispute during July and August last year. As a result, the net loss rose from 979,267*l*. in 1950-51 to 1,423,611*l*. in 1951-52. This was particularly disappointing since there had been a steady reduction in deficit during the three previous years. The Board are not hopeful of reducing the deficit during the coming year, in which the effects of the restrictions in fuel supply and in the foreign currency allowance have reduced revenue. By May, 1953, however, they expect that revenue will begin to overtake expenditure, when the economic effects of the introduction of the new aircraft—the Elizabethan Class (Ambassador) on March 13, 1952, and the Discovery Class (Viscount 701) in the near future—begin to be felt, together with improvements in methods, and a re-organisation of the administration. B.E.A. are able to record an unbroken safety record during the year. Delivery of the 40-47 seat Elizabethan aircraft has been delayed by more than a year. Owing to material shortages, there were delays also in the conversion of the fleet of Dakotas to Pionairs; the Pionair is a 32-seat air-liner of greater comfort than the Dakota. By March, 1952, however, the rebuilding of the Pionair fleet was nearly complete. In order to gain operating experience on the Rolls-Royce Dart propeller-turbine engines which will power the Discovery fleet, two Dakota freighters fitted with Darts have flown a total of 485 hours during the year. The Dart is thus the first propeller-turbine engine in the world to enter service, either military or civil, and it is probably the first aero-engine to enter commercial service without military experience. Various teething troubles have been eliminated, and a successful engine de-icing system has been installed. Part of the Viking fleet is to be modified for tourist traffic, to give an increased capacity of 38 seats instead of the present 27. The first bay of the new maintenance base at London Airport was taken over on March 17, and it is expected that in coming years it will contribute to increased efficiency and economy.

LETTER TO THE EDITOR.

FULL EMPLOYMENT.

To the Editor of Engineering.

Sir,—While not dissenting from the economic thesis of your leading article entitled "Full Employment," in your issue of September 19, I do not think that any useful purpose is served by discussing this subject in purely economic terms. The wage-earning population of this country will never willingly accept the proposition that "there must be a working margin of unemployment" and that "certain classes must be satisfied to represent that margin." Since a majority of the electorate is composed of wage-earners, any industrial system which insists upon a proposition which is totally unacceptable to that majority must eventually succumb to political pressure.

The reason for the wage-earner's imperviousness to economic argument on this point is that, to him, unemployment is primarily a social, not an economic, phenomenon. The dismissal of employees on grounds of "redundancy," which appears to managers to be simply a recognition of the facts of a given situation, appears to wage-earners as a scandalous betrayal of the rank-and-file of a group by their leaders. To ask wage-earners to accept the idea of a "working margin of unemployment," is like asking seamen to accept the right of a ship's captain to throw part of his crew overboard as a normal method of lightening ship during a storm.

If private enterprise is to survive both the political and the economic hazards of this century, it must find some way of adjusting itself to trade cycles and technological revolutions that does not outrage fundamental human beliefs as to what constitutes decent behaviour on the part of a leader towards those who have enlisted under his banner.

Yours faithfully,

Bjorn Guy.

18, Gardnor Mansions,
Church-row,
London, N.W.3.
October 8, 1952.

[We agree with our correspondent's last sentence—in fact our article was largely concerned with ways and means of ensuring full employment—but we were not as heartless as the first part of his letter suggests. We wrote: "As, however, full employment cannot fairly be held to mean that no one will ever be out of a job, there must be a working margin of unemployment, and, presumably, certain classes, say, textile and shipyard workers, must be satisfied to represent that margin. . . . Lord Beveridge . . . defined full employment as employment of 97 per cent. of the working population." A working margin of unemployment is unavoidable, though of course everyone must hope it will always be small. For it to be kept below the 3 per cent. of Lord Beveridge's definition, the country will need the industrial flexibility which is practically automatic in private enterprise but which will need fostering in public undertakings.—Ed., E.]

OBITUARY.

MR. PETER DOIG.

We note with regret the death of Mr. Peter Doig, which occurred on October 13 after a long illness. Mr. Doig, who was the first general secretary of the Association of Engineering and Shipbuilding Draughtsmen, was born in Glasgow in 1882. He was educated at Allan Glen's School in his native city and subsequently entered the Clydebank Shipyard of John Brown and Company, Limited, as an apprentice ship draughtsman. He was engaged mainly in the design department and on investigations in the firm's experimental tank. Soon after completing his pupilage, he went to the United States, where he was employed by the Fore River Shipbuilding Company, Quincy, near Boston, Massachusetts, now forming one of the constituent shipyards of the Shipbuilding Division of the Bethlehem Steel Company. It was as a result of his work in America that Mr. Doig came to be recognised as a specialist on screw-propeller design. Some years later, on returning to this country, he joined the staff of the ship-design department of Harland and Wolff, Limited, Belfast, but left some time afterwards to take up the position of chief draughtsman to a shipbuilding firm in Shanghai. Unfortunately, however, he suffered a breakdown in health and was obliged to return home in the middle of 1916. After a period on the staff of the Dalmuir Shipyard of William Beardmore and Company, Limited, he was appointed general secretary of the Association of Engineering and Shipbuilding Draughtsmen and took office on January 1, 1918. He continued in activity until 1945, when ill-health compelled him to retire. Mr. Doig was also interested in astronomy and was a Fellow of the Royal Astronomical Society. For a number of years he was editor of the *Journal* of the British Astronomical Association. He was also the author of several books and papers on the subject.

London Showroom and Service Depot for Nautical Instruments.—Kelvin and Hughes (Marine), Ltd., have now completed and put into operation a new showroom at 99, Fenchurch-street, London, E.C.3, which is intended to serve as a centre where shipowners, marine superintendents, shipmasters and others can see a full range of the firm's instruments in working order and have their functions explained. At the same address a service depot has been set up so that ships' officers, and others connected with the sea, may freely inspect any of the firm's nautical instruments and also make use of the service facilities of the organisation in connection with such work as chart correction, compass adjustment, radar, echo-sounding, etc., as well as for the repair of all types of nautical instruments.

THE BRITISH ASSOCIATION MEETING IN BELFAST.

(*Concluded from page 446.*)

Servo-Mechanisms in Aircraft.

On the last day of the meeting, Tuesday, September 9, Session A was occupied with the discussion of two papers, the first of which, by Mr. F. W. Meredith, dealt with servo-mechanisms in aircraft, and the second, by Lieut.-Cmdr. J. R. D. Walker, was concerned with the uses of servo-mechanisms on ships. We commenced to print Mr. Meredith's paper on page 481 of our issue for October 10, and conclude it on page 515 of this issue. Commander Walker's paper will be printed later. The meeting was held in the Whitla Hall of the Methodist College and the chair was occupied by Professor E. Giffen.

Professor Giffen briefly introduced Mr. Meredith and invited him to deliver his paper. The reading of the paper occupied the whole of the time available, and at its conclusion the chairman suggested that Commander Walker's paper should be taken immediately after the adjournment and the two papers subsequently discussed together.

Ships and Servo-Mechanisms.

After the interval, Commander Walker delivered his paper in abridged form, and at its conclusion showed a number of films to illustrate some of the matters referred to. One of these showed the steering gear of the Queen Mary erected in the makers' shops and being tested in conjunction with a full-size built-up rudder. Other films illustrated the action of the Denny-Brown stabiliser, the movements involved in turning, withdrawing and extending the fins being shown on a ship in dry dock. As is now widely known, the action of this form of stabiliser can be effectively demonstrated by extending and tilting the fins while the vessel is under way, causing her to roll in perfectly calm weather. One of Commander Walker's films illustrated an experiment of this nature being carried out on the British Railways' cross-channel steamer Falaise. It was certainly striking, even amusing, to see the vessel rolling quite noticeably on a sea as smooth as a mill pond.

At the conclusion of Commander Walker's paper, the chairman invited questions on both papers, explaining that Mr. Meredith was also present. The first member to put a question, Mr. T. H. Webster, asked whether it was always desirable to keep a ship on a straight course. An experienced helmsman could turn a ship's nose into a heavy wave when he saw one advancing and bring the vessel back on to its course directly afterwards. In reply, Commander Walker said an experienced quartermaster could certainly dodge bad seas, but except in very extraordinary conditions, the less a ship was yawed about the better, even in a rough sea. To a speaker who inquired what could be done to counteract the pitching of a ship, he said that presented a much more difficult problem than rolling. The forces involved were very much greater. He had no doubt that pitching could be dealt with to some extent, but it would be difficult, and there would not be so great a return for the money spent as in the case of rolling. A member inquired of Mr. Meredith whether the inertia of the moving parts of servo-mechanisms, especially in aircraft, would not impose a definite limit on the loop gain of the system. To this, Mr. Meredith replied in the affirmative, and went on to explain the effect of inertia in the case of a servo motor operating the rudder of an aeroplane. Another speaker raised the question of time-lag and pointed out that, as both ships and aircraft were large masses, the best way to combat the effects of external forces on them was to anticipate the effect in advance. He had been told that an attempt had been made to do that in combating the effects of gusts on aircraft, particularly on the Brabazon, by having a probe extending forwards from the nose in order to detect the gusts before they reached the wings of the aircraft. He asked if this had been done and whether it had been successful. Mr. Meredith, in the course of a brief reply to this question, said the probe of the Brabazon, which was called a "gust-alleviator," was intended to reduce the lift of the wing by the actuation of the flaps by the time the gust arrived and in this way to reduce the stresses on the aircraft. It was a very difficult problem and a great deal of work had been done on it, but he did not know whether the device had been brought into successful service.

The Chairman, after thanking the two authors for their papers and for having answered all the questions put to them, closed the proceedings and thus concluded the programme for Session A.

THE ANALYSIS OF STATICALLY-INDETERMINATE STRUCTURES.

Session B, on Tuesday morning, was devoted to the presentation and discussion of four papers by young engineers, the President of the Section, Sir Ben Lockspeiser, occupying the chair. The first paper taken was that by Mr. T. M. Charlton, entitled "Analysis of Statically-Indeterminate Structures by the Complementary-Energy Method," which was printed in full on page 389 of our issue of September 19.

Mr. Charlton's presentation of his paper was followed by a discussion in which the first speaker was Dr. E. C. Cherry, secretary of Section G. Dr. Cherry, after congratulating the author on his paper, said that he was an electrical engineer and had been using the quantity complementary energy for the analysis of electrical systems. He had not been aware of the fact that mechanical engineers also made use of the quantity until he had seen Mr. Charlton's work. The principle of stationary energy was proposed by Maxwell and Kelvin for the analysis of linear electrical systems, and it was regrettable that they and subsequent workers had not given priority to the non-linear case. The same criticism could evidently be made of the work of the early investigators in the mechanical field. The linear system was a degenerate case; it should be treated as a special case of a non-linear system. The energy principles discussed by Mr. Charlton could, he thought, be applied generally to dynamic problems as well as to those involving statics only. The Lagrangian approach was fundamental and of general utility.

Mr. Charlton said he was very interested to hear of Dr. Cherry's work and he agreed that Lagrange's method was fundamental since it dealt with the equilibrium of conservative systems generally. The structural principle of stationary total potential energy was the special case of Lagrange's principle when the kinetic energy was zero. The principle of stationary complementary energy gave the conditions for the compatibility of strains within a structure, provided that the loading did not produce gross distortion. It might possibly be considered as the inversion of the stationary total potential energy principle, but it followed from a special form of the latter which was not completely general, and, in fact, broke down when gross distortion was encountered. Continuing, Mr. Charlton said Westergaard had applied the complementary-energy concept to linear dynamic problems, but his work was unsatisfactory because he apparently made no attempt to formulate the limitations of the method. Engesser also seemed to have omitted to consider its limitations. He (the speaker) had been concerned with a re-investigation of the complementary-energy method, including its limitations, for structural systems. Dr. Cherry here referred to the principle of duality and said that as this was always applicable, there seemed to be no objection to the general use of the complementary-energy method for dynamical problems.

The next contribution to the discussion came from Sir Richard Southwell, F.R.S., who asked whether the author considered that, on balance, the method dealt with in his paper was a preferable approach to an indeterminate structure as compared with the customary methods. A difficulty which occurred to him was that there were some restrictions, and he felt that, unless those restrictions were borne in mind when approaching a problem, something might be done which was not justified. For example, when working with the real (conventional) energy method, we were dealing with a force, and occasionally the problem of momentum arose—such as an impact load on a structure. We were accustomed to the notion of energy as the space effect of a force and of momentum as the time effect of a force. What, he asked, became of momentum when the problem was inverted and force was replaced by a displacement? This consideration, Sir Richard concluded, led him to feel that he would rather work out a problem by the older methods first and then attack it by the new.

In reply to Sir Richard Southwell, Mr. Charlton said he did not generally recommend the complementary-energy method as a means of attacking everyday problems of structural analysis because it suffered from the computational disadvantages of most classical methods. He thought, however, that it was unfortunate that Castigliano's least-work principle had been universally accepted by engineers as a fundamental principle of nature whereas that was by no means true. The principle of stationary total potential energy was a fundamental principle of nature but Castigliano's principle was really a particular case of stationary complementary energy. The complementary energy method for statical systems broke down if the system loading produced gross distortion, whereas the total potential energy method was not restricted in that way. In the speaker's view, the use of the complementary-energy method for dynamical problems could not be recommended; the usual methods of approach, he thought, were preferable. The main purpose of his paper had been to clarify the classical principles of the theory of structures because he thought this was essential for progress in everyday methods of solving problems.

Sir Richard Southwell then said that, as he saw it, Castigliano was comparing solutions, all of which satisfied the conditions of equilibrium, but they differed in respect of "something" and that "something" was the initial work put into the indeterminate structures by self-strain. The principle of the conservation of energy, in which we all believed, told us that the work done on a frame would be added to the work that was there already to give a certain total. Castigliano's principle was a comparison of all possible equilibrium considerations, and out of them all he took the minimum strain energy—that which involved no self-strain originally. Mr. Charlton said that the same reasoning could be applied to the complementary energy method, with the difference that we were not dealing directly in terms of the fundamental concept of the conservation of energy. He could not see that Castigliano's least-work principle was a direct consequence of the conservation of energy (even though it might appear to be so) having regard to his own work on complementary energy.

SHOT PEENING AND THE FATIGUE OF STEEL.

The next paper taken was one by Mr. A. G. H. Coombs entitled "The Effect of Shot Peening on the Fatigue Life of Steel." It was presented by the author and was a report of experiments made to measure the penetration of beneficial depth, with reference to fatigue life, for various conditions of peening. The paper will be printed in ENGINEERING as soon as space is available. The only speaker on the paper was Professor J. A. Pope, who said there was a big issue behind the interesting and classical piece of work that had been reported on in the paper. The object was to enable engineers to get the maximum value out of their material by giving it a surface treatment to neutralise stress concentration. The material could be nitrided to give it a very hard surface; but the process was long and expensive and produced a hard and brittle surface which might develop cracks in handling, so that a condition worse than that obtaining before the treatment might be reached. Shot peening, on the other hand, was a cheap and rapid process; he saw no reason why it should not be applied to robust components such as marine crankshafts. There might, in fact, be overall distortion as a result of shot-peening unless the structure were robust. The possibility of the cracking of the surface, which the author had discovered, and which was quite new, was a danger and it was necessary to determine to what depth the cracks penetrated into materials of different hardnesses. If the cracks were no deeper than the zone of material that was machined away, the resulting specimen was superior to the original machined surface. The author had shown the improvement of a polished specimen as shot peened and had obtained an improvement of 20 per cent. In the case of helical springs, however, improvements of between 50 and 80 per cent. were being considered.

TEXTILE ENGINEERING.

