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

The Glen Affric scheme of the North of Scotland Hydro-Electric Board, which is to be formally inaugurated by H.R.H. The Duke of Edinburgh on Monday next, October 13, makes use of the water resources of a catchment area of some 124 square miles in Inverness-shire and in Ross and Cromarty, where the average annual rainfall is 107 in. It is the third scheme that has been proposed for the development of this area, the first, for which the Grampian Power Company was responsible, being rejected in 1928 by a House of Lords Committee, mainly on the grounds that it would harm the scenic amenities of the district; and the second, put forward by the same company in 1941, having been thrown out by the House of Commons for much the same reason, after it had been favourably reported upon by a Scottish Parliamentary Committee. This action, however, resulted in the appointment of a committee under the chairmanship of Lord Cooper to investigate the water power resources of the Highlands; and the report of this body led to the formation of the North of Scotland Hydro-Electric Board. To the unbiased observer, the works that have been carried out improve rather than detract from the beauties of the scenery. In fact, some of the most vocal local critics are beginning to modify their views on this subject.

As will be seen from the map reproduced in Fig. 2, on this page, the scheme utilises the waters of the Rivers Cannich and Affric, both of which are tributaries of the River Glass. To effect this utilisation a gravity dam has been constructed across the outlet of Loch Mullardoch on the River Cannich, and a second gravity dam has been built across the outlet of Loch Beinn a Mheadhoin on the River Affric. The water impounded in Loch Mullardoch is led through a tunnel to Loch Beinn a Mheadhoin and the latter reservoir is connected by a second tunnel to the main power station at Fasnakyle, whence the water is discharged into the River Glass. Additional water has been brought in by leading tributary streams into this second tunnel. There is also a second power station at the upstream end of the tunnel between Loch Mullardoch and Loch Beinn a Mheadhoin, so as to utilise the difference in level between the two reservoirs. The estimated annual output of the scheme is about 236 million kWh. There are no fish ladders since, in contradistinction to some of the Board's schemes, there has been no need to make this concession to one of the most important activities of the Highlands. The consulting engineers for the civil engineering works are Sir William Halcrow and Partners, Alliance House, Caxton-street, London, S.W.1, and Messrs. Kennedy and Donkin, 12, Caxton-street, London, S.W.1, have been responsible for the design of the electrical and mechanical equipment.

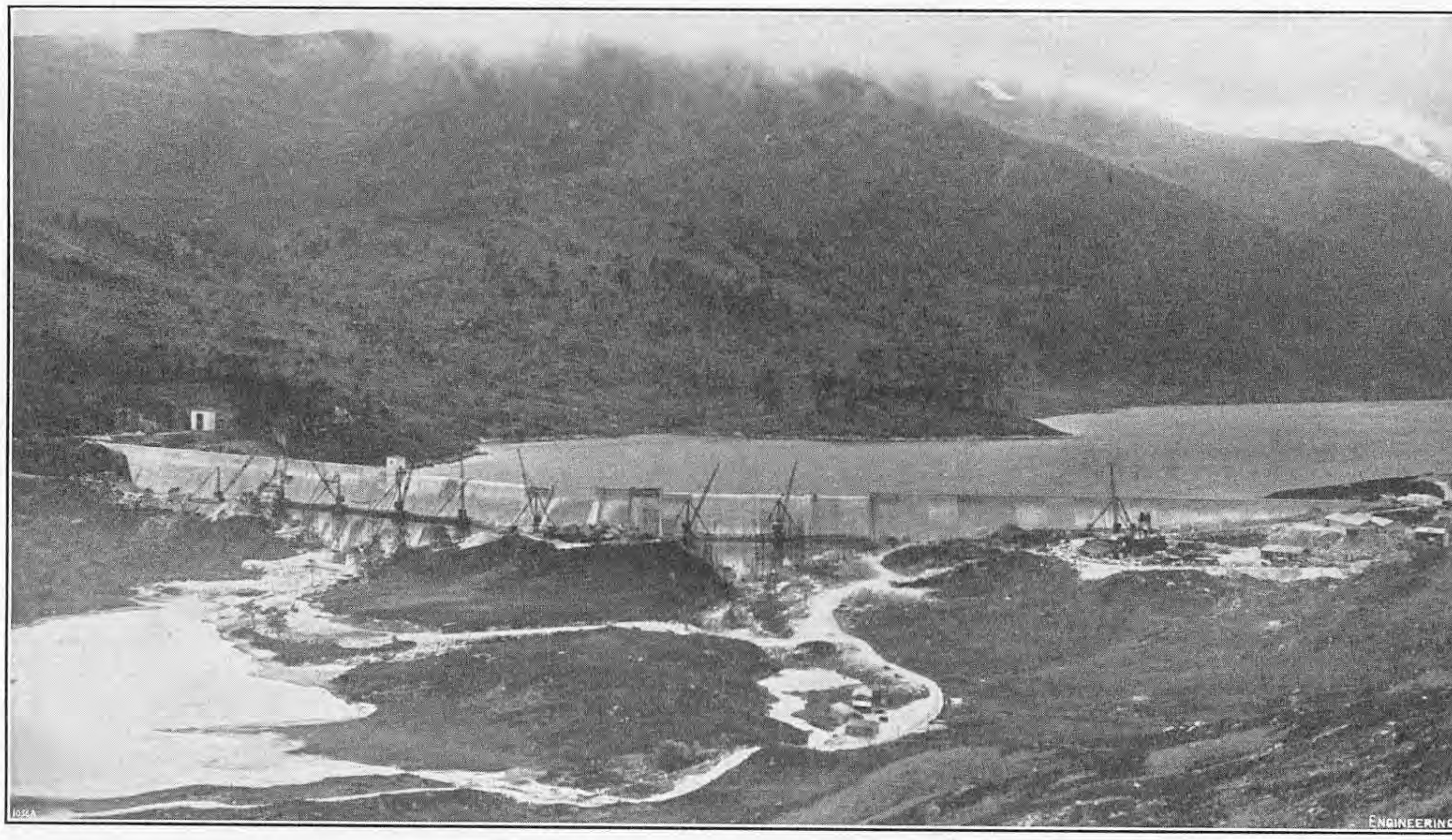
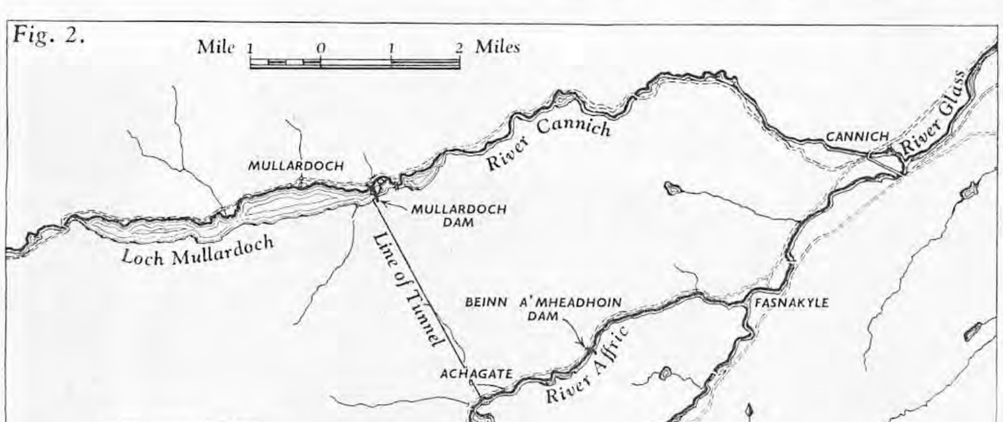


Fig. 1. Mullardoch Dam from the North-East.

Fig. 2.



Preparatory Work.

Considerable preparatory work was necessary before the actual construction could be begun. Two labour camps, one at Cannich and another at Cosac, near Mullardoch, were built to accommodate a total of 2,000 men; offices and workshops were also constructed. The road along Loch Beinn a Mheadhoin was diverted to a higher level and reconstructed with wide verges; four new bridges were also built. The road from Fasnakyle to Beinn a Mheadhoin was also improved and that from Cannich to Mullardoch was converted into a single-track motor road with passing-places. A temporary generating station was erected at Cannich and was equipped with six Mirrlees Diesel engines, coupled to 600-kW Bruce-Peebles alternators. These machines supplied current at 11 kV to the works through two overhead transmission lines. In addition, Diesel-driven portable plant was used to supply the necessary power, lighting, compressed-air and ventilating equipment for the tunnel excavations, details of which will be given below. Later, these electric lines were supplied from Beauly substation via Kiltarilty at 33 kV. The capacity of the Cannich station was then reduced to 1,200 kW and it was used as a stand-by.

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

FIG. 3. MULLARDOCH DAM UNDER CONSTRUCTION.