No other comments on Mr. Coombs' paper being forthcoming, the Chairman invited Mr. A. V. Pringle to deliver his paper on Textile Engineering. The paper, which will be printed in ENGINEERING shortly, gave a brief account of the textile industry in Belfast and explained its world-wide importance. It also discussed some of the more interesting mechanisms involved, numerous lantern slides being used to illustrate the author's remarks.

The first speaker in the ensuing discussion expressed his appreciation of the clarity with which the subject-matter had been presented by the author, and the second speaker, Mr. J. E. Serly, C.B.E., after expressing great interest in the paper, said that he could not believe that the processes and extremely clever machines described were all that the manufacturers desired. He inquired, therefore, where work was being done to improve them still further, or whether improvement was dependent on spontaneous invention. In reply, Mr. Pringle stated that by the 1750's the hand process had arrived at a state of perfection over a period of several thousand years; it could not have been possible to reach the end of all development in the subsequent 200 years. Improvements in machines, he said, came from various sources: some of the mills made their own improvements, various research institutes also effected improvements, but the machine manufacturers were probably the largest research organisations as far as machinery was concerned because they had to sell their machines. His one complaint against the developments being made to-day was that their object was to simplify the process—to make short cuts and make things easier for the operators—and this tended to reduce quality. He would like to see more developments with the object of improving quality. The machine manufacturers could not be blamed entirely, as the quality of the raw material had declined considerably.

At this point, the Chairman remarked that he would have expected to find a much greater use of light alloys in the machines as the movement of heavy parts involved the expenditure of a large amount of energy. To this Mr. Pringle replied that light alloys had been used to a much greater extent since the war than formerly, in the form of castings and sheet pressings. There was also a greater tendency to use plastics and other materials in place of steel, brass and cast iron. Another consideration to be borne in mind was that, in the flax trade, much of the machinery had been in use for 50 years, or more. He knew of a case in which a machine scrapped only three years ago was developed in 1836 and was in no way different from that supplied in 1949. The Chairman then inquired about the new American weaving machines, and Mr. Pringle agreed that some very good looms had been produced there. He also mentioned one designed on the Continent which, he said, was a beautiful job from an engineering point of view, but its cost was somewhere about six times that of another machine doing the same work. Finally, the Chairman remarked that the Americans made beautiful machines and were also able to sell them; a fact which Mr. Pringle said he could not deny.

BENDING STRENGTH OF CORRUGATED PLATE.

The last paper on the programme for the session was one on "The Bending Strength of Corrugated Plate," by Mr. J. B. Caldwell. It was presented by the author and will be printed in ENGINEERING in due course. As time was not available for discussion, the delivery of the paper completed the programme for the Belfast meeting, with the exception of visits paid in the afternoon to the Moygashel Mills, the Ballylumford power station (see ENGINEERING, vol. 159, pages 325 and 347 (1945) and the works of Ulster Laces, Limited, and Ulster Carpet Mills, Limited.

The annual meeting of the Association will be held next year in Liverpool, from September 2 to 9, and in 1954 in Oxford, from September 1 to 8.

THE IRON AND STEEL INSTITUTE.

THE special summer meeting, of the Iron and Steel Institute, held in Swansea from October 7 to 9, opened on the first day with a visit to the Trostre Works, Llanelly, of the Tin-Plate Division of the Steel Company of Wales, Limited. The visit was preceded by a reception and luncheon, held to mark the completion of the first stage in the company's modernisation programme. The luncheon was presided over by Mr. E. H. Lever, Chairman of the Steel Company of Wales, and the principal guest was Mr. Duncan Sandys, P.C., M.P., Minister of Supply.

In the course of his speech of welcome to Mr. Sandys, Mr. Lever stated that that day marked the conclusion of the first and most important stage in the development programme of the sheet and tin-plate industries of South and West Wales. It marked, indeed, the approaching closure of an epoch in that part of the British Isles and the penultimate stage in the transfer of hard physical toil from men to machines. The new plant at Trostre, large though it was, would not be large enough to supply all the tin-plate now required. World requirements of this material would continue to grow. It was only by the installation of such modern plants, however, that South Wales could maintain its position in the world's markets as a producer of tin-plates. Hence, gradually, production would be transferred from the old type of hand mills to equipment such as that at Trostre. This, however, introduced a human problem. The old-type mills had been the source of livelihood for people for several generations. This human factor had been fully borne in mind at all stages, and representatives of the workpeople had been taken into consultation at the earliest practicable moment. In this connection, the sense of responsibility shown by the trade-union representatives had proved an inspiring experience to the management.

In his reply, Mr. Sandys said that the new strip mills ultimately would be capable of turning out some 400,000 tons of tin-plate a year, a quantity equivalent to nine million boxes. The Trostre plant should be able to compete with the product of any other country in the world from the point of view of quality and price. In spite of the necessity for modernisation, there was still something to be said for the old type of hand mill. In view of the very great demand for tin-plate, there was every reasonable expectation that, given sufficient raw materials, many of these old mills would still have an important and valuable contribution to make to the national economy for some time to come. At the present time, Wales was also playing a leading part in Britain's steel industry. The output of steel ingots and castings in South Wales and Monmouthshire had increased from an annual rate of $2\frac{1}{2}$ million tons before the war to over $3\frac{1}{2}$ million tons at the present time, and that increase was continuing.

The toast to the President and members of the Iron and Steel Institute was proposed by Sir Charles Bruce-Gardner, Bt., deputy Chairman of the Steel Company of Wales, who outlined the importance of the scientific and research work encouraged and fostered by the Institute. In his reply, Captain H. Leighton Davies, C.B.E., J.P., the President, stated that the Trostre plant was an asset not only to the area in which it stood, but also to the nation as a whole.

The afternoon was devoted to a tour of the Trostre Works, with which we have already dealt on several occasions. Thus, the detailed description of the installation, given by Captain Leighton Davies, in his presidential address to the Institute, which he delivered on April 30, 1952, was reprinted in ENGINEERING on page 629 of volume 173 (1952). A briefer description will be found on page 382, *ante*. We propose, therefore, to confine ourselves to a few points of interest. The Trostre Works are situated about $1\frac{1}{2}$ miles from Llanelly and some 26 miles from the Abbey Works of the Steel Company of Wales. About one-third of the output of the hot-strip rolling mill at Margam is directed to the Trostre Works and is normally conveyed by rail in the form of coils having a maximum weight of 15,000 lb. and a maximum gauge and width of 0·093 in. and 38 in., respectively. On arrival, the material is uncoiled and passed, at a maximum speed of 500 ft. per minute, through a continuous pickling machine comprising five 80-ft. rubber-lined steel tanks containing different strengths of sulphuric acid. This treatment removes the scale formed during the hot-rolling process. After washing and drying, the strip is cold-rolled in a five-stand tandem rolling mill which runs at a maximum speed of 4,500 ft. per minute. The work rolls are 21 in. in diameter and 48 in. in body length and the back-up rolls are 53 in. in diameter and 47 in. in body length. After reduction to the required gauge, the strip is rewound as a 30,000-lb. coil. All traces of the palm oil employed in the cold-rolling operation are removed in one of two electrolytic-cleaning plants. The strip is then annealed in an atmosphere of nitrogen in batch-type furnaces consisting of bases and heat-resisting steel inner covers over which is placed one of several reinforced-steel refractory-lined casings having a row of 30 oil burners at each side and at each end.

Following annealing, the strip is again cold rolled to the required temper in one of two temper rolling mills, each consisting of two stands equipped with four-high rolls. After cutting up into plates, the material is ready for hot-dip tinning. Nine "Poole-Davis" tinning machines are in process of erection at Trostre; at present, hot-dip tinning is carried out at other works of the company. Alternatively, 30,000-lb. coils are brought to the electrolytic continuous tinning unit at Trostre, consisting of two acid-Ferrostan plants, where tin coatings of $\frac{1}{2}$ lb. per basis box are deposited at a speed of 800 ft. per minute. The strip is finally treated in an electro-chemical chromic-acid unit to prevent discoloration on lacquering and during stocking periods. Following this, it is covered with a very fine emulsion of cotton-seed oil and sheared into plates. After being automatically counted and packed, the plates are taken into stock. The two main impressions left in the minds of visitors to the Trostre Works are of the plant's spaciousness and cleanliness. We are glad to note that the management and men are determined that the cleanliness of the plant shall be maintained.

In the evening, a reception was held at the Brangwyn Hall of the Guildhall by invitation of the Mayor of Swansea, Mr. W. T. Mainwaring-Hughes, who welcomed the visitors to the City.

Wednesday, October 8, was to have been devoted to a visit to the Margam and Abbey Works of the Steel Division of the Steel Company of Wales Limited, but, unfortunately, owing to a strike of furnace bricklayers which brought these works to a standstill, the visits had to be cancelled at the last moment. We may recall, however, that we gave, on pages 1, 40 and 129 of volume 173 (1952) illustrated descriptions of the Abbey and Margam Works.

Instead of going to Margam, the members of the Institute remained in Swansea for a tour of the Queen's Dock area and of the near-by Llandarcy works of National Oil Refineries Limited, a subsidiary company of the Anglo-Iranian Oil Company, Limited. At the Queen's Dock the party were shown over reinforced-concrete jetties built to replace five wooden jetties which had been rendered completely unserviceable by attacks of the timber borer, *Teredo Navalis*. Other works proceeding in this area are three lay-by berths at which oil tankers can be moored while awaiting to occupy a jetty or to leave by the next tide. A new jetty and warehouse for handling stores and for victualling tankers are also being constructed. Operations at Llandarcy, which lies several miles inland from the Queen's Dock, and is linked to the latter by pipelines, were commenced in July, 1921. Originally, it was designed to refine 1,000 tons of crude oil a day, but, after the late war, the throughput of the refinery was increased from the pre-war total of 360,000 tons per annum to a quantity of the order of 4,800,000 tons per annum. The refinery expansion to make this increased production possible is being carried out at a cost of some 25,000,000*l*., and, so far, 250 miles of pipe, 36,000 tons of steel, three million bricks and 40,000 cubic yards of concrete have been installed or placed by the construction labour force of upwards of 3,000 men.

In 1949, a new atmospheric distillation plant was commissioned and several ancillary units have since been brought into operation. Units now nearing completion comprise a vacuum distillation plant which will provide material for a series of lubricating-oil plants and also for a catalytic cracking plant. It is hoped to complete the latter before the end of this year, and when this is in commission it will produce a higher-octane motor spirit than is at present in general use. A new boiler house, having an installed capacity of 600,000 lb. of steam per hour at 550 lb. per square inch, is nearing completion and will be followed by the installation of three turbo-alternators having a total capacity of 13,000 kW. These will exhaust into the process-steam mains at a pressure of 200 lb. per square inch, thus effecting considerable thermal economy.

After the Llandarcy visit, the visitors were taken to lunch at the Orangery, Margam Abbey, and, in the evening, a banquet and dance, given by the South Wales Siemens Steel Association and the Welsh Plate and Sheet Manufacturers' Association, was held at the Brangwyn Hall, Swansea. When proposing the loyal toast, the chairman, Colonel J. M. Bevan, M.C., D.L., J.P., Chairman of the Swansea meeting reception committee, announced that Her Majesty the Queen had been graciously pleased to become patron of the Institute. In the course of his speech to the toast of the "Iron and Steel Institute and Industries," Colonel Bevan said that South Wales had been a great metallurgical centre for well over a century and the district was determined to continue as such. The Institute widened the field of knowledge by encouraging research and development work and it thus contributed to the advancement of industry and the well-being of mankind. In his reply, the President of the Institute, Captain H. Leighton Davies, C.B.E., J.P., drew attention to the fact that many nations were represented among the Institute's membership and that it was making a substantial contribution towards better understanding among nations. The toast of the visitors from abroad was proposed by Sir Andrew McCance, D.L., D.Sc., LL.D., F.R.S., who also emphasised the cosmopolitan character of the Institute. The response was made by Mr. G. Schjelderup, Chairman, A/S Christiannia Spigerverk, Oslo, Norway, who spoke of the great industrial achievements realised by Great Britain and the extensive repair work and rebuilding operations carried out after two wars. He added that not only all the nations in Western Europe but the whole civilised world recognised how important it was that Britain should remain great and prosperous.

On the last day of the meeting, Thursday, October 9, morning visits were paid to the Aluminium Wire and Cable Company, Limited, Port Tennant; the British Iron and Steel Research Association Laboratories, Sketty Hall; the University College of Swansea; Imperial Chemical Industries Limited, Waurnarlwydd; the Metal Box Company, Limited, Neath; the Mond Nickel Company, Limited, Clydach; the National Smelting Company, Limited, Llansamlet; and the Steel Company of Wales, Limited, King's Dock, Swansea. Afternoon and whole-day excursions were also made to the Vale of Glamorgan, Llanwrtyd Wells and Tenby.

ECONOMY OF CEMENT.—The Ministry of Works have issued two memoranda designed to draw attention to ways and means of reducing the consumption of cement; No. 1 is entitled "Cement for Housing and Small Scale Building," and No. 2, "Cement for Engineering and Large Scale Building." Both memoranda stress the advantages and economies accruing from the use of ready-mixed concretes, the bulk delivery of cement, the careful design of a suitable mix for a particular purpose, and of adequate control of mixing and placing. Particular suggestions include the substitution of lime for part of the cement content in mortars and that concrete for paved areas may be avoided by the use of hardcore laid with a bituminous surfacing. Copies of the memoranda, price 3*d*. each, may be obtained from H.M. Stationery Office, Kingsway, London, W.C.2.

GLANDLESS CENTRIFUGAL PUMP.

HYDRAULIC & MECHANICAL DEVELOPMENTS, LIMITED, LONDON.

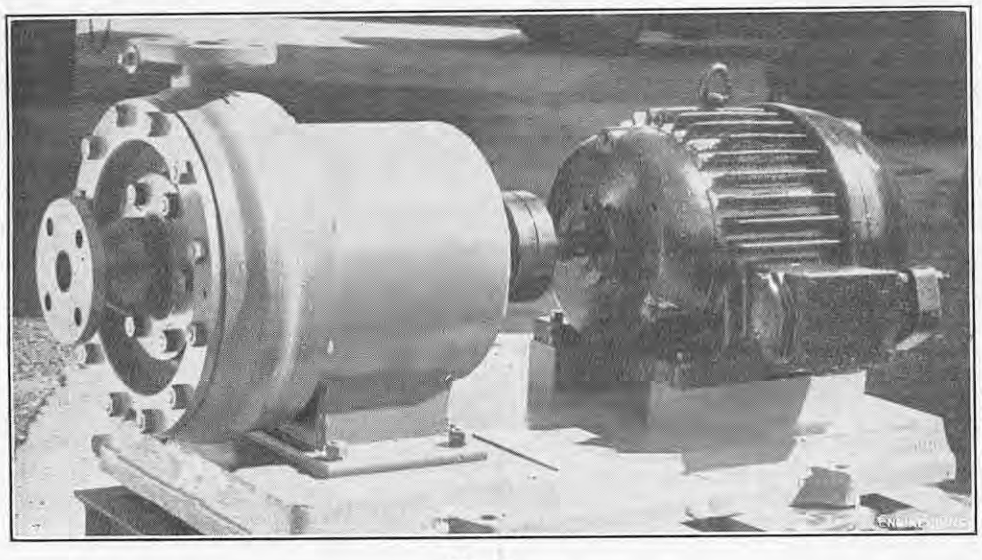
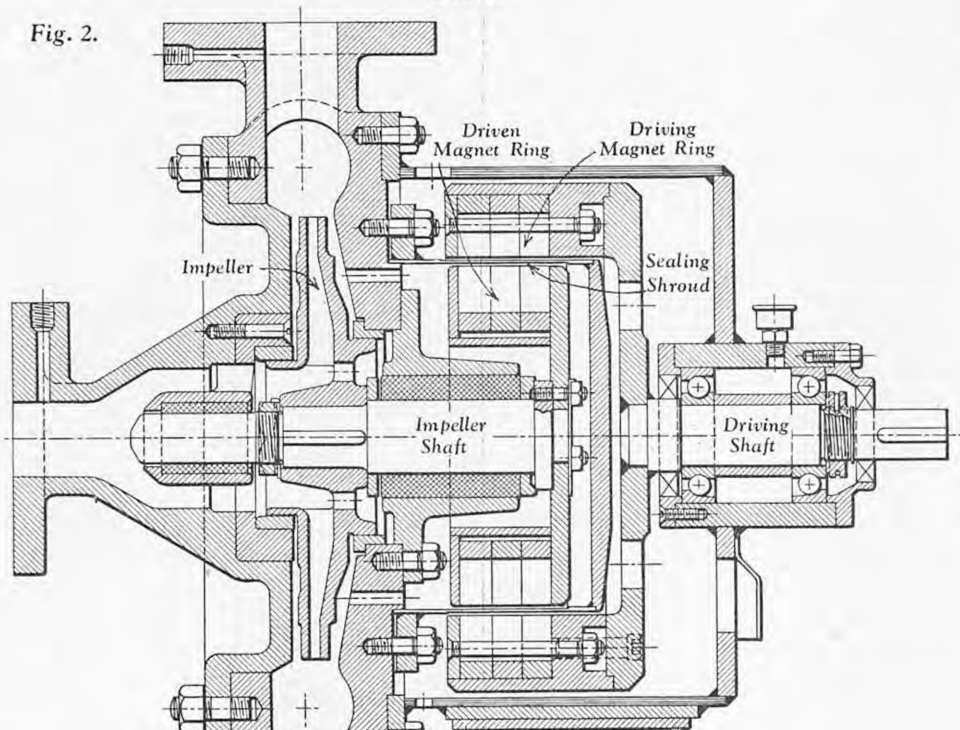


FIG 1.

Fig. 2.



GLANDLESS CENTRIFUGAL PUMP.

FOR pumping fluids under difficult conditions—for example, when handling corrosive or toxic liquids, or operating under high vacuum or at high temperatures—a glandless centrifugal pump incorporating a Howard permanent-magnet coupling has been developed recently by Hydraulic and Mechanical Developments, Limited, 116, Victoria-street, London, S.W.1. A standard range of pumps, from 1 in. to 3 in. is available, for medium-head operation, but other types of pump can be made to special order. The magnet coupling is designed to transmit 20 h.p. at 1,500 r.p.m., and proportionally higher powers at higher speeds.

A 1½-in. glandless centrifugal pump is illustrated in the photograph reproduced in Fig. 1, and a section through the pump is shown in Fig. 2. It will be seen that the impeller shaft carries, at one end, a ring of permanent magnets, which are separated by a small gap from an outer ring of permanent magnets mounted on the driving shaft. The latter, which runs in ball bearings, is driven by an electric motor. In the gap between the inner and outer rings of magnets is a metal sealing shroud which completely isolates the driving mechanism from the pump, but allows the magnetic drive to be transmitted through it. Thus, as the outer ring of magnets rotates, the inner ring is driven round in step with it. The torque exerted by the magnets depends on the gap between them. By increasing the gap, at the expense of torque, the thickness of the sealing shroud can be increased to withstand pressures of several hundred pounds per square inch. The pump can be made in any material suitable for the application. The sealing shroud and the inner magnet ring can be made from austenitic stainless steel, Inconel, and other materials with good corrosion-resisting properties. The impeller bearings, which are immersed in the fluid, may be of cast iron, bronze, carbon, Serobestos, etc.

STEEL SLEEPERS FOR EAST AFRICA.—A special train of 36 wagons was used by British Railways to carry 375 tons of steel sleepers from the Port Clarence, Billingham-on-Tees, works of the Anderson Foundry Co., Ltd., to Birkenhead for shipment to Dar-es-Salaam, East Africa. Although the sleepers were not ready for transport until October 4, British Railways gave an undertaking to have them alongside the ship at Birkenhead on the morning of October 6.

THE INTERNATIONAL MACHINE TOOL EXHIBITION AT OLYMPIA.

(*Concluded from page* 480.)

THIS series of articles on the Machine Tool Exhibition is concluded with brief descriptions of six exhibits, all of which are illustrated on page 504.

ROCKFORD PLANER.

The Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, exhibited approximately 80 machines, British and foreign, and also managed the stand of Vickers-Armstrongs Limited, which showed British Clearing presses and press brakes. The latter types of machines, some of which have been previously described in ENGINEERING, included a double-action hydraulic press weighing about 240 tons. The main stand exhibits included a large 7-in. spindle Giddings and Lewis boring machine weighing approximately 80 tons, Monarch lathes, Thompson grinders, "American" broaching machines, Drabert shearing and nibbling machines, Hille drilling machines, a Sack and Kiesselbach 500-ton cold hobbing press, Diskus grinding machines, Hartex grinding machines, Werner milling and grinding machines, a Sundstrand lapping machine, a new Brauer wire and tube straightening machine, and numerous others. A Rockford 72-in. hydraulic open-side shaping machine, which was also shown, was fitted with a hydraulic "KopyKat" duplicator, which is a servo mechanism with an independent hydraulic system, designed to duplicate contours and full forms using a template or master against which a stylus operates. The machine has an infinite number of cutting speeds between 0 and 110 ft. per minute, as well as horizontal and vertical power feeds. The 36-in. open-side planer is illustrated in Fig. 124.

UNIVERSAL WORKHEAD.

Wild-Barfield Electric Furnaces, Limited, Elecfurn Works, Watford By-pass, Watford, showed, among their exhibits, the universal workhead illustrated in Fig. 125, which is designed for use in conjunction with jigs on high-frequency induction-heating equipment. It has been developed to cover a wide range of components and purposes, and has been used mainly for melting, brazing, soldering and the heat-treatment of metals. It is supplied as a bench model or mounted on a stand. The design incorporates interchangeable jig panels, each of which can be supplied initially or subsequently at relatively low cost to cover one or more components. The workhead itself, enclosed in a screened housing, incorporates the latest air-spaced water-cooled radio-frequency transformer, the feeds from which engage through a clamping device with the applicator on the jig. Inside the workhead cubicle are fitted water filters, pressure-operated switches and other protective devices for the safety of personnel and equipment. All cooling-water tubes, of which a prescribed minimum length is necessary for satisfactory operation, are coiled and cleated inside the housing. Process timers are usually required to control the duration of the heating and also, in many cases, the operation of quenching or other devices. The process timer is then fitted on the sloping panel at the top of the workhead cubicle, and is capable of being set to any desired time cycle. Though the workhead itself is, in the main, standard, the jig panels are varied. All, however, are completely interchangeable; any jig can be fitted to the workhead. The jigs comprise an insulating panel (held to the workhead frame) on which are fitted sockets to receive the control circuit plugs and an applicator and work-locating fixture designed to suit the particular component for which the jig is intended. Other fittings depend upon the purpose, as, for example, automatic quenching devices in the case of hardening, turntables or other progressive units where movement of the component during heating is required. One of the most important advantages of the jig system is that the applicator and work-locating fixture are both fitted to the jig, and are therefore always in the same fixed relation to each other. The complete panel can easily be detached from the workhead frame, when it can be placed in a storage box. If installed initially for one particular part and one purpose, the use of the workhead may subsequently be extended by the acquisition of one or more additional jigs.

Model of Balanced-Hearth Walking-Beam Furnace.

The Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, were faced with the difficulty of showing the wide range of their products and those of their associated companies—many of them far too bulky even for an Olympian stand. They therefore displayed a number of models, one of which is illustrated in Fig. 126. It represents a producer-gas fired balanced-hearth walking-beam furnace, with an output of 10 tons an hour, which forms part of a completely mechanised steel-sheet rolling mill installed on the Continent. Such units stand up readily to the heavy demands made on them and are equally useful for heat-treating a wide range of products, including bars, packs, plates, springs, etc. These furnaces can be designed for any type of fuel. The parent company also showed models of a gas-fired radiant tube refractory roller-hearth furnace, a complete heat-treatment installation, twin Whiting cupolas and swivel-type skip charger, and a Hi-Nitrogen generator. Of the other companies of the group, Controlled Heat and Air, Limited, showed a model of a continuous drum spraying and drying plant; Metalectric Furnaces, Limited, a three-phase swing-roof tilting arc furnace; the Selas Gas and Engineering Company, Limited, showed a range of gas burners and injectors, oil burners, etc.; Thompson L'Hospied and Company, Limited, heat-resisting alloy castings; and Metal Porcelains, Limited, vitreous-enamelled samples.

Shot-Blast Cabinet.

Fig. 127, on page 504, shows the shot-blast cabinet that was displayed by Guyson Industrial Equipment, Limited, North-avenue, Otley, Yorkshire. Such cabinets are used for de-scaling hard surface deposits from light metal parts. A recent addition to the range—a bench model—is proving to be particularly suitable for laboratories and small workshops, and for mobile workshops and floating repair depots. Larger models are designed to operate from existing workshop air-supply lines. They reduce the labour costs involved in surface cleaning and enable the user to impart a much improved finish to his products.

Profile-Turning Lathe.

Messrs. Arthur Scrivener, Limited, Tyburn-road, Birmingham, showed three of their well-known centreless grinding machines, which are applicable to a wide range of workpieces; an automatic rotary hopper for feeding a centreless grinder; two surface grinders which are new developments; and the profile turning lathe illustrated in Fig. 128. This machine was tooled-up for machining a typical internal-combustion engine crankshaft. It is a special-purpose machine on which the cam form is machined by a shaving cut instead of the normal turning cut. The tool slides are reciprocated by a large master camshaft at the rear of the machine (as shown in Fig. 128), and the variety of profiles which can be produced on the lathe extend from a flattened ellipse to straight-sided polygons, as well as cam forms having straight, concave, convex or re-entrant flanks.

Welding Generator.

The Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire, exhibited their latest submerged-arc welding equipment—the manual "Lincolnweld" and the full automatic—which were demonstrated by the company's field engineers. They also showed a complete range of Lincoln Shield-Arc electrodes and accessories. The SA 150-ampere generator shown in Fig. 129 is provided with a self-indicating dual continuous control. It is suitable for a large number of applications, having highly responsive uniform welding current for fast welding of all metals and alloys, light-gauge and heavy materials. The speed and quality of work are particularly high.

LABOUR NOTES.

There was some easing last week of the tension in connection with the wage disputes in the engineering and shipbuilding industries, as a result of the joint meeting in London between officials of the Confederation of Shipbuilding and Engineering Unions and representatives of the Engineering and Allied Employers' National Federation on October 8. Conciliation officers of the Ministry of Labour, including Sir Robert Gould, the chief industrial commissioner, also took part in the meeting. Stress was laid on the damage which might be inflicted on the engineering industry and, thereby, on the national economy, should attempts be made to enforce the suggested ban on overtime and the restriction on piecework.

At a meeting of the general council of the Federation, prior to the joint meeting, it was decided that the council would advise the Federation's constituent associations to grant authority to their representatives to open negotiations with the Confederation's officials, "untrammelled by instructions that no increase should be granted in any circumstances." It was implied, however, that such a step would be conditional on the proposed restrictive action by the Confederation being postponed. The Federation had on previous occasions expressed its willingness to refer the dispute to arbitration, but the Confederation had not been prepared to accept such action as a means of ending the deadlock.

It had appeared for some time that the unions would not continue to press for their original demand for an all-round increase of 40*s*. a week, and, after hearing the proposals of the Federation's general council, the unions' officials agreed, at the joint meeting, that the overtime and piecework restrictions, due to be brought into operation on Monday next, should be indefinitely postponed. Discussions at the joint meeting lasted for some hours, however, and it was decided that there should be another meeting between representatives of the two sides on October 21. The wage dispute in the shipbuilding industry was discussed at a meeting between officials of the Confederation and of the Shipbuilding Employers' Federation on October 9 at the London offices of the Ministry of Labour. It was announced subsequently that the two sides would meet again on October 22 and that negotiations on wages would be opened.

Metal-patternmaking disputes are discussed by Mr. W. B. Beard, O.B.E., the general secretary of the United Patternmakers Association, in the Association's *Monthly Report* for October. He states that the Association had been involved in a strike by 50 of its members, which lasted for several weeks, and that there was still trouble with two other firms in the same district. In one case, the firm appealed to the industry's central conference, but the difficulty was referred back for settlement locally and negotiations were proceeding. These disputes involved a matter of principle which seemed to make them quite different from stoppages where the cause was obscure and had nothing to do with patternmaking as such. Quite often, such disputes were against all agreements which the Association had entered into with the employers.

The main purpose of the Association, as a trade union, was to safeguard the interests of its members and of patternmaking, and nothing seemed more important in that connection than to prevent inroads being made into the metal side of the industry by tool fitters and others, without the supervision and consent of the Association. Clearly, the Association could not prevent the development of mechanisation, Mr. Beard states, and, in many cases, there were not the members or the metal-working machinery to deal with all the work which was available, but the Association could at least try to control such work, see that its wage rates were paid, and make provisions for the training of apprentices.

In the strike referred to, a settlement had been effected by the terms of which the company agreed that the making of patterns in any material was the work of the patternmaker and that it was his job to see the work through from start to finish. It also agreed that its pattern shop did not have plant capable of performing all the machining operations necessary to make the metal-pattern equipment, then on order, by the required delivery dates, but that it was willing at all times to consider the purchase of additional plant when necessary. The Association, in consideration of the foregoing, agreed not to object to work on patterns and pattern equipment being done in the toolroom, or elsewhere, provided all non-patternmakers employed on such work received the rates accepted by the company as patternmakers' rates.

It was also part of the agreement that all pattern work capable of being done in the pattern shop should be executed by patternmakers and that there should be prior consultation between the patternmakers' shop representative and the company before such work was performed elsewhere than in the pattern shop. Having regard to the practical difficulties which might arise in the future, it was agreed that the maximum work should be executed in the pattern shop and that tools required to enable the existing machines to deal with a larger number of operations should be procured.

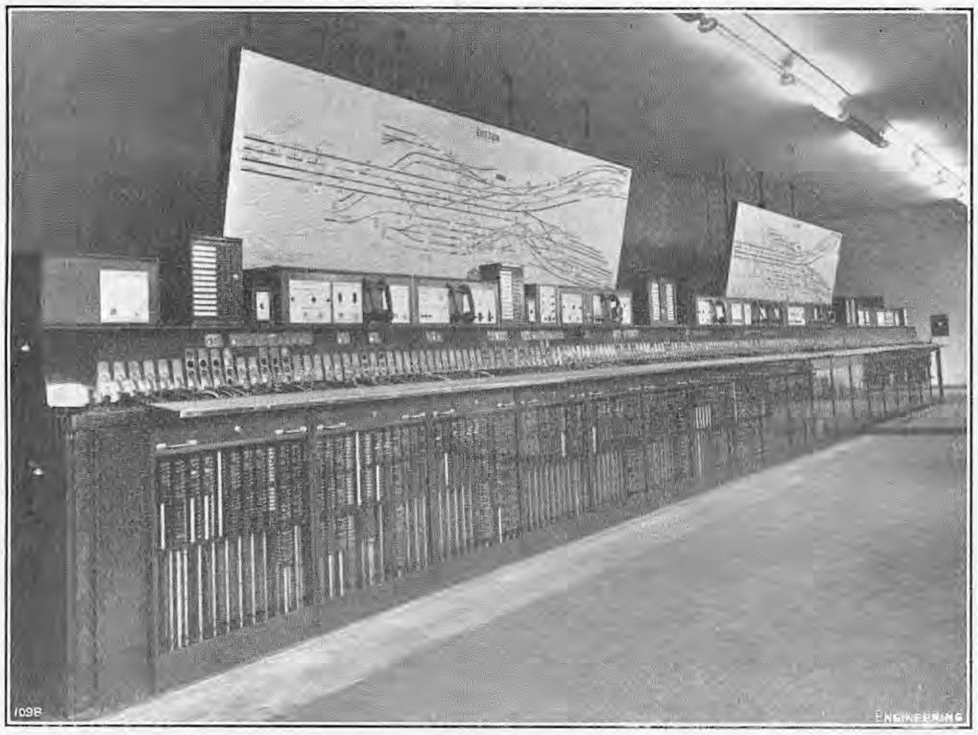
Foreign competition in the shipbuilding and ship-owning industries and the damaging effects of taxation are referred to in the annual report for 1952 of the Council of the Navigators' and Engineer Officer's Union, which was presented to the union's annual meeting in London yesterday. The Council considers that the principal international developments recently were the progress made by Germany and Japan in re-entering the industries, the increase of tonnage under the flags of Panama and similar states, and the competition in the North Sea and Baltic regions. Demands for new tonnage continued unabated, and the world's existing merchant-shipping fleet of over 87 million gross tons was 27 per cent. above the pre-war level. Freight rates, which reached a new peak in October, 1951, thereafter began to decline, until, by June, 1952, they were standing a point below the 1948 basic figure of 100.