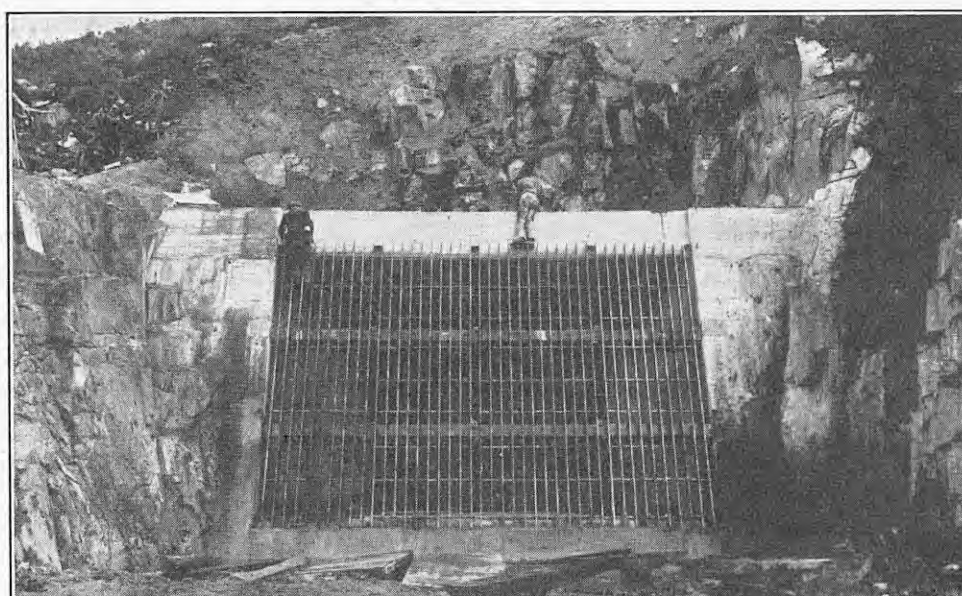


FIG. 4. INTAKE PORTAL, MULLARDOCH TUNNEL.

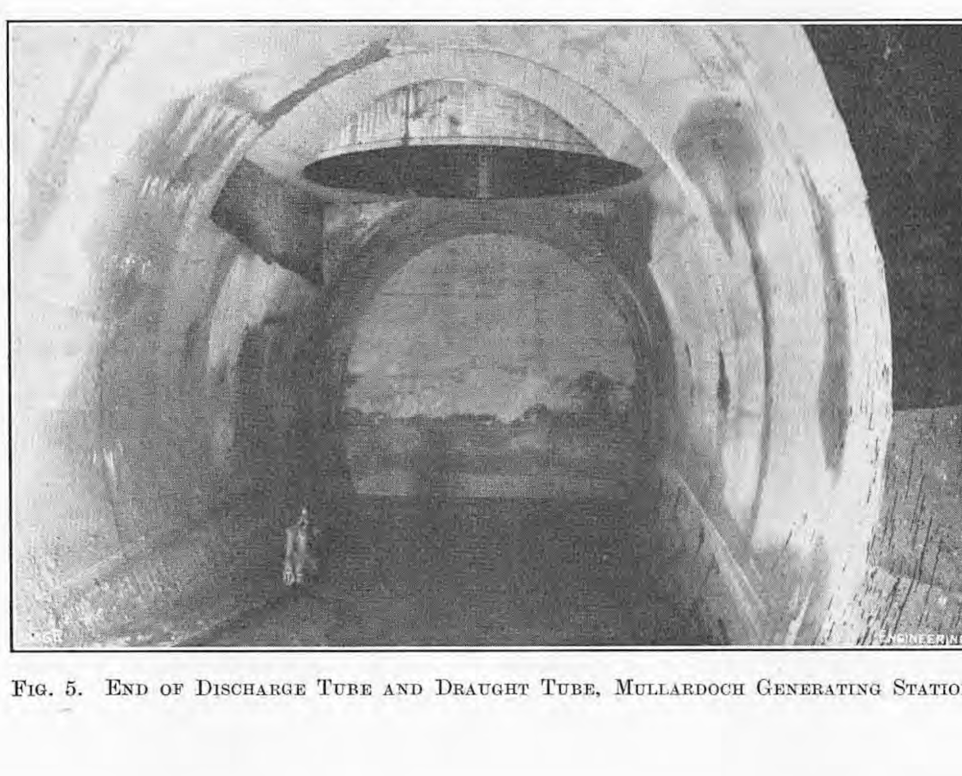


FIG. 5. END OF DISCHARGE TUBE AND DRAUGHT TUBE, MULLARDOCH GENERATING STATION.

MULLARDOCH DAM.

Photographs of the Mullardoch dam are reproduced in Figs. 1 and 3, on page 457, and on this page, and details of its construction are illustrated by the drawings reproduced in Figs. 6 to 14, on Plate XXXVII. It is the largest in the Board's area and by raising the level of Loch Mullardoch 113 ft. has converted it, and the adjacent Loch Lungard, into one sheet of water. It has also transferred the main fluctuations in water level to Glen Cannich. The dam is of the mass-concrete gravity type and consists of two wings set at an angle of 140 deg., one of which is 1,215 ft. and the other 1,170 ft. long. Between these wings is a central abutment which rests on an island in the middle of the loch. The total length of the dam is 2,385 ft., and its maximum height including foundation 142 ft. As will be seen, there are spill weirs 315 ft. long, without gates, in each wing, the crest levels of which are 817 ft. above the Liverpool Ordnance Datum; the maximum flood level is 821 O.D. Each spill weir has a capacity of 9,500 cusecs. As will also be seen, there is a scour culvert, 72 in. in diameter, near the south wing spill weir, the invert level of which is at 700 O.D. Entrance to this culvert is through an electrically-operated free rolling guard gate near the upstream face of the dam and the flow through it is controlled by a 72 in./60 in. needle valve at the downstream end. Next to this scour culvert is a second 72-in. culvert, which is closed by a sluice gate near the upstream face of the dam and by a hinged blank flange on the downstream face. This gate is operated from a headstock on a platform at 735 O.D. on the upstream face of the dam and cannot be opened until the water falls below that level. It thus enables the reservoir to be maintained at a low level in case of need. This second culvert is not provided with a needle valve. The gates and valves on these culverts were supplied by Messrs. Glenfield and Kennedy, Limited, Kilmarnock. The gates can be controlled by hand from the gate house, in which apparatus is installed for indicating and recording the water level in the reservoir at the generating station. The needle valve can also be manually operated and there is a by-pass 6 in. in diameter, with a measuring weir through which a constant volume of half a million gallons a day of compensation water is discharged into the River Cannich.

The design of the spill weirs and their associated channels was determined by model tests. As both spill weirs are wider than the watercourses into which they discharge, the problem was to ensure that the excess energy of the water was dissipated centrally. To do this was rendered more difficult by the fact that the weirs are not symmetrical about the water course. Steps and horizontal sections were therefore introduced into the channels where required to prevent the downcoming water from passing over the retaining wall and to regulate the flow into the stilling pools. The toe of each spill weir is faced with basalt ashlar pitchings.

The dam, for the construction of which Messrs. John Cochrane and Sons, Limited, 39, Victoria-street, London, S.W.1, were responsible, is built on massive psammitic and pelitic schist, the foundations being excavated through a thin layer of peat and moraine into sound rock to a minimum depth of 4 ft. There is a cut-off trench varying generally from 6 ft. to 12 ft. deep and 5 ft. wide at the bottom, with a batter of 1 in 4 near the upstream face, in which holes were drilled at 3-ft. centres to a depth of 20 ft. Grout was subsequently forced into these holes in one stage at pressures between 40 and 100 lb. per square inch. The depth of the cut-off trench at the outfalls was increased where necessary; and in two areas, where the rock was of poor quality, 40-ft. holes were driven between the 20-ft. holes and grouted at pressures up to 100 lb. per square inch. As a precaution

THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

(*For Description, see Page* 457.)

Fig. 6. PLAN.

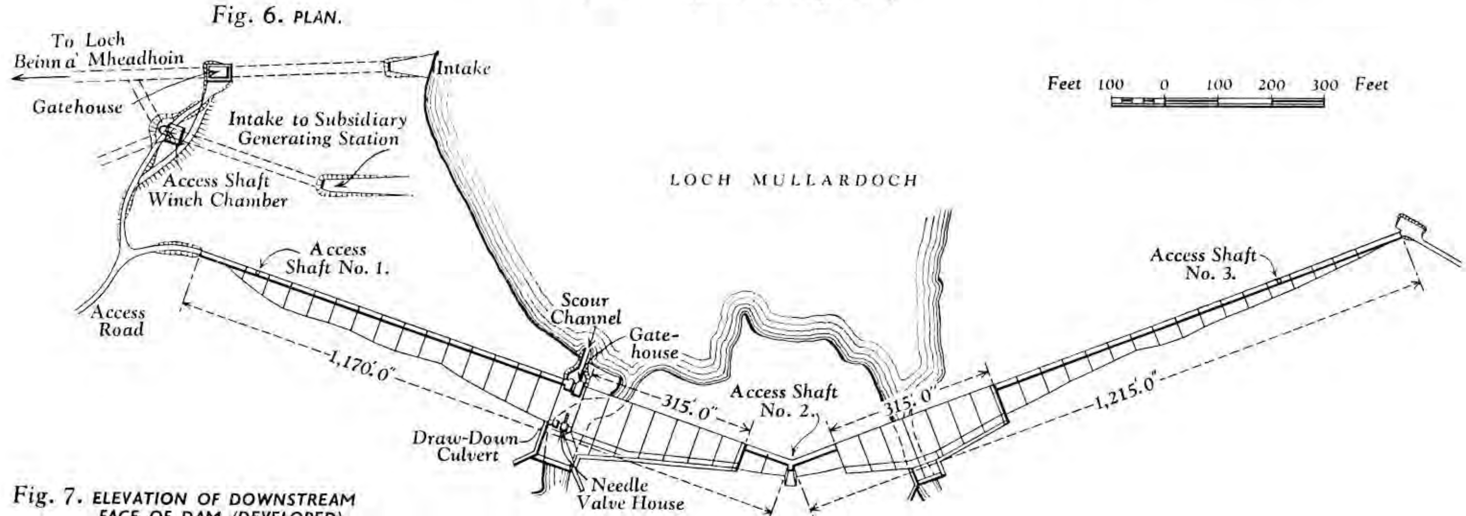


Fig. 7. ELEVATION OF DOWNSTREAM FACE OF DAM (DEVELOPED).