Last year, Japan was second among the world's shipbuilding countries and many of her new ships would be of the fastest and most modern type. With Britain still experiencing a critical period in her firm intention to re-build an economy overstrained and thrown out of gear by her war-time exertions, it was ironical that she should be facing competition in one of her greatest hard-currency earning industries from two ex-enemy nations, Germany and Japan. The Council recalls that these two countries were among the eight mentioned by Lloyd's Register of Shipping in its report for 1951, in which it was stated that acknowledgment should be made to the United States for the assistance which had enabled those war-stricken countries to resume so speedily their place among the leading shipbuilding nations of the world.

This renewed competition had come at a time when international events had led to general under-employment in the shipping industry. German ships were again engaged on some of their pre-war routes, such as those to the Middle East, Africa and South America. That country's shipbuilding yards, while hampered by the general shortage of materials, were working to capacity and turning out ships at a rate about twice as fast as that obtaining in the United Kingdom. A situation was now confronting this country where an increasing number of ships would be seeking a decreasing number of cargoes.

As to taxation, its incidence was effectively hampering the efforts of shipping companies to re-equip their fleets with fast modern vessels, without which competition from foreign nations could not be effectively matched and overcome. Throughout the year, prominent shipowners had continued to warn the Government of the inevitable outcome of the manner in which their companies were taxed.

POWER-OPERATED SIGNAL BOX AT EUSTON.



NEW SIGNALLING INSTALLATION AT EUSTON STATION, LONDON.

BEFORE the war, extensive plans had been made for the reconstruction of Euston station, London, in what is now the London Midland Region of British Railways. For economic reasons, these plans have had to be shelved indefinitely and, in their place, a less elaborate scheme has been substituted which will, it is hoped, overcome some of the difficulties of working the traffic into and out of this important terminus. On an average day the traffic consists of more than 70 incoming main-line and local steam trains and about the same number of outgoing trains. There is also a frequent electric service.

The first part of this improvement, which has now been completed and was brought into operation on Sunday, October 5, consists of the replacement of the three existing manual signal boxes by one new power-operated box, placed in a more convenient position on the Camden side of the second bridge over the approaches to the station. An existing fourth box will, in future, only be used for controlling shunting movements. Colour-light signalling has been adopted instead of semaphores, so that this system will now extend as far as Wembley Central, a distance of 8¼ miles from Euston. Complete tracking circuiting has also been installed. Other work has included the demolition of a road bridge at the outgoing end of the station, thus providing space for lengthening three of the main-line arrival platforms by 200 ft. to 300 ft., and extending three other platforms. The present complicated track layout at the approaches to the station will also be simplified to permit smoother operation and thus to reduce delays. The necessary work for these purposes has been started.

The new signalling system replaces one which has been in use since the Euston-Camden widening of 1905, although in the meantime a number of safeguards have been added. Its focal point is the new signalbox, an illustration of the interior of which appears above. This box, which was designed in the architect's office of the Civil Engineer's Department of the railway, and built by Messrs. Tersons, Limited, Seward-street, London, E.C.1, has load-bearing brick walls and reinforced-concrete floors and roof. It has been so arranged that a specially long uninterrupted view of the tracks is obtained from the operating floor.

The box contains a 227-lever frame, which was constructed by the Westinghouse Brake and Signal Company, Limited, York-way, London, N.1, and comprises 61 point levers (including two ground-frame releases), 126 signal levers (including 50 for ground signals and five for controls to Euston Carriage Sidings Signal Box), as well as 40 spares. It will control eleven incoming and outgoing tracks, including the flying junctions which allow traffic to pass to and from the station without fouling the two up and two down running lines and thus enable empty trains and light engines to be worked separately on both the arrival and departure sides of the station. When the layout is completed, trains will also be able to pass from the up slow line into the two local platforms, while a movement is simultaneously taking place into or out of the three main platforms, and the flexibility of working is thus increased.

The 61 point levers in the new box control 94 electro-pneumatic point mechanisms, the bolt, detector and movements of which are installed in the 6-ft. way. Air for operating these points is supplied to the normal and reverse magnets through a third or "lock" magnet until they have been detected in their new position. Each point lever is electrically "track-locked" by the track circuits immediately covering it and is also "route-locked" by one or other of the route stick relays, which is dropped when the appropriate signal lever is pulled. There are no normal and reverse indication locks, thus reducing delay when the setting up of a route involves a number of switch movements. An illuminated "N" or "R" is displayed behind each point lever, depending on whether the point detection relay is energised in the normal or reverse position.

The signal levers control 32 long-range multi-aspect colour-light signals, 26 subsidiary signals with an illuminated letter "C" for calling on purposes and 21 short-range yellow-aspect signals for controlling movements from a running line to a non-track-circuited siding. Route indications are given by theatre-type units. There are also 35 position light ground signals for controlling shunting movements. The signals are operated from the frame by one or more levers. These levers are arranged so that those controlling movements from parallel lines to the same group of destinations are beneath one of the route checking lamps which confirm the route actually set up. Alternative ways of reaching the same destination have, however, been signalled where possible. The running signal levers are locked in their normal positions, until all the points are set and the appropriate track circuits are clear. These locks are used instead of back locks to replace the signal stick relays. The levers are also approach-locked. The aspects of both running and ground signals are repeated in miniature behind each lever. When banking is used, as is the case with many departing main-line trains, the signals are replaced when the last wheel has passed. Incoming signals are, however, replaced by a track circuit ahead, which is so arranged that both engines on a double-headed train must pass the signal before it operates.

The platform departure signals are provided with position light subsidiary signals, which are also used for shunting purposes. Most of these signals are also fitted with back indicators, which show the word "off" and the route to be taken, thus enabling the departure of long trains which overhang the platforms to be signalled. The "off" signal is also repeated at the head of the platform for the benefit of the guard or of the driver of the banking engine. The signal to start is given by the guard to the driver by pressing a plunger on the platform. This illuminates a sign with a black letter "R" (ready) on both the front and back of the departure signal and also a repeater at the head of the platform.

Many of the ground signals, like the running signals, can be operated by more than one lever. This will simplify the working of the frame, at which there will normally be more than one signalman. The ground signals are free of control by track circuits except those required to prove clearances, and are locked normal, unless the points are correctly detected. They are generally approach-locked, and a number of them are also fitted with back locks in order to complete the holding of the route. When used individually they are not replaced to danger by a track circuit, but by the lever. As the ground signals provided on the arrival side to cover shunting movements have to be passed by running movements in the facing direction, they are placed at "off" automatically by the lever operating the incoming signal. They have, however, to be replaced to danger individually, as each portion of the route ahead is released behind the train.

A green aspect is only displayed on the incoming signals if a platform is clear to the buffer stops. Otherwise a calling-on aspect is employed to prevent the signalman from turning a normal length train into an already occupied platform. For this purpose a track-circuit is provided at a sufficient length from the buffer stops to accommodate vehicles which are normally required to stand at that position. If, however, any further portion of the platform is occupied the calling-on signal can only be given if the movement requiring entry can be completely accommodated on a berth track circuit from 50 to 70 yards long which is associated with the incoming signal. If, therefore, the outer platform track circuit is occupied, a movement into the platform can only be made by a short rake, such as a single engine or an engine and one or two vehicles. The movement of empty carriage trains into the departure platforms is safeguarded in the same way. A yellow aspect is displayed on the incoming signal of the platform used by electric trains, at which mail vans also stand, the mail vans themselves being protected by a red signal. The calling-on signals can be displayed, even though the track circuits immediately on the approach side of a platform are occupied, provided the track circuit next in advance is also occupied. This occupation proves that what is already in the platform is truly "overhanging" and is not simply an isolated vehicle or engine.

The track circuits used in the new installation are, with one exception, of the alternating-current condenser type, but at the head of one platform an axle counter is used, as vehicles stand on this portion of the line for so long that a track circuit would be unreliable. The condition of these track circuits is indicated on black and white diagrams which, as can be seen in the illustration, are installed in duplicate in the new signal box. As many as possible of the relays associated with these circuits are mounted in a special room in the signal box. This room contains 900 detachable-top relays, and ample space has been left for extensions. Other apparatus, including terminations, which cannot be accommodated in the relay room is installed externally in 57 steel cupboards. These cupboards, as well as the signals and points, are connected to the relay room by some 400 core miles of multi-core cable. Most of this cable is of the plain served type and is run on continuous timber supports with occasional expansion gaps. Some armoured cable has, however, been used and this is carried on metal brackets. The individual units have been wired up with single-core cable, which is laid in timber trunking. The signal structures in the lay-out include six gantries, the span of one of which is 71 ft., as well as four cantilevers and nine brackets. The larger structures are of all-welded construction.

A further point of interest about the new signal box is that block telegraph working on the four running lines has been replaced by train describers of the storage type, which were supplied by the Siemen's and General Electric Railway Signal Company, Limited, East End-lane, North Wembley. These describers generally give three indications in the up and four in the down direction, and in each case work to the adjacent signal box. Together with other apparatus, such as the signal telephones, they are mounted on a special panel above the lever frame. Other forms of communication installed include a teleprinter for train reporting and telephones both for selective calling and to allow the linemen to speak in emergency between the frame, the relay room and the external signals. There is also loudspeaker communication between the frame and the inspectors on the station.

Power for operating the new installation is obtained from the public mains on the three-phase four-wire system, the point of connection being a substation which has been built adjacent to the box. In emergency a supply will also be available from a 60-kW Diesel-engine driven generator, which is started up automatically. Compressed air for operating the points is obtained at a pressure of 50 lb. per square inch from one of two electrically-driven compressors or in emergency from a Diesel engine driven set. The cabling and provision of signals, etc., have been carried out by the regional staff under a resident engineer, new works, and the whole work is being executed to the specifications and requirements of Mr. S. Williams, regional signal and telegraph engineer.

PROPOSED DEVELOPMENT OF GATWICK AIRPORT.

On Monday, October 6, at a meeting held in London, the Government's proposal to develop Gatwick Airport, as an alternative to London Airport, was explained by the Ministry of Civil Aviation to representatives of the local authorities and of the Crawley New Town Development Corporation. Air traffic is expanding rapidly, it is stated by the Ministry, and by 1960 it is expected that air transport movements in the London area will have doubled. London Airport, even when fully developed, will not meet all future demands. In any case, an alternative airport is needed which will be capable of handling all types of aircraft. Gatwick has been selected, after examination of more than 50 sites in relation to weather, access to London, the amount of disturbance to property and to local amenities, and air-traffic control needs. Gatwick Airport, it is planned, would have two parallel runways, lying east to west, 7,000 ft. long and 200 ft. wide, separated by 3,200 ft., with a passenger terminal between the runways and an aircraft maintenance area in the south-east corner. A third subsidiary runway, 500 ft. long and 150 ft. wide, and running north-east to south-west, will not be constructed until required. The proposed layout has been designed to cause the minimum disturbance to local amenities. The approach path to the main runways will be mainly over open country. It will be necessary to divert the London and Brighton road, which will be severed by the main runways. The first stage will be the construction of the northern east-to-west runway and taxiways (expected to be complete by 1956), aircraft parking space, the main traffic-handling building, and the first group of maintenance hangars. It is not expected that the second stage—the construction of the southern east-to-west runway, additional taxiways, parking space, hangars and the subsidiary runway—will be commenced before 1958.

FULMER RESEARCH INSTITUTE.

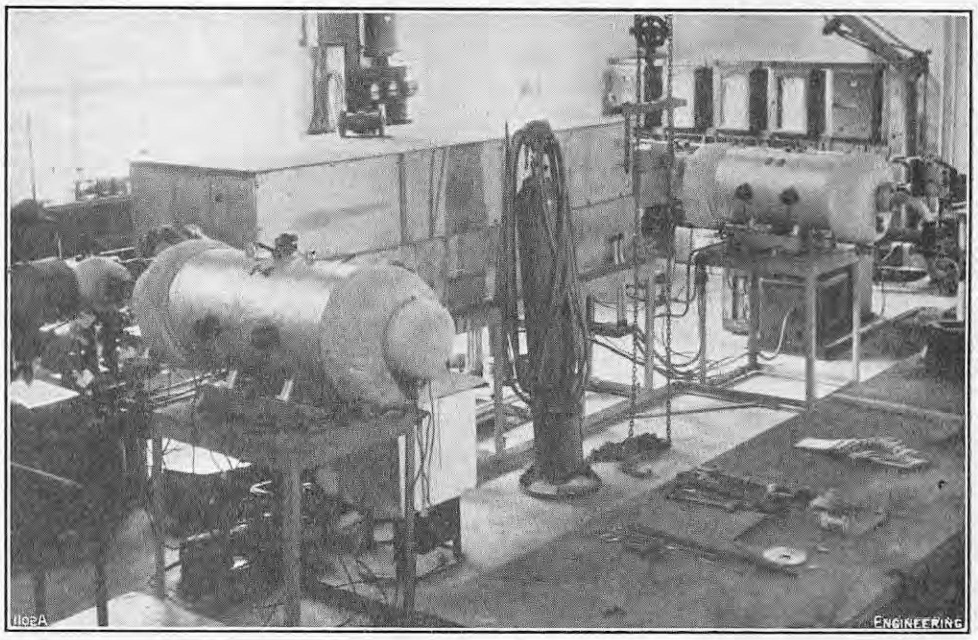


Fig. 1. Pilot Plant for Aluminium Distillation.

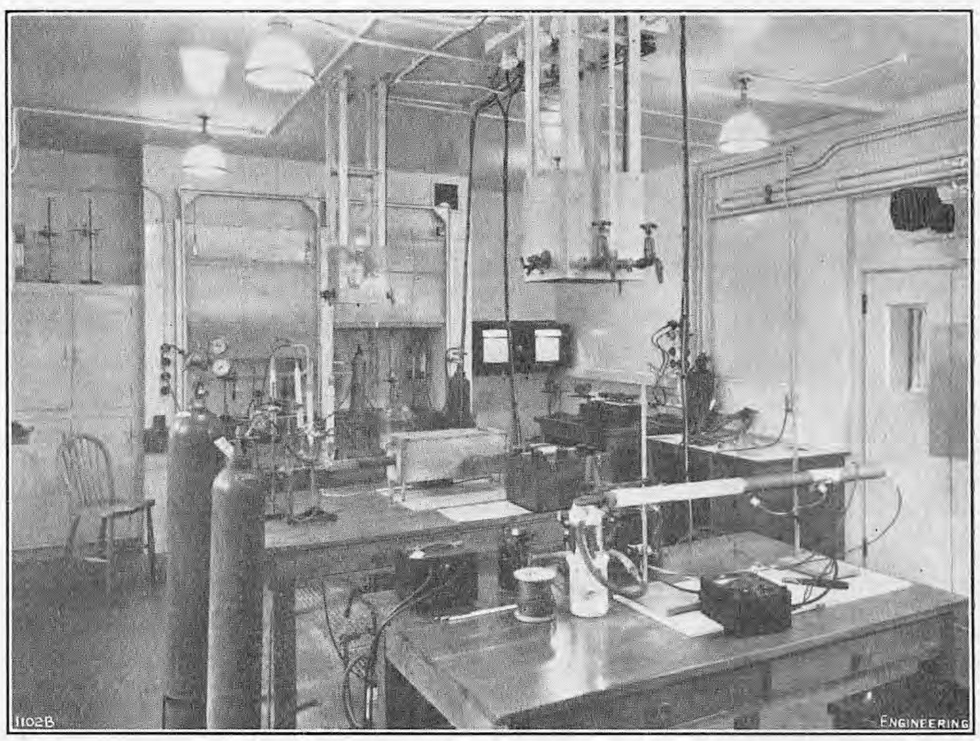


Fig. 2. New Physical Chemistry Laboratory.

THE FULMER RESEARCH INSTITUTE.

On page 443, *ante*, we gave brief particulars of some of the researches in progress at the Fulmer Research Institute, Stoke Poges, Buckinghamshire, which was open on September 30 to enable visitors to see the progress made during the first five years of the Institute's existence. We give below some additional notes on a few of the metallurgical researches now in hand in the laboratories and shops at Fulmer. For some time past, work has been proceeding on the preparation of pure aluminium by a distillation process. As many of our readers are no doubt aware, this metal cannot readily be distilled directly under technically feasible conditions, but it may be "catalytically" distilled by the agency of its normally unstable monohalides. Thus the reversible reaction:

$$2\,Al + AlCl_3 \rightleftharpoons 3\,AlCl$$

can be used to distil aluminium by bringing the vapour of the trivalent chloride in contact with aluminium-bearing material at high temperatures and low pressures and then cooling the resultant vapour of aluminium monochloride to condense the aluminium and re-form the vapour of the original aluminium trichloride. In the pilot plant, now in operation in the Institute's heat-treatment department, and shown in Fig. 1, on this page, the cylindrical apparatus in the left foreground is the evaporator in which aluminium trichloride, in the form of crystals, is vaporised and the vapour led over impure aluminium heated to a temperature of between 1,000 deg. and 1,400 deg. C., in a heat-resisting-alloy tube furnace. This furnace, which is electrically heated, is enclosed in the rectangular container seen in the background in Fig. 1. On cooling, as is indicated in the equation showing the reversible reaction, pure aluminium condenses out and aluminium trichloride is re-formed and recovered in the cylindrical condenser seen on the extreme right in Fig. 1. The process may be employed for purifying aluminium of commercial purity or scrap, or for the extraction of aluminium from materials produced by direct thermal reduction in the arc furnace.

Further work in this field is in progress under the joint sponsorship of Aluminium Laboratories Limited, and International Alloys Limited. Some of the work, on a laboratory scale, is conducted in a new physical-chemistry laboratory shown in Fig. 2, opposite. The apparatus seen on the table in the foreground is used for experiments on the reclamation of aluminium from low-grade scrap and dross by the catalytic distillation process which we have just described. The apparatus seen on the table in the background is used for the purification of magnesium by vacuum distillation. By another type of distillation method, involving the intermediate formation of one of its stable halide, beryllium has been distilled at temperatures far below those at which its vapour pressure is sufficiently high for its direct distillation. Similar work on titanium, including the preparation of the metal by indirect distillation, by the hydrogen reduction of titanium halides and by other means, is also in progress, but data regarding the methods used are not available for publication.

Investigations under the sponsorship of the Tin Research Institute have led to the development of new aluminium-tin bearing metals containing about 30 per cent. of tin. Bearing tests, it is stated, have indicated that the alloys have a high fatigue resistance, and promising results in engine trials using the new material have been reported. The "500" or Alminal series of alloys constitute, perhaps, the most interesting development of the work at Fulmer. These aluminium-copper-cadmium alloys, in the fully heat-treated condition, have properties considered to be at least equal to those of the normal Duralumin type, but they show a remarkable facility for hot working by forging or extrusion and do not age at room temperatures after solution treatment. The alloys, therefore, may be fabricated at a greater rate than the conventional Duralumins. Moreover, it is not necessary to carry out cold-working operations immediately after solution treatment, or to refrigerate the alloys, as is necessary in the case of Duralumin to avoid room-temperature hardening.

ALLOYS FOR PRESS TOOLS.—The Imperial Smelting Corporation Ltd., 37, Dover-street, London, W.1, have issued a second edition of their "Kayem" handbook (price 5s.), describing the properties and applications of their Kayem and Kayem 2 alloys for press forming and blanking tools. The latter metal is the harder of the two and has a greater wear resistance, but it is not recommended for drop-hammer work, for which the original Kayem alloy is more suitable. Both alloys can be produced easily and can be cast to close tolerances. It is stated that they do not deteriorate when stored, and can be melted and re-cast as new tools.

THE PROJECTILE AND ENGINEERING CO., LTD.—To celebrate their 50th anniversary, the Projectile and Engineering Co., Ltd., Acre-street, Battersea, London, S.W.8, have issued an illustrated brochure entitled "A Short Record of Half a Century's Progress, 1902-1952." In fact, the origin of the company dates back to 1879, when Mr. Claude T. Cayley started a die-manufacturing business. In 1887, this works was transferred to the present site, and in 1888 the company commenced production, by a hydraulic-forging process, of projectiles, and in 1902 the present company was formed, under the name Projectile Co. (1902), Ltd., to carry on the work. Early in the century they extended their range of manufactures to include storage vessels. During the first World War the company made ammunition of all sizes, and large extensions to the works were built. After the war, the manufacturing capacity was available for other fields, notably chassis-frame production, as well as for a wide range of general engineering products; accordingly, the name of the company was changed to the Projectile and Engineering Company. After 1935, the growing international tension caused their resources again to be turned to the manufacture of munitions, and during the second World War the whole works was devoted to war production, including chassis frames for army vehicles, gun-firing platforms, high-pressure oxygen cylinders, etc., as well as shells and bombs. Since the war, they have been engaged in producing motor-car chassis frames, woodworking machinery, injection moulding machines, die-casting machines, and moulds and dies.

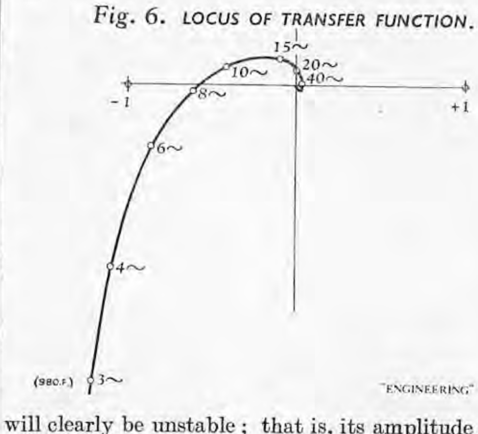
SERVO MECHANISMS IN AIRCRAFT.*

By F. W. MEREDITH, B.A., F.R.Ae.S.

(*Concluded from page 482.*)

Stability.—In a closed-loop servo-mechanism, the direct consequence of a misalignment is generally a force or torque after amplification of the misalignment signal. Generally this results in a rate of change of the motor velocity, and, if θ_o is a position, two stages of integration are involved in the power route. The result is that, in the absence of any variation in the input, θ_i, the mass of the motor and its load is subjected to an acceleration depending on displacement. Thus, if the whole loop is sufficiently linear, its dynamic state will approximate to that of a mass located by a spring; that is, an undamped harmonic oscillator. Now, if there is any additional time lag in transmission round the loop, the restoring force will be late and the oscillator

Fig. 6. LOCUS OF TRANSFER FUNCTION.



will clearly be unstable; that is, its amplitude will spontaneously increase. It is thus apparent that, apart from the specific requirements of the two routes, there is an additional requirement that the closed loop shall be sufficiently stable. In general, provided the performance of the individual elements can be expressed mathematically, the performance of the closed loop can be expressed by a differential equation. If also all the components are linear and the relationships are invariable, the characteristic equation will have constant coefficients. Such a system is capable of precise analysis and prediction

I have shown that an idealised simple position-locating loop constitutes an undamped oscillator. Clearly if the feed back includes a component of motor speed as well as position, the restoring force will act earlier and the oscillator will be damped. In either case the characteristic differential equation is of the second order and the loop may be classified therefore as a second-order loop. If, however, the output quantity is velocity, the idealised characteristic equation is of the first order representing a continuous subsidence of the fed back quantity and the system may be called a first-order loop. A first-order loop may also be approximated with a position feed back if the motor characteristic is such that its velocity is proportional to the misalignment. The infinitely-variable gear, as a means of modulating the output of a constant-speed motor, is an example of such a system in which the misalignment input is the displacement of the driven wheel from the axis of the driving disc. A hydraulic motor can approximate the same characteristic since the motor inertia is relatively negligible and the control valve misalignment approximately controls the rate of admission of the working fluid to the motor. As an idealised system there can also be a zero order loop; for example, when the fed back quantity and hence the misalignment is itself a force or a torque. Such a system is sometimes referred to as a torque amplifier. It is one form of power control that has been employed to operate the control organs of aeroplanes.

All practical closed-loop systems involve a characteristic equation of a higher order than their nominal order. As the loop gain is increased in pursuit of greater precision, inertia and elasticity of light rigid components become important, and, on the electrical side, stray inductance and capacity can no longer be neglected. When these effects are taken into account the order of the characteristic equation rises. Thus all closed-loop systems are capable of spontaneous oscillation under certain conditions. We shall see that this always sets an upper limit to the loop gain that can be employed.

I have referred to the loop gain $\mu\ \beta$ as if it were a simple ratio. This is only the case in an ideal zero order loop. In any practical system it must be regarded as a transfer function, that is, the relationship of two quantities which are related in time by a differential equation. If one quantity is a simple-harmonic oscillation, a second quantity, related to the first by a linear differential equation of constant coefficients is also a simple-harmonic oscillation of the same frequency. In general, these two oscillations will reach their peaks at different times; they are said to differ in phase. It is thus apparent that for any one frequency the loop gain may be represented by two quantities, the amplitude ratio and the phase difference. These two quantities may again be represented by a vector of which the length corresponds to the amplitude ratio and the angle corresponds to the phase difference. If now the frequency of the oscillation is slowly changed, the representative vector will also change and the free end of the vector will sweep out a locus. If this locus is marked out with a scale of frequency it becomes a complete representation of the transfer function from the one quantity to the other. A typical transfer locus representing the loop gain of a first-order system containing unavoidable lags is shown in Fig. 6. Such a diagram is known as the Nyquist plot of the open loop.

We may now consider what to expect if the Nyquist plot passes through the point -1. Physically, this means that at some frequency the loop gain will be a simple sign reversal. But, since we are dependent upon a sign reversal of the feed back in the comparator, a second sign reversal results in the feed back supplying exactly the signal required for its own support independently of any demand, once the loop is closed. Such a system will thus oscillate spontaneously at the frequency for which the transfer function is equal to -1. This is the physical basis of the Nyquist criterion of stability. A rigid statement of the Nyquist criterion in non-mathematical terms is impossible owing to the possible complexity of the Nyquist plot. For most purposes it is sufficient to say that, if the curve embraces the point -1, the system will be unstable when the loop is closed, but that if it excludes this point, as in Fig. 6, it will be stable. Thus any loop will become unstable eventually if the amplification is steadily increased. The difficulty in applying the criterion, in the over simplified form which I have stated, arises in the case of conditionally stable systems, that is, systems which are only stable over a specific range of amplification. It will be appreciated that a loop containing any unstable element, if stable for any amplification, must be conditionally stable since it will go unstable if the amplification is sufficiently reduced to allow the unstable element to perform uncontrolled.

It thus appears that there are conflicting requirements in the design of every closed-loop system. To reduce the error on which the system depends for its operation, we want to make the loop gain as large as possible and to ensure stability we must keep the gain within the limit set by the Nyquist criterion.

Servo Trains.—Most control systems, mechanical or otherwise, are found on close analysis to consist of servo-trains, that is an assembly of several closed-loop systems forming a major loop open or closed. In mechanical servo-trains of this kind a human operator often provides one of the elements, as when a helmsman steers a ship by compass. In all such cases the human operator can be replaced by a servo mechanism and it is often desirable to do so either for reasons of economy or because the range of successful operating frequency can be increased by eliminating the human discrimination lag. The main applications of servo mechanisms in aircraft are those which have been introduced to take over functions of the human pilot. Thus the automatic pilot is used primarily as a regulator

* Paper read before Section G of the British Association at Belfast on Tuesday, September 9, 1952.

of the flight attitude, the aeroplane control organs supplying the motive power. But the automatic pilot is also a local closed-loop system, with its own motive power, for amplification of the signals of the gyroscopic detectors to movements of the control organs. Within the automatic pilot many more local closed-loop systems are employed for computing purposes and to provide manœuvrability.

The Automatic Pilot.—The earlier automatic pilots were comparatively simple devices arranged to stabilise the aeroplane in straight flight. Two free gyroscopes were employed to define a frame of reference and the disturbances of the aeroplane were detected by pneumatic error detectors, one attached to each of the gimbal rings of one gyroscope, the third being operated by the second gyroscope. Pneumatic rams were used for the servomotors and the feed back was provided by a mechanical connection between the servomotor and the "follow-up" frame on which the gyroscope was mounted. Long term monitoring was provided by gravitational devices operating directly to precess the gyroscopes about the two horizontal axes. The arrangement thus followed closely that of Fig. 1, page 482, *ante*, and was, in fact, a further development of the Whitehead torpedo system. The azimuth datum was at the mercy of the random precession of the azimuth gyroscope until, in 1927, the principle of monitoring the gyroscope from a magnetic compass was introduced. This principle has since been developed as the basis of the modern aircraft compass, the speed and acceleration of the aeroplane rendering the principle of the marine gyro-compass inapplicable.

These early automatic pilots were produced principally for stabilising bomber aircraft and manœuvre was limited to slow changes of pitch datum, produced by displacement of the datum of the longitudinal gravitational monitor, and slow turns executed without banking. An ingenious device for countering the effect of the centripetal acceleration on the lateral gravitational monitor was introduced in 1933. This device was based on the principle of the Lanchester pendulum, wherein a gyroscopic torque, proportional to the rate of turn, is arranged to balance the torque produced by the centripetal acceleration acting on the pendulum.

As the streamlining of aeroplanes progressed the method of flat turning, to bring the aeroplane to the correct heading for the release of the bomb, had to be abandoned because, after a discrete change of heading, the aeroplane continued to move in the same direction and only subsided on to the new course with a time lag of about 15 or 20 seconds. In nautical terms, there was too much leeway. Thus, both for military and for civil purposes the need emerged for an automatic pilot capable of executing correctly co-ordinated turns and generally of a high degree of manœuvrability. Now the co-ordination of turn requires that the tangent of the angle of bank shall be proportional to the product of the rate of turn and the forward speed. In general, the designers of automatic pilots have been reluctant to rely on computation requiring accurate measurement of the forward speed and many alternative devices have been tried. Of these, perhaps the most successful, dating from 1938, relies on the principle of disturbance compensation which I have described. In this system, the error in co-ordination is detected by a lateral pendulum, the signal from which is used to monitor the rate of turn, the angle of bank being the quantity controlled by the pilot's input. Since, however, a high loop gain could not be employed on the rate of turn control without introducing oscillatory instability, a datum disturbance compensation to the rate of turn demand was introduced proportional to the ordered angle of bank and inversely proportional to a preset estimated forward speed. By these means the required degree of precision of co-ordination was obtained without requiring a prohibitive loop gain in the rate of turn control.