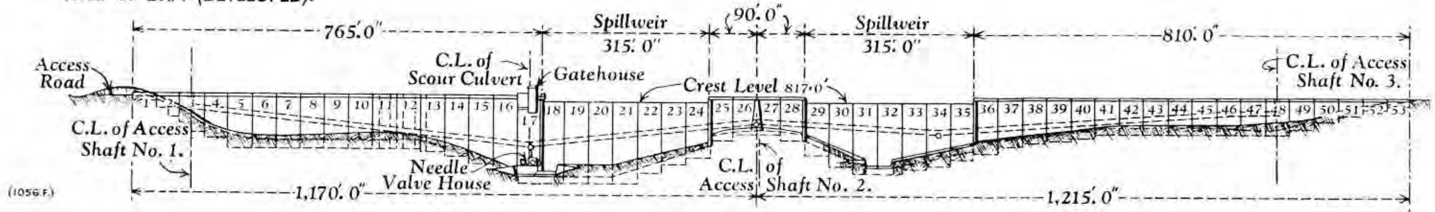


Fig. 8. TYPICAL NON-SPILL WEIR CROSS SECTION AT BLOCK JUNCTION.

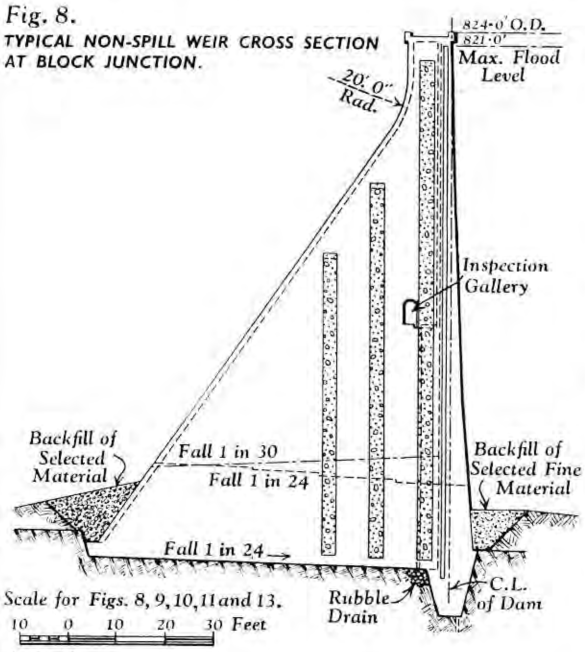


Fig. 9. DAM PROFILE.

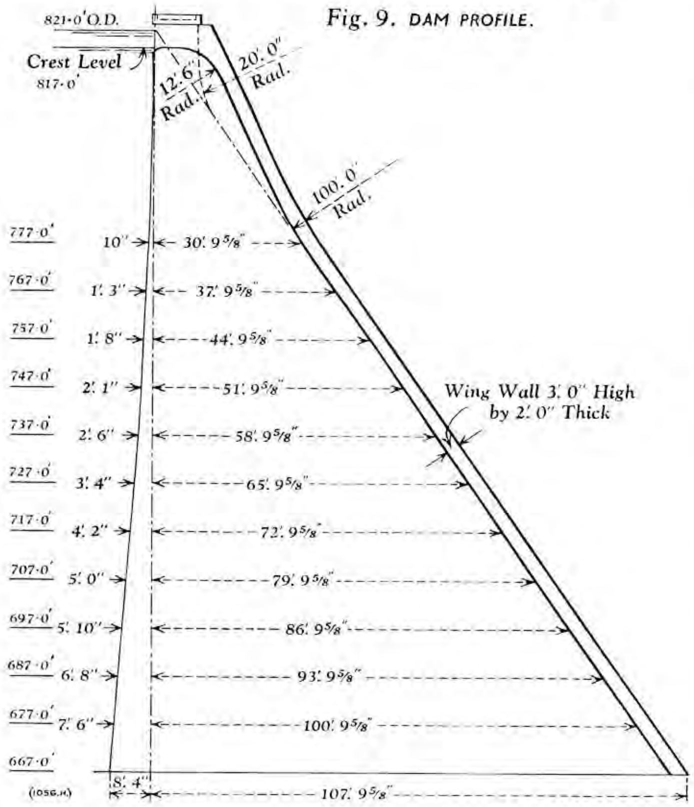


Fig. 12. DOWNSTREAM PROFILE OF BLOCKS NO. 8, 11, 14 AND 16.

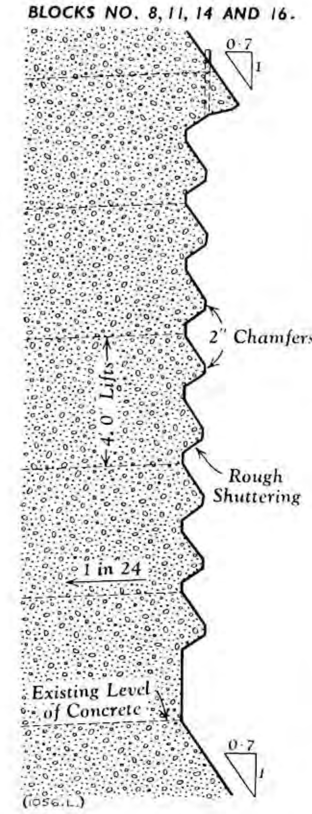


Fig. 10. BLOCK NO. 14.

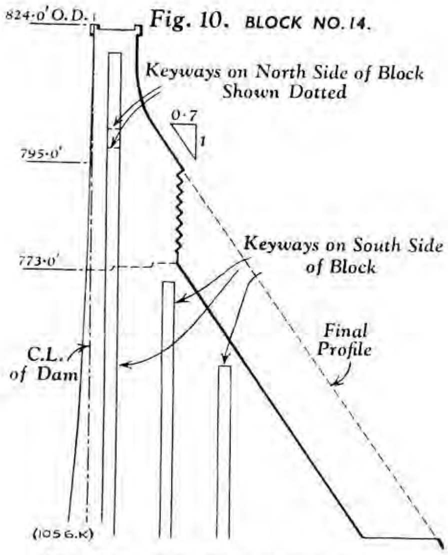


Fig. 11. BLOCK NO. 13.

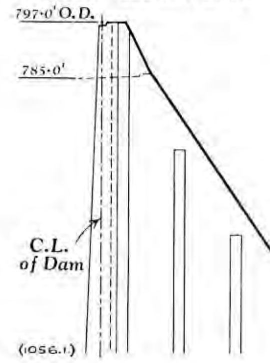


Fig. 13. BLOCKS NO. 19 TO 24.

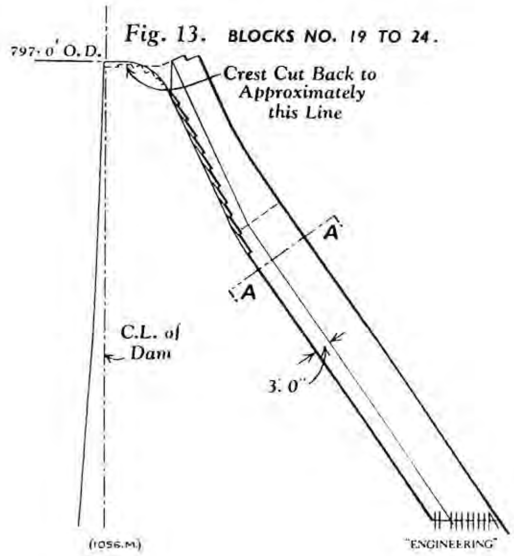
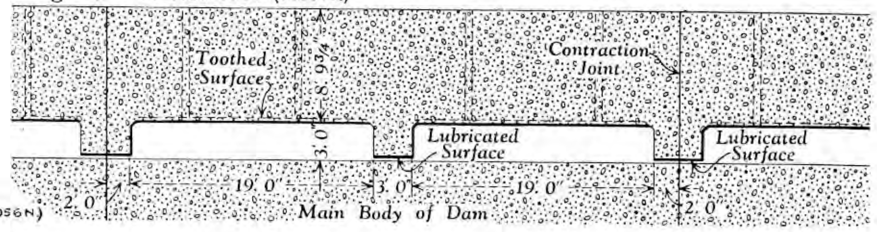


Fig. 14. SECTION A-A (FIG. 13.)



THE GLEN AFFRIC HYDRO-ELECTRIC SCHEME.

Fig. 15. FRONT ELEVATION.