The increasing complexity of the modern automatic pilot has necessitated resort to electrical signalling systems and electrically-driven gyroscopes. Generally, this change has been accompanied by a change over to electric motors to provide for a single source of power. This has provided a degree of flexibility in design and adjustment which could not have been easily attained by the original pneumatic systems. As a result, the automatic pilot is capable of correcting the inherent lack of damping in yaw of the modern aeroplane, a task generally beyond the capacity of a human pilot and of manœuvring up to and through the barrier of sonic speed.

Among the many difficulties with which the designer is faced, is the fact that gravitational monitors are of very limited use at very high speeds. With our earthbound habits of thought we are apt to regard the pendulum as a device which seeks the vertical and which may be somewhat disturbed by accelerations of its mounting. It is more realistic to recognise that the resultant gravitational field inside a moving craft is solely produced by the resultant external force applied to the craft and that gravitation is not an external force but a convention of the system of axes we choose to call unaccelerated. Thus, in an interplanetary vehicle there would be no gravitational field other than that caused by the reaction of propelling rockets. The aeroplane flying at 50,000 ft. is not yet an interplanetary vehicle but, unless one can be assured that it is not accelerating relative to axes fixed on the ground, the pendulum cannot be relied upon to give any indication of the vertical. This does not mean that the pendulum is useless but rather that gyroscopes must be relied upon for much longer times to achieve the state of unaccelerated flight in which the pendulum can perform its monitoring function. Since the magnetic compass is also gravity dependent—the magnetic field defines a line and not a plane—the same remarks apply to magnetic monitoring of azimuth.

Electric automatic pilots have generally relied upon the thermionic valve for signal amplification and for the required "shaping" of transfer functions. Recently, the magnetic amplifier has been steadily displacing the valve and prototype autopilots are flying with all valves eliminated. The magnetic amplifier relies on the ability to modify the performance of an inductance by variation of the degree of saturation of the core. This saturation is controlled by a direct-current winding in which the alternating flux is balanced. By the use of regenerative feed back, very useful power amplification can be obtained in a single stage and several stages can be used in cascade. For power applications the technique is competitive with the valve amplifier in respect of size and weight and is to be preferred for reliability. The main difficulty in the use of magnetic amplifiers is the inherent time lag involved in varying the controlling flux. However, by the application of loop theory, a somewhat complicated system of feed-back can produce a cascade amplifier to handle the power required in an automatic pilot with a lag of the order of ten milliseconds when used with a 400-cycle supply. By greater refinement or by the use of a higher supply frequency, still quicker response is practicable. It is therefore probable that magnetic amplifiers will find a wide field of application apart from aviation.

Blind Approach.—Recently, the automatic pilot has been developed to seek and follow a track defined by radio, primarily for blind approach in fog. With this development the aeroplane becomes a component in yet a wider loop and the wings of the aeroplane provide the servo power. These applications of the servo art provide the most complex stability problems. The main component, the aeroplane itself, varies widely in its transfer functions, due to the range of speed and altitude over which it has to operate. Moreover, it is sometimes an inherently unstable component. Riding the radio beam at short range from the transmitter provides a still more complex problem, since it involves relationships no longer expressible by differential equations with constant coefficients because the range from the transmitter and the tolerable errors are continuously changing. In addition the track, defined by the radio, is distorted by interference patterns caused by unavoidable reflections when the aeroplane is close to the runway and the greatest precision of location is required. This introduces in an acute form the problem of discriminating signal from "noise," i.e., the useful intelligence from spurious signals. Fortunately, a "noise-free" representation of the rate of change of the error from track can be obtained from the aircraft compass since the direction of the track is known. It is thus not necessary to accentuate the "noise" by differentiating the error signal in order to obtain the required loop stability.

In spite of the difficulties of the problem, the stage has now been reached that automatic approaches under conditions of bad visibility can safely be made provided the last hundred feet of the "let down" can be made by visual guidance. By the use of suitably-designed aerodrome lighting systems, landings are practicable in almost every condition of visibility because the thickest ground fogs are generally of limited height and, provided the aeroplane has been correctly placed by the automatic approach system, the position of the lights can be recognised by the patches of illumination on the top of the fog layer. It may confidently be predicted that in another ten years, complete automatic control will be a normal method of effecting the landing manœuvre.

Any control system involves a risk of malfunctioning due to failure of one of the components in the train and, when so many components are involved, as in the case of automatic landing, this risk is considerable. It is, therefore, essential that any system of blind landing—or even of blind approach—should be so monitored that a failure of any part of the system will become apparent to the pilot before a dangerous situation has developed. If possible, such a monitoring system should comprise an entirely independent train of communication but, provided the component reliability can achieve a high enough standard, it may suffice to ensure that each section is so monitored that a fault in that section becomes apparent.

Should it prove desirable to use an entirely independent train of communication, the system known as Ground Control of Approach—or G.C.A.—could be employed. In this system, the position in plan and elevation of an approaching aeroplane is continuously observed by radar operating on the ground and instructions are communicated by radio-telephone from a trained observer to the pilot. This system was extensively used for military aeroplanes in the later stages of the last war and, although it does not provide an absolutely safe method of control, it could undoubtedly supply the required monitoring for an independent automatic approach system.

Power Controls.—In the early days of aeroplanes, the control surfaces—rudders, elevators and ailerons—could be moved easily as required by direct mechanical connection from the cockpit controls—the rudder bar and the control column, or, as it came to be known, the "joy-stick." But, as the size and speed of the aeroplanes increased, the operating forces naturally became heavier. At first, this difficulty was easily met by the device of aerodynamic balance, that is, the extension of some of the movable surface in front of the hinge line so as to balance part of the aerodynamic forces about the hinge. Close aerodynamic balance was never practicable, however, because the effects are essentially non-linear; the amount of balance surface required varies with the angle of the control surface. However, until quite recently the ingenuity of the aerodynamic designer has been capable of keeping the operating forces within the capacity of the pilot over the required range of angles and flight speed without introducing the instability of over-balance.

The rapid increase in the speed of flight which has taken place in the last decade has produced a situation in which aerodynamic balance no longer suffices, for, it must be remembered, these aerodynamic forces increase with the square of the speed. Thus, in the larger modern aeroplanes, servo mechanisms are required to enable the pilot to move the controls. These servo mechanisms are known as power controls and are the counterpart of the steering engines of the marine art. Aerodynamic servo controls, suggested by Flettner some 30 years ago, have been in use for some time. In these aerodynamic servos, the pilot's rudder bar, for example, instead of being connected to the rudder, is connected to a flap or tab hinged to the rear of the rudder. Thus, the tab modulates aerodynamic power to move the rudder and the feed back is provided by the resulting hinge moment of the rudder. Such controls are now generally known as "servo tabs."

In a further elaboration of the servo tab, known as the "spring tab," the rudder bar is connected differentially to the tab and the rudder so as to provide an additional mechanical fed back and the relative movement of the tab is restrained by a spring. With this arrangement, the spring dominates the feel at high speeds, when the aerodynamic forces are large, and provides a rudder-bar reaction substantially proportional to the rudder angle, while, at low speeds, the spring is but slightly deflected and the reaction approximates to the load on the rudder. A further advantage of the spring-tab arrangement is that the gearing between the rudder bar and the rudder decreases as the airspeed (and, consequently, the spring deflection) increases. It thus provides a reduction in the gain of the aeroplane control loop to offset partially the increase in the aerodynamic part of the loop.

These servo tabs and spring tabs, however, do not provide a complete solution of the problem because the forces required to move the tabs themselves are not negligible. This difficulty can be met to some extent by aerodynamic balance of the control so as to reduce the size of the tab required and again by aerodynamic balance of the tab itself. However, in transonic flight the flow pattern changes drastically, with the result that the centres of aerodynamic pressure on the movable surfaces also change drastically. It is therefore extremely unlikely that close aerodynamic balance can be achieved in this regime.

As a result of these difficulties and also for reasons connected with the problem of flutter, that is, unstable oscillations due to accidental aerodynamic loops, the present trend is towards hydraulic motors for power controls. Hydraulic motors seem ideally suited for the purpose on account of their overall lightness and their low inertia. It cannot be said that really satisfactory designs of hydraulic power controls have yet been achieved. The two main difficulties are to provide against catastrophic malfunctioning in the event of any failure and to provide the required threshold sensitivity of performance. An aeroplane cannot be stopped in transit, as a ship can, to repair a fault in the steering engine. It is therefore necessary to design a power control system so that the pilot can retain control in the event of any foreseeable failure. This requirement can only be met by duplication of all parts of the system in which failure can occur. It is also necessary to ensure that a runaway cannot occur in any circumstances since the application of full control at high airspeed would certainly cause structural failure. Manual reversion can be employed for some aeroplanes but in most cases the forces would be well beyond the control of the human pilot. Thus, the power control must be designed so that a faulty motor cannot prevent the remaining serviceable motor from exercising effective control. These safety requirements set a difficult but not insoluble problem.

At modern flight speeds the control organs, especially the elevator, require to be located to a precision of about a tenth of a degree, or, say, one part in 500 of the range of control. In the presence of unavoidable friction causing threshold insensitivity and because of the "dead spot" associated with the reversal of action of hydraulic valves, this is an arduous design requirement. Naturally, it is necessary to increase the loop gain as far as the loop stability will permit and generally it is found that the elasticity of the aeroplane's structure provides stray feed back couplings. It is, therefore, not surprising that many power control systems fall short of the required degree of precision of location. The resulting imperfection is generally most noticeable when the aeroplane is flying under the control of an automatic pilot which is sufficiently sensitive to set up a steady small amplitude oscillation or "hunt" of the whole aeroplane as a result of the extra phase lag introduced into the transfer function at small amplitude. This is a situation which cannot be rectified by modification of the transfer function of the autopilot local loop; the remedy necessarily lies in the improvement of the threshold performance of the power control loop.

Flutter.—We are all familiar with the phenomena known as Aeolian tones without perhaps realising that the singing telegraph wire is an example of an unstable aerodynamic servo loop. As the wire oscillates across the wind it generates free eddies travelling downstream such as we observe when we paddle a canoe. The detachment of the eddies change the circulation round the wire and the circulation controls the cross wind force. We thus have a feed-back mechanism which, in this case, causes spontaneous oscillation. The mechanism is closely analogous to that of the reed in a musical instrument.

Oscillations of the structure of an aeroplane due to accidental aerodynamic servo loops are known as "flutter" and have caused fatal accidents. The phenomenon has been studied both analytically and experimentally for about a quarter of a century and a number of design rules have been provided to reduce the risk as a result of which flutter incidents are now rare even on prototype aircraft. Fortunately, the relationships on which flutter depends are generally non-linear, with the result that the critical flight speed for instability is dependent on amplitude and so dependent that an increasing speed is required to sustain an increasing amplitude. Thus an experienced test pilot, on his guard against flutter, when increasing the speed of a prototype aeroplane above that at which he has had previous experience, can detect an incipient flutter and generally check it in time by reducing speed.

The possibility remains that a flutter could develop on a new prototype aeroplane in which the critical speed was reduced with increasing amplitude, in which case reduction of speed once the flutter had started might prove catastrophic. For this reason, when the possibility of flutter is suspected, the precaution is sometimes taken of deliberately shock exciting the suspected mode at progressively increasing flight speeds and recording the rate of decay so as to detect an approach to a condition of zero damping without approaching dangerously close to this condition. It may well be that some such technique will have to be adopted as a routine in all flight test programmes of prototype aircraft.

The control surfaces of aeroplanes can provide the coupling to cause flutter. Thus, if the tail structure is oscillating from side to side the rudder will tend to move in sympathy and, under certain conditions, the resulting forces on the rudder will be phased so as to cause the main oscillation to increase For this reason it is customary to provide mass balance in front of the hinge to counter the tendency for the control to move in response to acceleration. However, if the control surface is sufficiently rigidly located by a servo motor it may be possible to omit this balancing mass. If this argument can be substantiated the power control can be provided at little or no weight penalty because the servo motor and the balance mass are about equal in weight.

Auxiliary Controls.—I have, as I warned earlier, rather concentrated on the main applications of the art of servo mechanisms in aircraft—those involving the control of the aircraft itself. There are, of course, other applications of great importance, particularly in the control of the power unit. One of the most elegant and successful of these applications is the mechanism for controlling the pitch of the airscrew to maintain constant speed of rotation with variable operating conditions of the engine. With the introduction of turbine engines, in which the temperatures are necessarily operating as close as possible to the limits set by the materials, servo mechanisms have had to be developed to regulate the fuel supply so as to control the temperature of the gases entering the turbine.

Instrumentation.—The instrumentation of the aeroplane, particularly the military aeroplane, provides numerous applications of the servo art in computation, data transmission and stabilisation. We have often seen references in the war communiqués to radar-controlled bombing of unseen targets. The complexity involved in such extensions of the military arts can perhaps be appreciated from a published statement that 40 per cent. of the cost of a recent American bomber is accounted for by electronic equipment, which contains no less than 1,200 electronic valves. These figures, perhaps, suggest the scope of the technological revolution to be expected when the efforts of technologists can be diverted from the needs of war to the service of man.

THE ADVANCING FRONT OF CHEMISTRY*.

By PROFESSOR W. WARDLAW, C.B.E.

(*Concluded from page 484.*)

IT has been mentioned that the less common metals are assuming increasing importance, but the use of many of them in industry must be severely curtailed by the limited supplies available. Actually, it is a vicious circle. New ideas are not developed because of the shortage of the element, and, at the same time, it does not appear worth while to develop methods for increasing supplies when uses are not apparent. In the search for new metals the vacuum induction furnace has played a major rôle. By this technique the preparation and melting of metals can be carried out free from oxygen, nitrogen or carbon and without contact with ceramic crucibles. The reduction of the iodide of a metal *in vacuo*, developed experimentally some 25 years ago, is being applied on a large scale to yield very pure metals. The reduction of the tetrachloride by liquid magnesium has produced tons of titanium and zirconium, two of the most difficult metals to prepare. The more optimistic predictions for titanium as a high-temperature material failed to be realised, but titanium continues to find favour as a metal of exceptional promise in aircraft, marine and armament work.

Zirconium is entering a new era. The outstanding property is its excellent corrosion resistance, while its very small affinity for neutrons commends its use as a structural material in atomic power plants. The carbides of both titanium and zirconium are also in the news. The first is proving suitable for jet-engine applications, and the second is of interest as a source of zirconium tetrachloride for the production of zirconium metal. Both titanium and zirconium appear to have a future in important alloys which can be made by arc-melting in argon or helium atmospheres. Interest is maintained in mixtures of refractory metals and oxides, such, for example, as titanium and alumina. It is said that such mixtures withstand higher temperatures than are possible for the metal alone. Among the special oxide refractories are zirconia with traces of calcium oxide. This is used in the manufacture of turbo-jet engine blades. Electrolytic methods for the production of titanium are being explored, and there is little doubt that at the accelerated rate at which research is being carried out results of great importance will emerge in this field of the less-known metals. It is significant that, in the United States, quite recently, industry got its first chance to see pure hafnium metal. Hafnium is always present as an impurity in zircon sand, which is used as a source of zirconium.

A development of the utmost importance concerns the rare element germanium, the existence of which was predicted by Mendeléeff in 1871 before its discovery in 1886. In 1948, the Bell Telephone Laboratories in the United States produced a crystal triode—a germanium crystal with two cat's-whiskers spaced a hairbreadth apart on its surface—which, when incorporated in a valveless radio receiver, operated a loudspeaker. Few could have foreseen that, when the early cats's-whisker and crystal wireless set was superseded by the modern sets using thermionic valves, the crystal would again become the focal point of development. With investigations proceeding so rapidly it is difficult to foresee the full implications of this valuable discovery of 1948. However, this new situation calls for supplies of germanium, and hitherto germanium has been difficult to obtain. A British firm has recently perfected a commercial process for the extraction of germanium from flue dust.

The story behind this development is a fascinating one. Some years ago, Professor Goldschmidt, a Norwegian scientist, in the course of his geochemical research, examined a piece of British coal spectrographically and found that it contained an unusually high percentage of germanium, much of which remained in the ash. Further search revealed that it came from Hartley Colliery, near Newcastle-

* Presidential address to Section B of the British Association, delivered at Belfast on September 4, 1952. Abridged.

upon-Tyne, where most of the coal was found to contain recoverable quantities of both gallium and germanium. The late Sir Gilbert Morgan, at that time Director of the Chemical Research Laboratory, Teddington, was able to establish that the germanium content varied according to the source of the coal, and that the greatest concentration of this element occurred in the dust deposited in the flues of gas-works producer plants.

It must not be inferred that the rarer elements are the only elements which are commanding special attention at the present time. Recently, at Liége, in Belgium, nine countries including Britain co-operated in the design, construction and trial of a new type of blast-furnace, which will run on pure oxygen instead of air. Behind this idea lies the possibility of a revolution in iron and steel-making. In practice, much will depend on the feasibility of making cheap oxygen in great tonnage. Silicon, which occurs widely in Nature, is much in the news nowadays. Industry is interested in at least three groups of silicon compounds, the silica sols, silicon esters and silicones. The silicones represent an important range of compounds which, since 1943, have been prominent in industrial practice. The production of silicones in Great Britain has hitherto been comparatively small, but supplies will be much greater in the future, and this will promote the wider use of these extremely useful substances. One of their most important properties is their water repellancy.

A valuable characteristic of a silicone film is that it is chemically inert and does not deteriorate on prolonged exposure to moisture, sunlight and weathering. These properties are utilised by incorporating silicones in automobile and furniture polishes, and in the waterproofing treatment for nylon and other fabrics. The simplest silicones are the methyl silicones, which may exist as oils, resins and rubbers. Resinous silicones have excellent dielectric properties and are used for electrical insulation; they are stable at temperatures at which the usual organic insulating materials decompose rapidly. Silicone rubber may be used for electrical insulation and for other purposes for which rubber is required, especially at elevated temperatures. It will be evident that the chemist has evolved a group of substances with entirely novel properties, which are proving most valuable in many ways.

There are few known elements which have not been used in attempts to make fluorescent materials. The largest consumer of these fluorescent substances or phosphors is the fluorescent lamp. The world production of these lamps is now at least 100 millions annually, demanding tons of phosphors of the highest purity. Some of the best-known phosphors have their prototypes in natural minerals, but there is still much to discover and explain about these remarkable materials. In this field of work the active co-operation of the inorganic chemist, the physical chemist and the physicist continues to extend our knowledge of chemical substances which, about 25 years ago, were laboratory curiosities and are now made on an industrial scale. In recent years, developments have proceeded with great rapidity in the field of fluorine chemistry. The preparation of fluorine by Moissan in 1886 solved one of the major problems in chemistry at that time, and between the years 1900-1925 the brilliant Belgian chemist, Swarts, laid the foundation of organic fluorine chemistry. During the past 20 years, workers both at home and abroad have developed methods for the controlled interaction of fluorine and organic compounds. This has given that remarkable category of compounds, the fluorocarbons. A detailed study of CF_2Cl_2 has shown that it is non-toxic, non-corrosive, non-inflammable, has no odour and is not absorbed by foodstuffs, etc. Such compounds—the Freons—are used extensively in the United States in air-conditioning and refrigeration, and commercially are the most important group of organic fluorine compounds.

Detailed final results of the 1948 Census of Production are now becoming available and the preliminary examination discloses an illuminating picture of the changing structure of British industry. The census has confirmed great changes in the relative importance of the various industry groups. A shift in productive resources and outputs from industries such as mining and textiles, towards engineering, vehicles and chemicals, is clearly revealed. The growth of the chemical industry is spectacular. By starting with a comparatively few substances and combining these into various forms, an ever-increasing range of new products have been made available. People frequently misinterpret the term "synthetic;" they consider it means artificial, and therefore inferior. Actually, when naturally occuring substances are duplicated by synthesis, the justification is higher purities and lower costs. Synthesis very frequently leads to products with unique properties, having no natural counterpart. Synthetic fibres, for instance, have made us independent of certain natural fibres and have widened the choice of clothing and fabrics. Synthetic resins are supplementing metals in hundreds of different ways. Synthesis has made possible the thousand and one new chemicals in common use to-day.

The chemical industry is, of course, not one industry, but literally thousands of specialist industries, differing in the details of the processes and problems of manufacture, yet linked by the fact that they are all based on the science of chemistry. It has been a spearhead in the drive for exports and particularly in the groups of drugs, medicinals, dyes, fertilisers and alkalies. This industry faces lively and exciting competition in the world chemical market, but intensive research, manufacture of new products, the use of improved methods as well as a vast programme of reconstruction and expansion, should give it a powerful position. Incidentally, there are many voices raised to-day to impress on us the prime importance of chemistry to industry, agriculture, medicine and defence. It is most desirable that this should be said, and said often. There is a real danger, however, that the practical applications of chemistry, rather than its theoretical principles and fundamental discoveries, should be uppermost in our esteem. No one can say what useful practical device may ultimately come from discoveries made purely in the pursuit of knowledge. Applied science draws its life-blood from pure science. Although we may be fascinated by applied science, it must never weaken our allegiance to pure science.

Excess Profits Levy.—The Federation of British Industries, 21, Tothill-street, London, S.W.1, have prepared a "Guide to the Excess Profits Levy" [price 1s.], which explains the major provisions of the complicated legislation on this subject.

Economy of Iron and Coke in Foundries.—A leaflet giving practical hints for saving iron and coke in foundries has been prepared by the Council of Ironfoundry Associations, Crusader House, 14, Pall Mall, London, S.W.1, from whom copies are available. The Council state that unless strict economies are made the iron-founding industry will be faced with great difficulties.

LUBRICATOR FOR CHAINS.

SNOWDON, SONS AND COMPANY, LIMITED, LONDON.

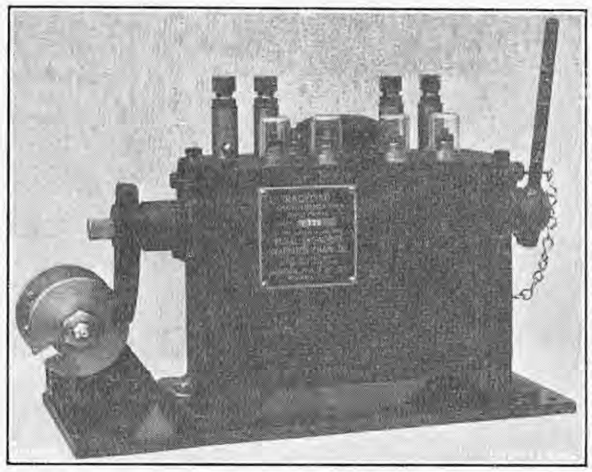
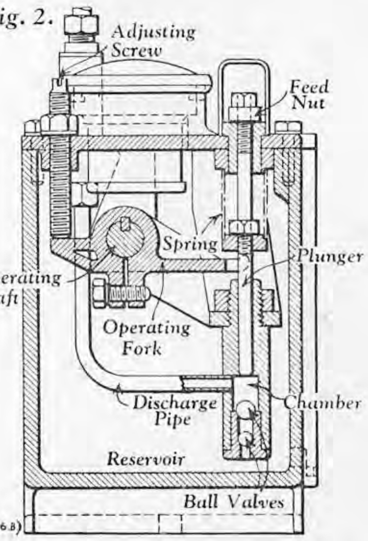


Fig. 1.

Fig. 2.



LUBRICATOR FOR CHAINS.

A new type of automatic lubricator for chains, known as the Radford chain lubricator, has been introduced recently by Messrs. Snowdon, Sons and Company, Limited, 4, Chantrey House, Eccleston-street, London, S.W.1. The Radford chain lubricator, which is illustrated in Fig. 1, can be designed to feed a metered quantity of oil to every link of a chain in any desired time sequence. The number of feed nozzles provided depends upon the type of chain, but each feed has an independently operated and adjustable pump. An adjustment is also provided for regulating all the feeds simultaneously.

The principle of the Radford chain lubricator may be understood by referring to Figs. 1 and 2. On the left of Fig. 1 may be seen a cam wheel which is driven, through suitable gearing, from the chain or its driving mechanism. The cam carried on the cam wheel is designed so that it lifts the operating arm gradually, but allows it to return to its normal position with a "snap" action. The operating arm is fixed to a shaft passing through the body of the lubricator. Within the lubricator housing, the operating shaft (Fig. 2) is attached to an operating fork controlling the movement of the pump plunger. Thus, when the cam lifts the operating arm, the shaft rotates causing the operating fork to raise the plunger, drawing oil from the reservoir, through two ball valves, into a pump chamber. When the operating fork is released by the cam, the plunger is "snapped" back by a spring, causing a measured quantity of oil to be ejected through a discharge pipe, by way of ball valves (not shown in Fig. 2) to the feed nozzle. Each plunger stroke can be individually adjusted by a feed nut. Alternatively, all the feeds can be adjusted simultaneously by a screw which alters the setting of the operating shaft.

The housing, cover plate and bearings are in cast iron. The plungers are of cast steel. The whole mechanism is mounted on the underside of the cover and may, therefore, be readily withdrawn for servicing. The plungers are enclosed at the top in transparent plastic covers to protect them from corrosion, and to allow their movements to be observed, any failure being immediately visible.

Boilers in Operation for 51 Years.—Eight of the eleven boilers which were installed by Messrs. Babcock and Wilcox, Ltd., Farringdon-street, London, E.C.4, in the Bloom-street power station of the Manchester Corporation in 1901 are still able to carry load. Originally each had an output of 18,000 lb. of steam per hour at a pressure of 160 lb. per square inch and 90 deg. F. of superheat, and was fitted with a chain-grate stoker, the heating surface being 5,137 sq. ft. At first, four 3,000-indicated horse-power Musgrave engines were supplied, but from 1917 to early in the present year the boilers were connected to a 40-MW turbine. When this conversion took place the grates were lengthened from 8 ft. 6 in. to 10 ft.

LORRY-MOUNTED 20-TON CRANE.

STEELS ENGINEERING PRODUCTS, LIMITED, SUNDERLAND.

FIG. 1. CRANE CHASSIS, WITH LEYLAND "HIPPO" COMPONENTS.

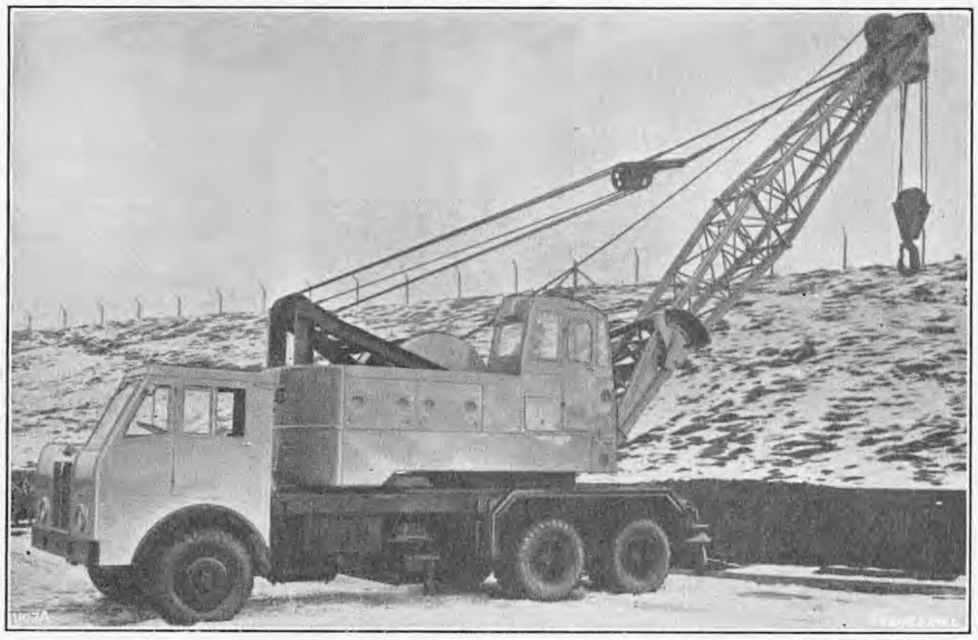


FIG. 2. 20-TON JIB CRANE.

LORRY-MOUNTED 20-TON CRANE.

FIG. 1, above, shows the chassis for the Coles 30-ft. jib crane, which is constructed by Steels Engineering Products, Limited, Crown Works, Sunderland, and believed to be the most powerful mobile crane in production in this country. The main chassis components—the power unit, gearbox, and axles—are taken from the Hippo chassis manufactured by Leyland Motors, Limited, Leyland, Lancashire, who are supplying 50 such chassis to Steels Engineering Products. The frame itself, however, is constructed by the latter company. It consists of a heavy structure built up from deep rolled-steel joists, and incorporates the slewing base for the crane. The rear wheels are carried on rocking beams pivoted at their centres to brackets attached to the chassis frame. When the crane is travelling between sites, the jib is lowered to lie alongside the cab. Power-assisted steering is provided to assist the driver in handling this heavy vehicle on rough ground, hydraulic pressure being supplied by a pump driven from the 125-h.p. Leyland Diesel engine. The foot brake, which operates on the front and rear wheels, is pneumatically actuated. The main four-speed gearbox and the auxiliary gearbox together provide a range of road speeds from $26\frac{1}{2}$ m.p.h. to 2·1 m.p.h. at 1,800 r.p.m.

The complete crane, installed on the lorry, is illustrated in Fig. 2. It is fitted with a 30-ft. lattice jib as standard, but additional jib centre sections are available enabling the jib to be extended to 80 ft. It is also equipped for working with a $\frac{3}{4}$-cub. yard dragline, or a double-line grab. The crane may be operated when fully mobile, or as a fixed-base unit with extended outriggers. With a 30-ft. jib, the crane can slew a 20-ton load through a full circle at a radius of 10 ft., with outrigger extended, and a 10-ton load at a radius of 18 ft. 6 in. The slewing speed is $1\frac{1}{2}$ r.p.m. The derricking motion, from maximum to minimum radius, can be carried out in 90 seconds. All three motions are driven by individual variable-voltage direct-current motors of the series-wound commutating-pole type, and are provided with automatic electromagnetic brakes. A fourth motor drives an air compressor operating the hoist brake and clutches. Power for the electric motors is supplied by a 23-kW generator mounted at the rear of the superstructure. All the electrical equipment is designed for tropical operation. The generator may be driven by either a petrol or a Diesel engine of 70 to 80 h.p.

LAUNCHES AND TRIAL TRIPS.

S.S. "CAIRNDHU."—Single-screw cargo vessel, with accommodation for twelve passengers, built by William Gray & Co., Ltd., West Hartlepool, for the Cairn Line of Steamships, Ltd., Newcastle-upon-Tyne. Second vessel of an order for two. Main dimensions: 419 ft. between perpendiculars by 60 ft. by 37 ft.; deadweight capacity, 9,200 tons on a draught of 27 ft. $0\frac{1}{4}$ in. Double-reduction geared steam turbines, developing 4,650 s.h.p., constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne; and two Babcock and Wilcox oil-fired water-tube boilers, constructed by the shipbuilders. Service speed, 13 knots. Trial trip, August 28 and 29.