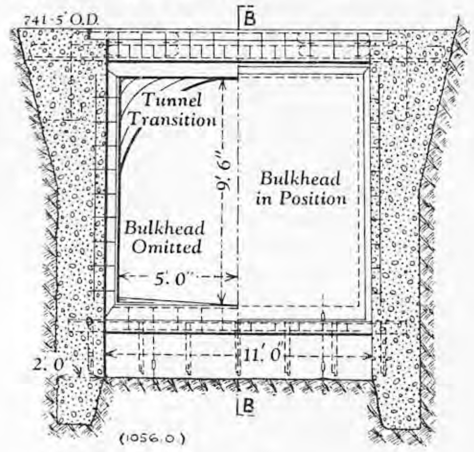
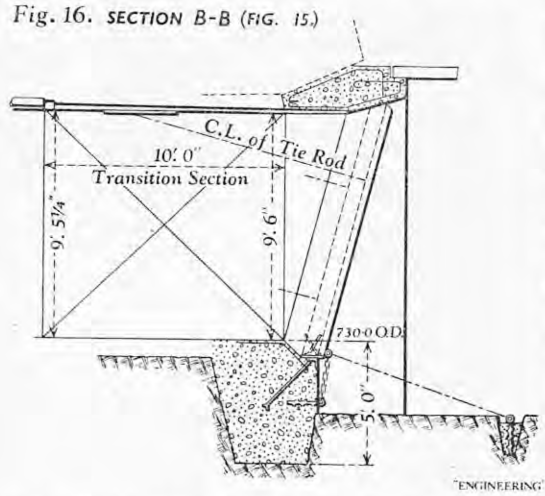


Fig. 16. SECTION B-B (FIG. 15.)



against uplift pressure, a hand-packed rubble drain was built just downstream of the cut-off trench from which vents 3 in. in diameter, to relieve the pressure, lead to a trench in the inspection gallery and thence to the downstream face of the dam. Similar vents are provided above the inspection gallery.

Constructional Details.

The dam, work on which was begun in August, 1947, was built in 53 blocks, each 45 ft. long. The concrete was laid in 4-ft. lifts in climbing shuttering; and afterwards vibrated. This shuttering, which was designed by Mr. C. Parry, consisted of wooden sections 7 ft. 6 in. wide, which were carried on steel soldiers. These soldiers were secured by two lines of bolts screwed into nuts sunk in the concrete at vertical heights corresponding to the lift. The nut which was to be sunk in the next lift, carried a placer bolt at the top of each soldier and when the shuttering was struck, the nut was moved a distance corresponding to one line of bolts. Thus, each line of bolts was first set in position, then used as the upper fixing for the shuttering and finally as the lower fixing. Each lift was finished off with two 6-in. steps throughout the dam, contraction joints, in which U-shaped seals of ⅛-in. annealed copper sheet were inserted, being left between adjacent blocks. These seals, after being welded to the previous lengths, were filled with bitumen, their tips being painted with bituminous paint before the next block was poured. The hearting concrete used was a 7-to-1 mix containing 375 lb. of cement per cubic yard, the maximum size of the aggregate being 2½ in. The facing concrete was a 4-to-1 mix. To limit the maximum temperature of the hearting concrete to 100 deg. F. during placing, low-heat Portland cement was used in the early stages of construction. For reasons of cost this was later replaced by ordinary Portland cement, the temperature being kept below the required limit by lengthening the intervals between the lifts. The progress of the work, however, was not hampered by this procedure. Embedded thermometers were used for observing the temperature of both classes of concrete and the quality of the work was constantly checked in a laboratory which was set up on the site for that purpose. Investigations were also conducted in this laboratory into the use of aggregate with maximum sizes of 4 in. and 6 in. Gauges and plumb lines were built into the dam at various points to measure any contraction, tilt, or deflection.

The coarse aggregates for making the concrete were obtained from a quarry some three-quarters of a mile downstream of the dam and the sand from moraine deposits upstream. After passing through washing, crushing, and screening plant, the graded aggregate was transported to the neighbourhood of the batching and mixing plant by cable ropeways, that for the stone having a capacity of 75 tons and that for the sand a capacity of 40 tons per hour. It was there deposited in heaps from which it was recovered by belt conveyors and taken to the batching plant. The coarse aggregates were batched by volume and the sand by weight. The cement, which was brought by road, was also batched by weight and taken from store to the plant by a drag-chain conveyor. Mixing was carried out in three one cubic yard mixers with an aggregate maximum output of 75 cubic yards per hour. The concrete was unloaded from these mixers into bottom-dumping skips, which were placed on wagons. These wagons were then hauled along jubilee tracks by Diesel locomotives to a gantry, which extended along the downstream face of the dam. This gantry was formed of Bailey-bridge units and spanned the north and south outfalls of the dam at a deck level of 755 O.D. It was supported on steel trestles at about 135 ft. centres and carried fixed derricks. A travelling derrick, a crane and excavator were, however, employed at the end of the dam where the ground was close to the deck level of the gantry.

To carry out the work of construction, a cofferdam was first built across the north channel of the river and all the blocks in that portion of the dam, except one, were built up. The opening thus left allowed the water to pass when the cofferdam was removed. A second cofferdam was then built across the south channel and that section of the dam fully constructed. On completion, this cofferdam was also removed and the water diverted through the culverts. The northern cofferdam was then replaced and that portion of the dam completed. Finally, the dam was closed by shutting off the culverts. About 113,000 cubic yards of rock were excavated for the building of the dam and about 309,000 cubic yards of concrete were used in its construction. Over 5,000 cubic yards were placed per week, this amount being generally controlled by the moving and setting of the formwork by the carpenters.

During the construction of the north wing a cut was made in the capital expenditure of the Board, and as a result it was decided to reduce the height of the dam by 20 ft., thus involving a step back on the downstream side of each block at the height which had then been reached. Subsequently, however, this decision was reversed and it became possible to restore the height to the original figure. To do this was not altogether easy, since the blocks, already in position were at different heights and step-back levels, and had all to be brought to their full thickness so that their strength would be commensurate with the greater height. The procedure adopted, which was complicated by the fact that reinforcement could not be used owing to the shortage of steel, is illustrated in Figs. 10 to 14, Plate XXXVII, and may be briefly described. The downstream faces of those blocks on which only a small amount of work at the reduced height had been carried out, were continued vertically upwards until the profile appropriate to the increased height had been reached. The top of the block was then completed to profile and toothing was formed on the vertical portion of the downstream face to engage the backing concrete. On the other hand, the tops of blocks that were nearly or fully completed were cut back, as shown in Fig. 13, Plate XXXVII, toothing being also cut in the horizontal faces of the step-back left by the reduction in the height of the dam.

To counteract the differences in contraction of the old and new work, the backing concrete was placed in sliding slabs between which and the face of the dam slots were left. Two slots, each 19 ft. wide and 3 ft. deep, were formed from top to bottom in the backing slab. An access gallery at step-back level was left at the bottom of each slab. To simplify shuttering, a series of precast ribs was used to form the sides of the slots. Two layers of constructional paper, between which grease was spread, were laid on these ribs to ensure that the backing concrete moved freely when contracting. Horizontal keys were also provided to form a system of toothing on the inner face of the backing slabs. In the case of blocks on which a vertical toothed face had been formed, a corresponding face was provided on the backing slab at a distance of 3 ft. Grouting chambers were left in the faces of the backing slabs and the portions of the dam face included in the slots were scabbled. After sufficient time had elapsed for the new concrete to contract, the 3-ft. working space was filled with aggregate, the size of which exceeded 1½ in., and Colcrete grout was poured in to form the concrete and fill the voids. These operations were carried out on 15 blocks in all, in some cases to the full height of 90 ft. and in others for smaller distances.

As a result of the construction of the dam, the level of Loch Mullardoch has been raised by 113 ft. to a crest level of 817 O.D.; and a reservoir has been formed with an area of 2,330 acres at crest level and of 2,402 acres at top water level. The capacity at crest level is 7,470 million cubic feet, and at top water level 7,860 million cubic feet, the difference between maximum draw-down and crest level being 6,830 million cubic feet. The gathering ground for this portion of the scheme has an area of 31,837 acres in which the average annual rainfall is 107·8 in.

Mullardoch Generating Station.

As under normal conditions the reservoir level at Mullardoch will vary between 817 and 725 O.D. and that at Beinn a Mheadhoin between 735 and 725 O.D., space for an underground power station has been excavated near the dam at the former place, so as to utilise the range of gross heads which will be available. The intake to this station, which is 200 ft. downstream of the main tunnel intake, is of rectangular section with a semicircular roof and water flows into it through a Venturi section, the necessary measuring instruments being installed in the main tunnel gate house. This gate house is connected to a power house chamber, which is 32 ft. long by 26 ft. wide by 25 ft. high, as shown in Fig. 5, to which access is obtainable through a 12-ft. diameter shaft. A gate shaft of the same dimensions is also provided. The chamber will eventually be equipped by Messrs. Gilbert Gilkes and Gordon, Limited, Kendal, with a vertical Francis turbine. This machine will be coupled to a Bruce Peebles induction generator with an output of 2·4 MW. The turbine will discharge through a vertical draught tube into a tunnel, which rejoins the main Mullardoch tunnel some

150 ft. downstream of the gate shaft. These tunnels are both of the same dimensions and have been lined up to a point 150 ft. from their junctions. At present, the connection between them is sealed by a blank flange as shown in Figs. 15 and 16, while the mouth of the station intake has been temporarily closed by a reinforced concrete slab, as shown in the same drawings.

Mullardoch Tunnel.

As shown in the map, Fig. 2, page 457, lochs Mullardoch and Beinn a Mheadhoin are connected by a tunnel $3\frac{1}{4}$ miles long, which discharges into the latter reservoir one mile upstream of the dam. The water from Loch Mullardoch enters this tunnel through an intake which is shown in Fig. 4. The equipment of this intake includes a coarse screen and stop logs, while 330 ft. farther down-stream is a 120-ft. gate shaft containing emergency and control gates. There is also a Venturi section by means of which the state of the flow can be indicated at Fasnakyle generating station. Both the emergency and control gates, which were manufactured by Messrs. Glenfield and Kennedy, Limited, Kilmarnock, are electrically operated, control being at present effected from the gate house. Provision has been made, however, to enable the control gate to be operated from Fasnakyle.