M.S. "ESSEQUIBO."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the Royal Mail Lines, Ltd., London, E.C.3. Second of two sister ships. Main dimensions: 415 ft. between perpendiculars by 58 ft. 6 in. by 38 ft. 4 in. to shelter deck; gross tonnage, about 5,500. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Trial trip, September 9, 10 and 11.

M.S. "BRATTLAND."—Single-screw oil tanker, built and engined by Aktieselskabet Burmeister and Wain, Copenhagen, for Aktieselskabet Borgestad, Borgestad, Norway. Main dimensions: 465 ft. between perpendiculars by 62 ft. 10 in. by 34 ft. $7\frac{1}{4}$ in. to main deck; deadweight capacity, 13,250 tons on a summer draught of about 27 ft. $4\frac{1}{2}$ in. Six-cylinder two-stroke single-acting B. and W. oil engine, developing 4,600 b.h.p. at 110 r.p.m. and a loaded speed of 14 knots. Launch, September 10.

M.S. "LUCERNA."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, Yorkshire, for H. E. Moss & Co., Liverpool. Second vessel of a series of three for these owners. Main dimensions: 528 ft. 10 in. overall by 69 ft. 6 in. by 38 ft.; deadweight capacity, 16,677 tons on a draught of 29 ft. $10\frac{5}{8}$ in. Hawthorn-Doxford five-cylinder two-stroke opposed-piston oil engine, developing 5,500 b.h.p. at 112 r.p.m. in service, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Service speed, about $13\frac{1}{4}$ knots. Trial trip, September 13.

M.S. "CLYDEFIELD."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for Hunting and Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 515 ft. between perpendiculars by 70 ft. by 37 ft. 9 in.; deadweight capacity, about 16,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting oil engine. Launch, September 16.

M.S. "CARDIFFBROOK."—Single-screw cargo vessel, built and engined by John Lewis and Sons, Ltd., Aberdeen, for the Williamstown Shipping Co., Ltd. (Managers: Comben Longstaff & Co., Ltd.), London, E.C.3. Main dimensions: 250 ft. between perpendiculars by 38 ft. by 17 ft. 9 in. to upper deck; deadweight capacity, about 2,270 tons on a draught of 16 ft. 11 in. Lewis-Doxford prototype three-cylinder opposed-piston oil engine, developing 1,100 b.h.p. at 145 r.p.m., and a speed of $11\frac{1}{2}$ knots in service. Trial trip, September 16.

LIGHT VESSEL NO. 13.—Built by Philip and Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Twenty-first light vessel built for the Corporation. Main dimensions: 130 ft. by 25 ft. by 15 ft.; gross tonnage, 350. The lantern contains six 500-watt lamps giving a beam visible for from 10 to 12 miles in clear weather. Launch, September 17.

M.S. "ZARP."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for Fishery Products, Ltd., St. John's, Newfoundland. Main dimensions: 112 ft. 6 in. between perpendiculars by 25 ft. by 12 ft. Eight-cylinder direct-reversing Diesel engine, developing 530 b.h.p. at 300 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester, and installed by Amos and Smith, Ltd., Hull. Launch, September 20.

M.S. "LONDON SPLENDOUR."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the London and Overseas Freighters, Ltd., London. Fifth vessel for these owners. Main dimensions: 592 ft. 1 in. overall by 80 ft. by 42 ft. 3 in.; deadweight capacity, about 24,650 tons on a summer draught of 32 ft. $3\frac{5}{8}$ in. Wallsend-Doxford six-cylinder single-acting two-stroke oil engine, developing 6,600 b.h.p. at 116 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Speed, 14 knots. Launch, September 22.

S.S. "CARL SCHMEDEMAN."—Single-screw self-unloading cargo vessel for carrying bauxite ore, built by Vickers-Armstrongs Ltd., Barrow-in-Furness, for Reynolds Jamaica Mines, Ltd., Kingston, Jamaica. Main dimensions: 500 ft. between perpendiculars by 66 ft. by 37 ft. 3 in. to main deck; deadweight capacity, 13,150 long tons on a draught of 27 ft. 9 in.; gross tonnage, about 15,000. Brown-Boveri cross-compound geared turbines, developing 6,600 s.h.p. at 112 r.p.m. in service, constructed by Richardsons, Westgarth and Co., Ltd., Wallsend-on-Tyne. Steam supplied by two Foster-Wheeler oil-burning water-tube boilers. Service speed, 16 knots. Trial trip, October, 3, 4 and 5.

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 the paragraph.

Reels for Winding Wires.—In December, 1948, when a specification for reels for covered winding wires was first issued, it was thought that it would be a long time before it could be fully adopted in view of the alterations in machinery and practice that would be required. Actually, however, the specification has proved so successful that it is now possible still further to reduce the range of sizes of the reels and a revision of the specification, B.S. No. 1489, entitled "Reels for Covered, S lid, Round Winding Wires for Electrical Purposes," has recently been published. In the new edition, the recommended reels for different gauges of wire have been adjusted in the light of experience a system of reference numbers has been brought in, marking requirements have been added, and other modifications introduced. These modifications have made it necessary to effect some adjustment to B.S. No. 1559, which covers reels and wooden drums for bare wire, stranded conductors and trolley wire for use in the United Kingdom. Accordingly, an amendment slip has been prepared and issued. Manufacturers of certain radio and electronic components have found difficulty in de-reeling very fine resistance wires, and it has been shown that unless the reels for these wires are made to precision limits, the wire stretches, giving rise to inaccuracies in the manufactured component. In consequence, a new specification, B.S No. 1888, covering precision reels for bare and oxidised resista ce wires (0·0005 to 0·0048 in. in diameter, inclusive) has been published. [Price of each specification, 2*s.* 6*d.*, postage included; amendment slip gratis.]

TRADE PUBLICATIONS.

Split Seals.—An illustrated brochure describing the different types of split seals, their operation, performance rating and advantages, has been issued by Charles Weston & Co., Ltd, Irwell Bank Works, Douglas Green, Salford 6.

"Twin Arc" Welding Instruction Book.—Information on the installation, operation and maintenance of the TA.250 twin-arc welding plant and the best twin-arc welding techniques for various types of joints is given in a booklet received from the Quasi-Arc Co. Ltd., Bilston, Staffordshire.

Electrical Installations.—An illustrated booklet recently published by the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, gives some interesting information about the electrical installations carried out by that concern in various parts of the world.

Aircraft Electrical Equipment.—We have received an illustrated catalogue issued by the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, of electrical equipment for use in aircraft, covering galley equipment, fans, fluorescent lighting and other lighting fittings, water heaters, humidifier units, and electric cables.

Battery Charger.—A simple domestic portable battery charger suitable for 6-volt and 12-volt batteries is described in a leaflet received from Standard Telephones and Cables, Ltd., Rectifier Division, Boreham Wood, Hertfordshire.

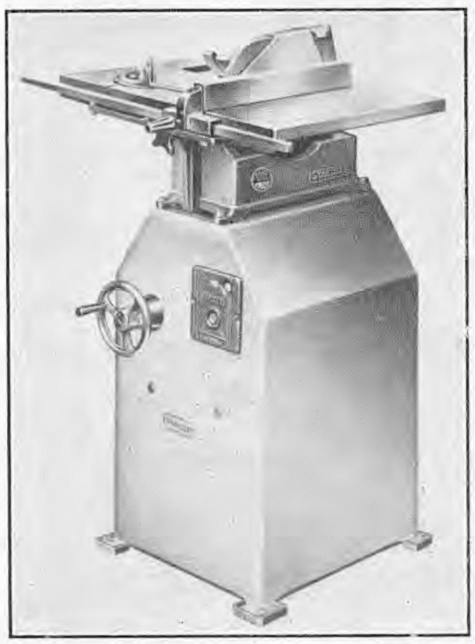
Heat-Resisting Glassware.—The British Heat Resisting Glass Co. Ltd., Phœnix Works, Loxdale-street, Bilston, Staffordshire, have issued an illustrated booklet giving the physical, mechanical and electrical properties of Phœnix glass.

Aviation Equipment.—We have received a copy of the Dunlop Aviation Equipment Manual, issued by the Dunlop Rubber Co. Ltd., Aviation Division, Foleshill, Coventry. It contains data on wheels and tyres, brakes and brake-control systems, pneumatic actuating systems, flexible pipes, windscreen wipers, armament controls, de-icing systems, and various rubber components and accessories.

Gears and Gear Units.—An exceptionally wide range of gears and gear units—typical examples of their products—are illustrated in a booklet issued by Urquhart Lindsay and Robertson Orchar, Ltd., Blackness Foundry, Dundee. The firm's gear-cutting capacity covers external-tooth straight spur gears up to 30 ft. in diameter, as well as internal-tooth straight spur, straight-tooth bevel, double-helical spur, external-tooth spiral, internal-tooth spiral, and worm gears. Provision is also made for small gears from about 2 in. in diameter, 16 D.P. The speed increasing and reducing gear units range from 4 to 2,000 h.p. and are made for many special purposes. The booklet gives some useful technical notes on gears and their lubrication.

FLOOR-TYPE SAW BENCH.

AN 8-in. diameter wood-cutting saw, giving a maximum depth of cut of $2\frac{3}{4}$ in., is incorporated in the floor-type saw bench shown in the accompanying illustration, and introduced recently by the Startrite Engineering Company, Limited, Waterside Works, Gads Hill, Gillingham, Kent. The machined cast-iron table, which is supported on a robust cast-iron main frame, can be tilted through 45 deg. and locked in position: a setting scale is provided. The table measures $17\frac{1}{2}$ in. by 23 in., and is provided with a removable insert which allows the rapid interchange of cutters. A graduated mitring gauge is fitted, arranged to swivel 60 deg. in either direction. A ripping fence, with an indexed rail, is also supplied. The saw spindle, which runs in sealed ball bearings, is mounted on a pivoted iron casting. The raising



and lowering of the spindle is controlled by a handwheel and screw, a scale being provided to indicate the depth of cut.

The saw is driven, through a V-rope and balanced-groove pulleys, by a $\frac{3}{4}$-h.p. squirrel-cage motor, mounted on a hinged platform so that it moves integrally with the saw-spindle assembly. The motor is controlled by a push-button starter with a thermal overload release. Alternatively, a 1·1-h.p. petrol engine can be supplied instead of the electric motor. The drive unit is housed within a sheet-steel base cabinet, which also contains a sawdust chute and a tool shelf, accessible through a hinged door. The saw guard is a light-alloy casting, shrouded by pivoted Perspex cheek plates, and is self-adjusting to the thickness of the material being cut. Additional equipment available for use with the saw bench includes an 8-in. diameter sanding disc, an 8-in. diameter abrasive wheel, and hollow-ground blades for plastic material.

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION.—The 1952 conference of this Association will take place at the Grand Hotel, Birmingham, on November 5, 6 and 7. The afternoon of the first day will be devoted to works visits. November 6 will open with the annual meeting of the Association at 9.30 a.m., after which the conference and an exhibition of sheet-metal working equipment and techniques will be formally opened by the Lord Mayor of Birmingham, Alderman W. P. Bowen. At 2.15 p.m., papers on "Factors Which Influence the Selection of Metal Finishes," by Mr. A. W. Wallbank, and on "Ultrasonic Testing" will be read, and at 6.45 p.m., films on "Multi-Point Welding" and "The Automatic Ejection of Pressings" will be shown at the Mason Theatre of the University of Birmingham. At the first of two technical sessions on November 7, a paper will be read by Mr. R. S. Watts on "Materials Used in the Manufacture of Press Tools," and at the second there will be a discussion on "Press Tools for Punching, Blanking and Forming." Applications to attend the conference should be sent to the honorary secretary of the Association, Mr. Alastair McLeod, 49, Wellington-street, London, W.C.2.

BOOKS RECEIVED.

Die Dampfturbine im Betriebe. By PROFESSOR E. A. KRAFT. Second revised and enlarged edition. Springer-Verlag, Reichpietschufer 20, Berlin W.35, Germany. [Price 60 D.M.]

The Ropeman's Handbook. The National Coal Board, Production Department, Hobart House, Grosvenor-place, London, W.1. [Price 5*s.*]

Brisbane City Council. Twelfth Volume of the Brisbane Statistics, Embracing the Period from the Inception of the Council in 1925 to the End of the Financial Year, 1949-50. Brisbane City Council, Brisbane, Queensland, Australia.

Rocket Propulsion, with an Introduction to the Idea of Interplanetary Travel. By ERIC BURGESS. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 21*s.* net.]

Electrical Measuring Instruments. By DR. C. V. DRYSDALE and A. C. JOLLEY. Part I. *General Principles and Electrical Indicating Instruments.* Second edition, revised by DR. G. F. TAGG. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 75*s.* net.]

Ministry of Transport. Railway Accidents. Report on the Derailment which Occurred on 3rd December, 1951, *at Culter in the Scottish Region British Railways.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

National Building Studies. Special Report No. 15. *A Survey of the Behaviour in Use of Asbestos-Cement Pressure Pipes.* By DR. F. E. JONES and J. P. LATHAM. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Ministry of Housing and Local Government. Report of the Working Party on Small Diameter Water Pipes. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

Rugby Engineering Society. Proceedings. Session 1951-52. Volume XLII. The Hon. Librarian and Recording Secretary, Rugby Engineering Society, c/o Publicity Department, The British Thomson-Houston Company, Limited, Rugby. [Price 10*s.* 6*d.*]

British Intelligence Objectives Sub-Committee Surveys. Report No. 33. *The German Rayon Industry During the Period* 1939-1945. Prepared by DR. A. R. URQUHART. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 25*s.* net.]

"Hutte." Taschenbuch für Betriebsingenieure. Fourth revised edition. Part 2. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 33.50 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 58*s.* $7\frac{1}{2}$*d.*]

Durchlaufträger. By PROFESSOR ADOLF KLEINLOGEL and ARTHUR HASELBACH. Seventh revised and enlarged edition of KLEINLOGEL'S *Der durchlaufende Träger,* in two volumes. Vol. II. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 46 D.M. in paper covers, 49 D.M. bound]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 80*s.* 6*d.* in paper covers, 85*s.*9*d.* bound.]

Kegelrader Tafeln fur die Berechnung der Abmessungen von Geradzahn-Kegelrädern ohne Profilverschiebung. Edited by DR. H. HELLMICH. Schriftenreihe Antriebstechnik No. 2. Friedr. Vieweg und Sohn, Burgplatz 1 Braunschweig, Germany. [Price 9.60 D.M.]

Scientific Research in British Universities, 1951-52. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 8*s.* 6*d.* net.]

Aircraft Instrument Design. By W. H. COULTHARD. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 40*s.* net.]

The Birmingham Exchange. Directory of Members, Subscribers and Representatives, 1952. The Secretary, The Birmingham Exchange, Stephenson-place, Birmingham, 2.

Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 21st December, 1951, *at Piershill Junction, Edinburgh, in the Scottish Region, British Railways,* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

Analytical Mechanics for Engineers. By PROFESSORS FRED B. SEELY and NEWTON E. ENSIGN. Fourth edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 44*s.* net.]

Factory Organization and Management. By N. F. T. SAUNDERS. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 16*s.* net.]

Measurement of Productivity—Work Study Application and Training. Joint Committee of the Institute of Cost and Works Accountants and the Institution of Production Engineers, 36, Portman-square, London, W.1. [Price 5*s.* post free.]

Bibliography of Papers Published by Houdry Staff. Houdry Process Corporation, 1528, Walnut-street, Philadelphia 2, Pennsylvania, U.S.A.