The main tunnel, for the driving of which Messrs. Cochrane and Sons, Limited, were responsible, is of horse-shoe section with an equivalent diameter of 15 ft. 9 in. The total fall is 3 ft. through a tough mica schist, which varies from pelitic to psmammitic with inlayers of pegmatite of different thicknesses. The tunnel was driven from the two portals, the use of intermediate access points being prohibited by the lie of the land.

The equipment used consisted of three compressors, which were installed at each end of the tunnel and each having an output of 850 cub. ft. of air per minute at a pressure of 100 lb. per square inch. These compressors were connected to a 6-in. steel main with Victaulic joints, which was laid in the tunnel and was provided with valves at suitable points. From this main two 2-in. hoses with Unicone couplings were led to the manifold on a drilling carriage, which ran on an 8-ft. gauge track and thence to the drifters. A high-pressure water supply for the drills was obtained from the loch through a 2-in. air-driven Hayward-Tyler pump. Ventilation was effected by a fan with a capacity of 3,500 ft. per minute, which supplied air through ducting or extracted the blasting fumes, reversible gates being provided for the purpose. To obtain the necessary illumination, a 440-volt circuit was brought into the tunnel and connected to 3-kVA transformers at intervals of 1,500 ft. These transformers stepped down the voltage to 110 volts for the supply of 60-volt lamps placed 30 ft. apart.

The drilling equipment at first consisted of hollow round steels $1\frac{1}{4}$ in. in diameter, which were used in conjunction with two types of cruciform detachable bit. As, however, trouble was experienced with normal bits in certain sections of the rock, light high-speed rotary jack hammers, mounted on pneumatically-extending legs and using tungsten-carbide tipped Swedish drill steels, were subsequently employed. As a result, it was possible to increase the average rate of advance by $7\frac{1}{2}$ per cent. and to reduce the air consumption by about 50 per cent.

A drilling round 9 ft. deep and yielding an average advance of 8 ft., was adopted and the spoil was removed by air-operated Eimco rocker shovels with a capacity of 10 cub. ft., which discharged into skips. These skips had a capacity of 2 cubic yards and were transported along a track with a 2-ft. gauge to the tip by 30-h.p. Diesel locomotives. No large quantity of water was encountered, but pumps for drainage were installed and, although the tunnel was for the most part unlined, the presence of faulty rock required the insertion of steel rings and lagging in two places.

The outlet of the Mullardoch tunnel is about one mile up-stream of the Beinn a Mheadhoin dam and is equipped with a hand-operated Glenfield and Kennedy fixed roller gate, which measures 10 ft. by 14 ft. and is operated by hand. Just upstream of this gate is an opening which is protected by a screen and communicates with a shaft through which water can be pumped by four portable submersible pumps. The tunnel can therefore be emptied without de-watering the reservoir. Each of these pumps has an output of 120,000 gallons per hour and they were constructed by Messrs. James Beresford and Son, Limited, Birmingham.

(*To be continued.*)

LITERATURE.

Prospection Géophysique, Vol. II.

By Edmond Rothé and Professor J.-P. Rothé. Gauthier-Villars, 55, Quai des Grands-Augustins, Paris, VIe, France. [Price 6,000 francs.]

The first volume of this comprehensive treatise on geophysical prospecting was published two years ago. It dealt with the seismic and ionometric methods, and was reviewed on page 556 of our 170th volume (1950). The remaining four methods—the gravitational, electric, magnetic and geothermal—were reserved for discussion in the present volume, which is proportionately longer and correspondingly costly. As in the previous volume, the theory of the respective methods and of the equipment designed to realise them in practice is largely based on lectures given by the late Professor E. Rothé in the Geophysical Institute of the University of Strasbourg; and the analyses of representative field surveys carried out with this equipment are contributed by Professor J.-P. Rothé.

The gravitational method is second only in importance to the seismic method, particularly in the search for oil. No description is given of the pioneer torsion balance developed by Eötvös for detecting small local variations in the force of gravity, the reader being directed to an earlier publication by the senior author. Spring gravitimeters are treated in considerable detail, including the modern "Western" model. For the Holweck-Lejay elastic pendulum, reference is made to another work by the same author. The Haalck differential barometer gravity-meter is fully covered and there is a valuable discussion of the precision attainable with such instruments. The following chapter, on the applications of the gravitational methods, quotes instances of the use of all types of gravity-meter and includes a section on the Askania torsion balance.

The various constituents of the earth's crust differ widely in their electrical resistivities, and the apparent resistivity between selected pairs of points on the surface of the earth can be readily determined. Other procedures involve the introduction of direct or alternating current into the ground, and the study of the resulting distribution of lines of current flow and equipotential lines, the detection of currents generated by electro-chemical action in certain types of deposit, and the measurement, just above ground level, of the magnetic field arising from alternating currents induced in the earth from suitably disposed transmitting loops. These resistivity, surface-potential, spontaneous-polarisation and electromagnetic field methods are considered in turn, and a note on the "skin effect" is added. The interpretation of these electrical measurements is usually far from straightforward and the principles upon which it is based occupy first place in the chapter on applications. Electrical surveying is particularly useful in water prospecting, and examples of this, as well as of mineral prospecting, are given, together with sections on the use of earth currents and well logging.

Magnetic methods depend on the fact that certain ore deposits distort the normal terrestrial magnetic field in their neighbourhood and the very sensitive apparatus (some of it self-recording) now available to detect this effect is fully described. As with the electrical method, the first step in the interpretation of the resulting measurements is the theoretical study of the fields due to uniformly-magnetised bodies of simple regular form, examples of which are given under the heading of "Applications." Selected magnetic surveys resulting in the location of mineral deposits are examined, attention is drawn to the occurrence of regional magnetic anomalies, and an account is given of the advantages of mounting magnetic survey instruments in aeroplanes. The concluding chapter is devoted to the technique of geothermal measurements and the implications of such measurements in prospecting.

Very complete references are provided to the extensive literature of the subject. Massive though this volume is, it needs supplementing with the two earlier works by Professor E. Rothé, to which numerous references are made. The topics dealt with are treated with great thoroughness and attention to detail, though some space might have been saved by referring to standard texts on physics for certain results that are fully worked out. The attention devoted to instrumentation and to the reduction and interpretation of field data are particularly valuable features of this important work.

Theoretical Aerodynamics.

By Professor L. M. Milne-Thomson. Second edition. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 40*s*. net.]

The first edition of this treatise was reviewed in Engineering, vol. 166, page 5 (1948), and the fact that a second edition has appeared so soon is a clear indication of public approval. While our review of the first edition expressed strong appreciation of the book, it drew attention to certain important limitations of scope and outlook. These concerned the very scanty discussion of the effects of viscosity, including the theory of the boundary layer, and the inadequate treatment of the dynamics of aircraft, with special reference to the theory of control and stability. It is proper to inquire, therefore, whether these questions have been better covered in the second edition, but the answer is in the negative. Apart from some amendments of terminology required to bring the work into agreement with current usage, the first 19 chapters of the book are unchanged; these constituted the whole of the first edition. The persistent neglect of the boundary-layer theory by the author can only be interpreted as showing scepticism about its value; which is to be regretted because it is impossible to make progress with the dynamics of real—i.e., viscous—fluids without using the concept of the boundary layer. It is invariably found that the numerical value of an aerodynamic derivative coefficient, such as a lift curve slope or hinge moment characteristic, as given by "potential theory," is too high, and the discrepancy is very serious for tab hinge moment characteristics. Unless, therefore, mere empirical correction of the results of an inadequate theory is to be accepted, a procedure which is basically unsound and unscientific, it is essential to cultivate the boundary-layer theory, as it provides the only extant method of dealing with the influence of viscosity for flow at the high Reynolds numbers of full-scale flight.

A long and entirely new chapter on supersonic "conical flows" has been added to the second edition. A conical flow is defined as one in which the pressure, the density and the three components of velocity are all constant on any straight line through a certain fixed point. The theory of such flows is considerably simpler than that of general three-dimensional gas flows and it has a number of useful applications to supersonic wing theory; the author gives a number of such applications to "delta" and other wings. This chapter is a very useful addition. In conclusion, this is a book which has deservedly won recognition from the scientific and engineering public, but it cannot be accepted as a completely satisfactory standard treatise until it contains an adequate discussion of the influence of viscosity on aerodynamic phenomena. The theme of aircraft dynamics is really foreign to the book and the chapters devoted to this subject might well have been omitted and the space so gained given to the theory of viscous effects. The book is excellently produced and printed, and the price, for these days, must be regarded as very moderate.

THE INSTITUTE OF METALS.

(*Continued from page* 414.)

WE continue below our report of the recent Annual Autumn Meeting of the Institute of Metals, held in Oxford. On the morning of Tuesday, September 16, five papers were considered at session B, which dealt with contributions on physical metallurgy and was held simultaneously with session A, where papers of industrial interest were discussed. A report of the proceedings at session A appeared on page 414, *ante*. The chair at session B, with which we now propose to deal, was occupied by Professor F. C. Thompson, senior vice-president of the Institute.

MICROSCOPICAL EXAMINATION BY POLARISED LIGHT AND THE METALLOGRAPHY OF URANIUM.

The first two papers considered were both by Mr. B. W. Mott and Mr. H. R. Haines of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, Berkshire. The first paper was entitled "The Application of Polarised Light to the Examination of various Anistropic Metals and Intermetallic Phases." The authors stated that polarised light had proved a useful aid in the metallographic examination of anistropic metals and alloys (i.e., materials having different properties in different directions). In some cases, however, it was doubtful whether any marked advantages were obtained, in the use of polarised light to obtain grain contrast, over the results of the more conventional etching techniques. On the other hand, no reliable etching treatment had been found for revealing the grain structure in uranium, and all the data obtained, so far, at Harwell, on the effect of thermal and mechanical treatments on the structure of this metal had been from examination under polarised light. Moreover, polarised light could sometimes be used to distinguish between intermediate phases in an alloy system, the similar etching characteristics of which made difficult a distinction by examination under ordinary illumination.

In the second paper, on "The Metallography of Uranium," Messrs. Mott and Haines confirmed that all attempts to etch uranium in the conventional reagents used for revealing the grain size of other metals and alloys had failed to yield a reliable etching treatment. This had led to the use of polarised-light techniques and it had been found necessary to polish the surface of the metal electrolytically to produce a reaction to polarised light. Using a cathode of uranium, platinum or steel, the most successful solution to date contained one volume of orthophosphoric acid, two volumes of concentrated sulphuric acid, and two volumes of water. Polishing was carried out at a current density of 0·5 to 0·75 ampere per square centimetre, and the technique which gave the best results was to remove the anodic layer formed continuously during polishing, by wiping the specimen with a camel-hair brush. The α phase of uranium was stable from room temperature to 660 deg. C., and had an orthorhombic structure; the β phase, which was stable from 660 deg. to 775 deg. C., had a tetragonal structure; finally, the γ phase was a body-centred cubic structure and was stable from 775 deg. C., to the melting point at 1,128 deg. C.

The remaining three of the five papers were "Some Observations on the Deformation of Polycrystalline Zinc," by Mr. J. A. Ramsey; "The Opaque-Stop Microscope as a Means of Studying Surface Relief," by Mr. W. M. Lomer and Dr. P. L. Pratt; and "Twin Accommodation in Zinc," by Dr. P. L. Pratt and Mr. S. F. Pugh.

STUDIES IN ZINC DEFORMATION.

In the first paper on the deformation of polycrystalline zinc, Mr. J. A. Ramsey, who is a research officer in the Aeronautical Research Laboratories, Department of Supply, Melbourne, Australia, stated that his investigation had shown that polycrystalline zinc, when deformed, behaved in a manner similar to aluminium. Both at elevated temperature and at slow strain rates, zinc tended to form a sub-grain or cell structure within the grains. There was evidence that the cell structure was produced directly by the deformation and could not be adequately explained by the same mechanism as that suggested for polygonisation.

The other paper on zinc was by Dr. P. L. Pratt and Mr. S. F. Pugh, of the Atomic Energy Research Establishment, Harwell, and concerned "Twin Accommodation in Zinc." The authors stated that they had made a study of the plastic deformation of single crystals of zinc, using the opaque-stop and X-ray microscopic techniques to examine cleavage faces. By these complementary methods, the stresses arising from the twinning shear had been found to be relieved by accommodation kinking.

THE OPAQUE-STOP MICROSCOPE.

As stated above, the paper entitled, "The Opaque-Stop Microscope as a Means of Studying Surface Relief" was presented with the two papers on zinc deformation. It was by Mr. W. M. Lomer, of the Cavendish Laboratory, Cambridge, and Dr. P. L. Pratt, who is now at Harwell. The authors stated that the study of slopes and surface irregularities under the conventional microscope was difficult, especially at high powers of magnification, because the high numerical aperture meant that the objective collected light reflected over a wide range of angles. The insertion of suitable opaque stops in the optical train enabled much smaller changes of slope to be detected and estimated. The improvement in sensitivity to angle was by a factor of about 30. In addition, the opaque-stop arrangement could give the effect of either sensitive dark-field, or of oblique, illumination, and was available even at high magnification, where the objective-mount design prevented the use of true oblique illumination.

In the afternoon of Tuesday, September 16, visits were paid to the Atomic Energy Research Establishment at Harwell; the Locomotive, Carriage and Wagon Works of British Railways, at Swindon; the Abingdon works of the M.G. Car Company, Limited, and Riley Motors, Limited; the works and testing shops of the Northern Aluminium Company, Limited, and Aluminium Laboratories, Limited, at Banbury; the works of the Pressed Steel Company, Limited, at Cowley; and other establishments and places of interest in Oxford and its neighbourhood. In the evening a dinner was held in Magdalen College Hall, by invitation of the chairman and committee of the Oxford local section of the Institute.

ON the morning of the third day of the meeting, Wednesday, September 17, two simultaneous sessions, A and B, were again held. As was the case on the previous day, papers of industrial interest were discussed at session A, while the proceedings at session B were devoted to the consideration of papers on physical metallurgy.

GRAIN REFINEMENT IN CAST METALS.

There were four papers on the agenda at session A, and the first two were considered jointly. They were: "Grain Refinement of Aluminium-Alloy Castings by Additions of Titanium and Boron," by Mr. A. Cibula, and "The Nucleation of Cast Metals at the Mould Face," by Mr. J. A. Reynolds and Mr. C. R. Tottle.

When presenting his paper, which was a communication from the British Non-Ferrous Metals Research Association, Mr. Cibula stated that previous work had shown that the grain refinement produced by the addition of titanium or boron to aluminium casting alloys was primarily caused by nucleating particles in the melts. The nuclei in titanium-containing alloys had been found to be titanium-carbide crystals, though only a small proportion of the added titanium was present in this form. The main objects of the present work had been to identify the nuclei in other fine-grained aluminium alloys and to find ways of increasing the proportion of the refining elements present as nucleating compounds. By centrifuging the particles from molten alloys containing boron, but no titanium, and observing the change in grain-size produced, evidence had been obtained that the nuclei in these alloys were aluminium-boride crystals. The minimum boron addition for the adequate refinement of these alloys therefore depended mainly on the solubility of aluminium boride in molten aluminium. Attempts to increase the concentration on titanium carbide in alloys containing titanium had achieved no useful results, owing to difficulties in forming or dispersing the carbide as fine particles. The addition of boron, instead of carbon, was more effective in producing refinement, nucleating particles of titanium boride being formed at very low concentrations of titanium and boron; moreover boron was more easily added than carbon, as aluminium-boron master alloys could be utilised.

The grain refinement of some commercial casting alloys by simultaneous additions of titanium and boron had been studied in detail; grain coarsening due to high casting temperatures, repeated remelting, or gravity segregation during solidification was less than in alloys containing much larger percentages of titanium alone. Alternative methods of adding titanium and boron, and the refinement produced by borides of transition metals other than titanium, had been investigated. As the boron additions required when titanium was present were small, the mould reaction previously encountered in alloys of high boron content had been largely avoided.

The paper on "Nucleation of Cast Metals at the Mould Face," by Messrs. J. A. Reynolds and C. R. Tottle described work carried out in the Department of Metallurgy of King's College, Newcastle-upon-Tyne. The authors stated that the nucleation of some cast metals and alloys, effected by applying metal powders to the face of a standard mould, had been investigated by comparing the grain-size of ingot surfaces produced with and without the coating. In general, powdered metals having the same crystallographic form as the metal being cast were effective as nucleating agents, and this had been found to apply to the solidification of tin, lead, zinc, aluminium, antimony, magnesium and copper. In cases in which the cast metal readily formed an oxide film, the reduction of this film to the metal had been found to occur when some coatings were applied, giving rise to simple homogeneous nucleation by the particles produced. Homogeneous and heterogeneous nucleation of alloys could take place under the same conditions as with pure metals, the crystal structure of the solid first formed from the melt being the ruling factor. The reduction of oxide films also occurred and, in the case of an 18 : 8 austenitic steel, resulted in isomorphous nucleation of the δ solid solution by chromium particles reduced from the film.

Mr. E. A. G. Liddiard, who opened the discussion, said that research on grain refinement was extremely difficult to carry out, because, as was the case with all foundry investigations, there were so many variables which had to be controlled. Among other factors, turbulence could affect grain size quite considerably, while another factor, which was of importance in determining the final grain size, was the degree of undercooling that had taken place. Work at the Fulmer Research Institute had confirmed many of Mr. Cibula's findings. They agreed that titanium and boron made excellent grain refiners in aluminium-base alloys. They had found no evidence of mould reaction, however, by the addition of salts of boron; but, by adding less boron in the form of a hardener alloy, they had obtained mould reaction. Possibly the hardener contained something other than boron which promoted mould reaction. In the paper by Messrs. J. A. Reynolds and C. R. Tottle he had been disappointed to find so few data of experimental technique, especially in relation to melting and casting. The authors would have perhaps been wiser to confine themselves to one mould material rather than give their attention to sand and synthetic as well as to cast-iron and steel moulds. Nevertheless, they had shown that nucleation of some cast metals and alloys could be effected by applying metal powders to the face of a mould and that was a valuable piece of work which was of considerable practical importance. He fully agreed with their last sentence, however, which was to the effect that further work was necessary to confirm the mechanism of the nucleation in alloys.

Mr. W. A. Baker stated that the metal powders used by Messrs. Reynolds and Tottle were nearly all pyrophoric and it was a wonder that they had obtained any results at all by their use. The paper, however, showed that they had succeeded in effecting nucleation. Dr. F. C. Frary, who spoke next, said that in the melting shops of the Aluminum Company of America the titanium was always added in the form of a rich alloy, just before casting. He had always suspected that the small quantities of carbon present in aluminium had an effect on the properties of the metal and the careful work by Mr. Cibula on the influence of titanium carbide was therefore particularly welcome. Minute traces of phosphorus were also usually present in aluminium and a study of its effects would be of value.

Dr. D. V. Atterton asked Mr. Cibula whether he had made additions of titanium and boron to large melts. His paper had shown that his melts were usually about 3 kg. in weight. A subsequent speaker, Mr. H. E. Dixon, said that, when using a welding wire containing titanium for the welding of certain aluminium alloys, the porosity in the metal, especially that deposited at high temperatures, had been reduced. Fusion welding was, to a certain extent at all events, equivalent to a casting process in which the cooling conditions were very rapid. Dr. Frary, speaking again, said that the reduced porosity mentioned by Mr. Dixon might be due to the retention of gas, in solution in the metal, as a result of the quick freezing of the melt. Another speaker, Dr. J. C. Chaston, said that when making grain-refinement additions to a melt, the casting temperature was of particular importance. If it were too high the benefits of the additions might be lost and no grain-refinement would result in the melt.

Mr. Cibula, in a brief reply, referred to alternative methods of adding titanium and boron to aluminium-alloy melts. He stated that he had made a few experiments using salts (such as potassium titanofluoride and potassium borofluoride) and had found them apparently more effective than normal additions in the form of hardener alloys. The final results had seemed to show, however, that the normal hardener additions were preferable. He did not wish to be dogmatic on the matter as the salts had just been added to the melts and stirred in and it was quite probable that this technique could be improved upon. With regard to additions of titanium and boron to larger melts, the efficiency of the method had been fully maintained for melts of 13 kg. At present, melts of the order of several tons were under way but a difficulty was that of stirring the hardener alloy into such a mass of metal when the furnace employed was not of the rotary type. It was possible that, for these large melts, salts would eventually prove preferable.

In the course of his reply to the discussion on the paper by Mr. Tottle and himself, Mr. Reynolds stated that many details of melting and casting had been omitted for brevity. Most of the metals they had used were of the commercial type, of the order 99·7 per cent. purity, but they had also employed highly-pure materials for certain of their experiments. There was no doubt that a very pronounced reaction occurred between the metal powders on the faces of the moulds and the melt; all their experiments had shown unmistakable evidence of this. The reaction was usually rapid and, in many cases, took place almost instantaneously after pouring.

METAL/MOULD REACTION IN CASTINGS.

The third and fourth papers considered were both communications from the British Non-Ferrous Metals Research Association and were by Mr. N. B. Rutherford; they were discussed jointly. The first paper was entitled "The Effect of Mould Material and Alloying Elements on Metal/Mould Reaction in Copper-Base Alloys." When presenting the paper, Mr. Rutherford said that when a metal was cast in a sand or other mould in which a steam atmosphere was generated, it reacted with the steam and might absorb hydrogen during the reaction. The term "metal/mould reaction" had been used to describe this effect. Experiments had been made to determine the influence of different mould materials on the mould reaction in phosphor bronze containing 10 per cent. of tin and 0·5 per cent. of phosphorus. The conclusions to be drawn from the work were that reaction would occur between the metal and the mould when the phosphor bronze was poured into natural and synthetic moulding sands or core sands bonded with vegetable or mineral oils, cereals, synthetic resins, or cellulose glycollic acid. The use of a mould coating of plumbago and water on a high-permeability synthetic moulding sand was likely to intensify the reaction. A mould coating of aluminium paint produced a variable degree of inhibition. Excellent protection was afforded by a coating of aluminium-magnesium alloy paint on various moulding and core sands, for castings both of phosphor bronze and of gunmetal containing residual phosphorus in excess of 0·03 per cent. The metal/mould reaction could be almost completely inhibited in phosphor bronze by the addition of 5 per cent. of ammonium bifluoride to a synthetic moulding sand. The addition of 0·5 per cent. of silica to 88 : 8 : 4 gunmetal containing 0·1 per cent. of phosphorus would inhibit mould reaction. More than 0·02 per cent. of silicon in an 85 : 5 : 5 : 5 leaded gunmetal was undesirable; mould reaction was promoted and the surface of the castings was badly affected. Nominal additions of 0·1 per cent. aluminium, 0·5 per cent. of chromium, 0·1 per cent. of vanadium, 0·1 per cent. of boron, and possibly small amounts (0·01 per cent.) of calcium, would inhibit mould reaction in 10-per cent. tin bronze containing 0·5 per cent. of phosphorus. It was probable that pouring and moulding practice would require modification if additions of aluminium and chromium and, possibly, vanadium and boron were used commercially. Nominal additions of 0·5 per cent. of iron or manganese, or 0·2 per cent. of magnesium, would intensify the reaction. This, however, was unaffected by small additions of nickel, beryllium, titanium, zirconium, barium, or sodium.

In the course of his second paper, which was on "The Effect of Metal/Mould Reaction on 85 : 5 : 5 : 5 Leaded Gunmetal Sand Castings," Mr. Rutherford stated that varying degrees of metal/mould reaction were induced in this type of leaded gunmetal by casting it into green-sand moulds from four pouring temperatures between 1,050 deg. and 1,200 deg. C., and by varying the residual phosphorus content from 0·002 to 0·15 per cent. The castings were in the form of ribbed plates, $\frac{1}{4}$ in., $\frac{1}{2}$ in., and 1 in. thick, and 1-in. and 2-in. diameter bars. The plates were intended to simulate poorly-fed industrial castings. It had been shown in earlier work that the pressure-tightness and strength of the poorly-fed parts of special test castings made in phosphor-bronze or lead-free gunmetal were substantially improved if the metal were slightly gassy (equivalent to 1·5 to 2·5 per cent. of voids in a sand-cast D.T.D.-type test bar) instead of being thoroughly degassed, and that even better results were obtained by using degassed metal and causing some gas to be absorbed by the casting while it froze in the mould. As a result of the present work, it was concluded that the value of the metal/mould reaction as a means of increasing the proportion of pressure-tight castings was less with leaded gunmetal than with phosphor-bronze or lead-free gunmetal. With the 85 : 5 : 5 : 5 alloy, however, it could be used with advantage where the rate of solidification was rapid, as in castings having a section thickness of the order of $\frac{1}{4}$ in., or in thicker-section castings poured below 1,100 deg. C.

Dr. D. V. Atterton, in opening the discussion, asked the author for further information on the exact mechanism of metal/mould reaction; was it rapid or was it a comparatively slow process? Dr. Atterton added that the author had mentioned that an aluminium-35 per cent. magnesium alloy paint had produced a high degree of inhibition of mould reaction. He had also mentioned a paint consisting of aluminium-45 per cent. magnesium alloy powder, and it would be of interest to know which was the more effective. A subsequent speaker, Mr. H. E. Dixon, said that it was gratifying to note the extensive use made of factorial experiments and of statistical methods of analysis. Mr. R. W. Ruddle, who spoke next, said that it was quite possible that variations in the thickness of the inhibitive paint coating and in its quality might have an influence on its efficiency. Mr. A. B. Graham, who closed the discussion, said that, in the casting of many metals and alloys, quite strange mixtures were now being applied as mould dressings, often in layers of quite considerable thickness. These had a definite influence on the grain size and also on the quality of the surface of ingots or billets to be used for forging, extrusion or other hot-working operation. Metallurgists were deeply interested in the final outcome of these metal-mould and similar reactions which were complicated by the large number of variables present.

In a brief reply, Mr. Rutherford said that he did not know what was the exact mechanism of the metal-mould reaction. He could add nothing to what had been stated in his two papers. A study of mould coatings and controlled metal-mould reactions did not furnish a panacea for all the ills from which ingots and billets suffered, but placed another tool in the hands of foundrymen which they would find useful on a number of occasions. One difficulty was the old one of applying laboratory experiments in practice, but the discussion had revealed that this was now taking place.

(To be continued.)

STAFFORDSHIRE COLLIERY IMPROVEMENT SCHEME.—Proposals have been approved by the National Coal Board for substantial improvements to be undertaken at Hem Heath Colliery, near Trentham, Staffordshire, at a total cost of about 5,750,000*l*. As a result of the proposed reconstruction, it is anticipated that the output at the colliery will reach a level of 1,250,000 tons of coal a year by 1965, or an increase of about 400 per cent. on the present rate of production, and that employment will be provided for some 3,000 men compound with the present average of less than 600.

1953 BRITISH PLASTICS EXHIBITION AND CONVENTION.—Arrangements are being made to hold the second British Plastics Exhibition and Convention at the National Hall, Olympia, London, W.14, from Wednesday, June 3, to Saturday, June 13, 1953. The convention will be arranged on a similar basis to that held in 1951, and will be opened with an inaugural address on the afternoon of June 3. Subsequent sessions will deal with new uses of plastics for industrial purposes, and the growing importance of unplasticised polyvinylchloride and glass-reinforced plastics will receive special consideration. The exhibition is being organised by *British Plastics*, Dorset House, Stamford-street, London, S.E.1, with the co-operation of the British Plastics Federation, 47-48, Piccadilly, London, W.1. The Federation, the Plastics Institute, and the plastics and polymer group of the Society of Chemical Industry are also co-operating in the arrangements for the convention.

PREVENTING CORROSION BY VAPOUR PHASE INHIBITOR.—The Shell Petroleum Company, Limited, St. Helen's Court, Great St. Helen's, London, E.C.3, have developed a vapour phase inhibitor, incorporating dicyclohexlammonium nitrate, for protecting stored metal parts from corrosion. Known as Shell V.P.I., it is available in powder form or as a coating on paper. As a result of tests carried out over a number of years, it has been demonstrated that Shell V.P.I. effectively prevents aircraft engines from deterioration when stored for long periods. The engines can be started immediately without any "de-preserving" treatment, such as is required when the conventional method of sealing the metal surfaces against the entry of air and water is employed. Such sealing, moreover, is not generally completely effective in preventing rusting. In applying V.P.I. to an engine, it is sprayed into the openings. It is slightly volatile, and its vapour penetrates to every part of the engine, inhibiting the action of moisture and oxygen on the metal parts.

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

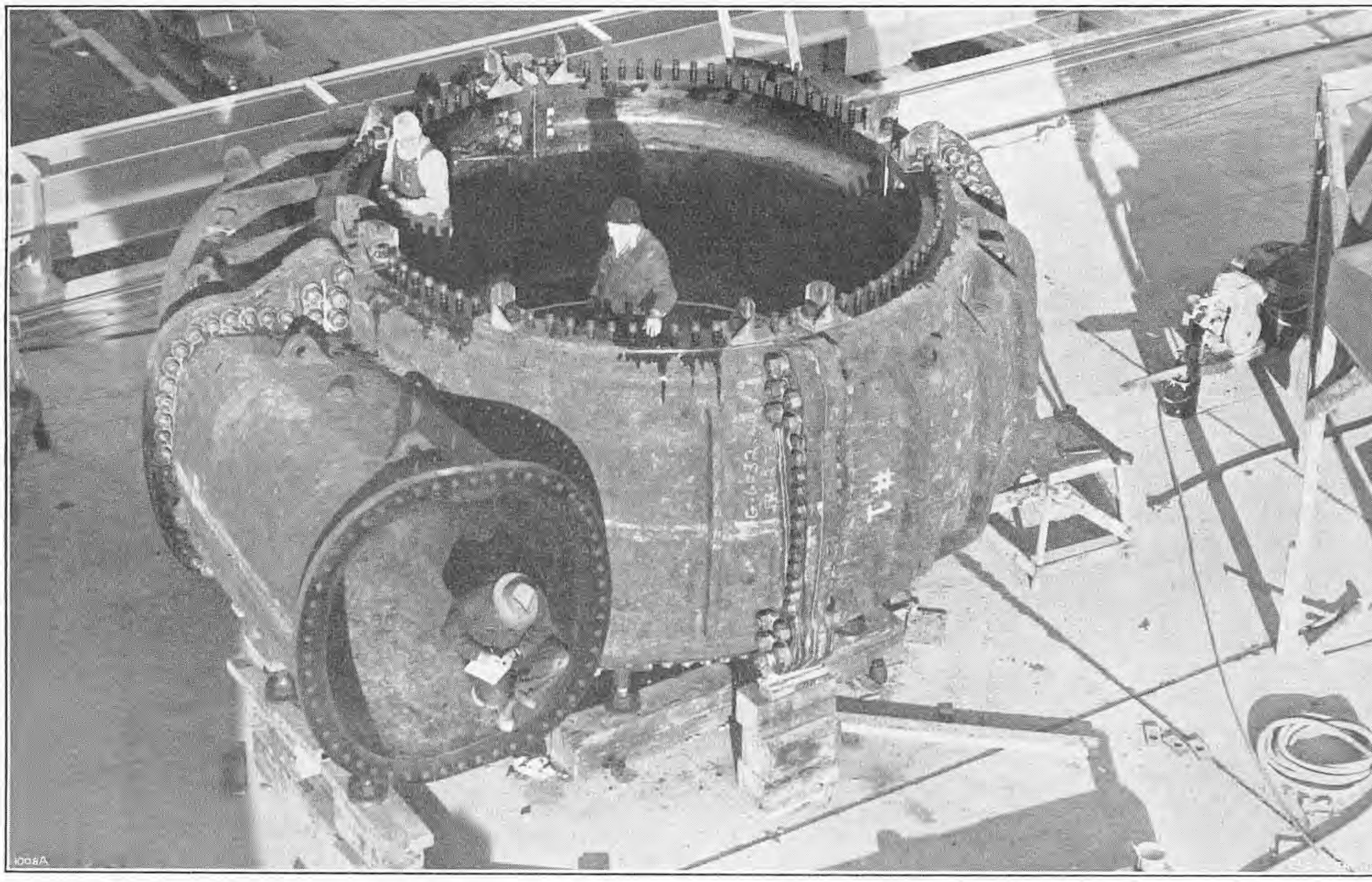


FIG. 8. PUMP CASING BEFORE BEING EMBEDDED IN CONCRETE.

THE TRACY PUMPING PLANT OF THE CENTRAL VALLEY PROJECT, CALIFORNIA.

(*Concluded from page* 426.)

THE six pump units with which the plant is equipped are claimed to be the most powerful and to have the highest lift of any pumps ever installed for irrigation work, with the exception of the plant at Grand Coulee. As mentioned in the first part of this article, the pumps were manufactured by the Worthington Pump and Machinery Corporation. They are centrifugal 84-in. vertical-shaft, bottom-suction, twin-volute units. The capacity of each pump at the rated speed of 180 r.p.m. is 369,000 gallons per minute, or 767 cub. ft. per second, against a head of 197 ft. They are driven by 22,500 h.p. three-phase synchronous motors made by the Allis-Chalmers Manufacturing Company, of Milwaukee, Wisconsin. The general layout of the plant and the position of the motors in relation to the pumps are shown in the cross-section given in Fig. 6, on Plate XXXII, *ante*.

A cross-section of one of the pumps is shown in Fig. 9, on page 464. The casing is a built-up unit consisting of five cast-steel sections bolted together and embedded in the concrete foundation of the building, together with the cast-steel intake elbow. One of the casings after erection and before the running of the concrete is shown in Fig. 8, on this page. Each casing weighs 72 tons. A photograph showing the impeller being handled by the gantry crane is reproduced in Fig. 10, on Plate XXXVIII. It weighs 19 tons and is bolted to a 20-in. diameter shaft with 32-in. diameter flanged ends and 9·75 ft. long. This shaft weighs 5 tons. At its upper end it is bolted to an intermediate shaft 20·75 ft. long and of the same diameter. The motor shaft is connected to the top of this intermediate shaft, which may when necessary be removed without disturbing either the pumps or motor. The total weight of the rotating parts is 110 tons, and this is carried by a single Kingsbury thrust bearing incorporated in the motor and illustrated in Fig. 11, on Plate XXXVIII. In addition to supporting the weight of the rotating parts, the bearing carries a hydraulic load of 22½ tons. The position of the journal bearings above the impeller is shown in Fig. 9. Each unit has an independent lubricating system; in each case there are two pumps, one driven by an alternating-current motor and the other by a direct-current motor; they act as stand-bys, one for the other.

The main Allis-Chalmers three-phase synchronous motors are supplied with current at 13·8 kV. They are designed to deliver 22,500 h.p. when running at 180 r.p.m. and at a 0·95 leading power factor. The weight of the rotating parts of each motor is 70 tons. In both mechanical and electrical features, the motors are similar to the manufacturer's alternating-current generators, the only difference being that amortisseur damping windings are fitted to conform with the starting and pull-in requirements. The motors are started on full voltage, the starting kilovolt-amperes being quite low. They are enclosed and air-cooled on a recirculating system which incorporates a surface-type air-to-water heat exchanger. The enclosed construction excludes dust, reduces fire hazard and makes it possible to incorporate provision for introducing an inert gas. The surface air cooler is split into sections arranged around the stator yoke. The stator frame is made up of two sections, as will be clear from Fig. 14, on Plate XXXIX, which shows winding in progress in the maker's works. A view of the completed rotor is given in Fig. 12. Two erection views are reproduced in Figs. 15 and 16, on Plate XXXIX, the former showing a stator being lowered into position and the latter the first three motors in various stages of completion on site.

The Kingsbury thrust bearing, shown in Fig. 11, is designed to run in either direction, as it may have to deal with reversed rotation due to power failure. It runs in an oil bath. There are two whitemetal-lined guide bearings made in sections to facilitate assembly and dismantling. The upper guide bearing is above the thrust bearing and bears on a ground and polished surface of the thrust-runner. Forced feed is not provided for the guide bearings; helical grooves in the linings are stated to be so effective that oil reaches the top of the bearings in less than one revolution of the motor. The thrust bearing is water-cooled by means of a copper cooling coil in the oil bath. There is a panel for each unit provided with control gear, oil and air temperature indicators and recording instruments; it is stated that after starting-up the units can be left to run virtually unattended.

Fig. 1, on page 425, and Fig. 6, on Plate XXXII, in the first section of this article, show large circular hatches in the roof of the pump room. These hatches are 28 ft. in diameter and the covers can be removed to give access to the pump and motor units below. The hatch is clearly seen in Fig. 15, which shows the handling of a motor stator by the 100-ton gantry crane which travels along the roof. This crane, which was built by the Cyclops Iron Works, San Francisco, to a Bureau of Reclamation specification, has an auxiliary 20-ton hook in addition to the main 100-ton hook. A general view of the crane handling a motor rotor is given in Fig. 17, on Plate XXXIX. For lighter lifts, such as the intermediate shaft or the pump rotor, the 21-ton jacking frame illustrated in Fig. 13, on Plate XXXVIII, is used. This is moved into the required position by the gantry crane and then run into the pump house to pick up the intermediate shaft or other part. The frame with its load can then be transferred to the machine shop by the gantry crane. The whole building, comprising the pump house, machine shops and administrative and control rooms,

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

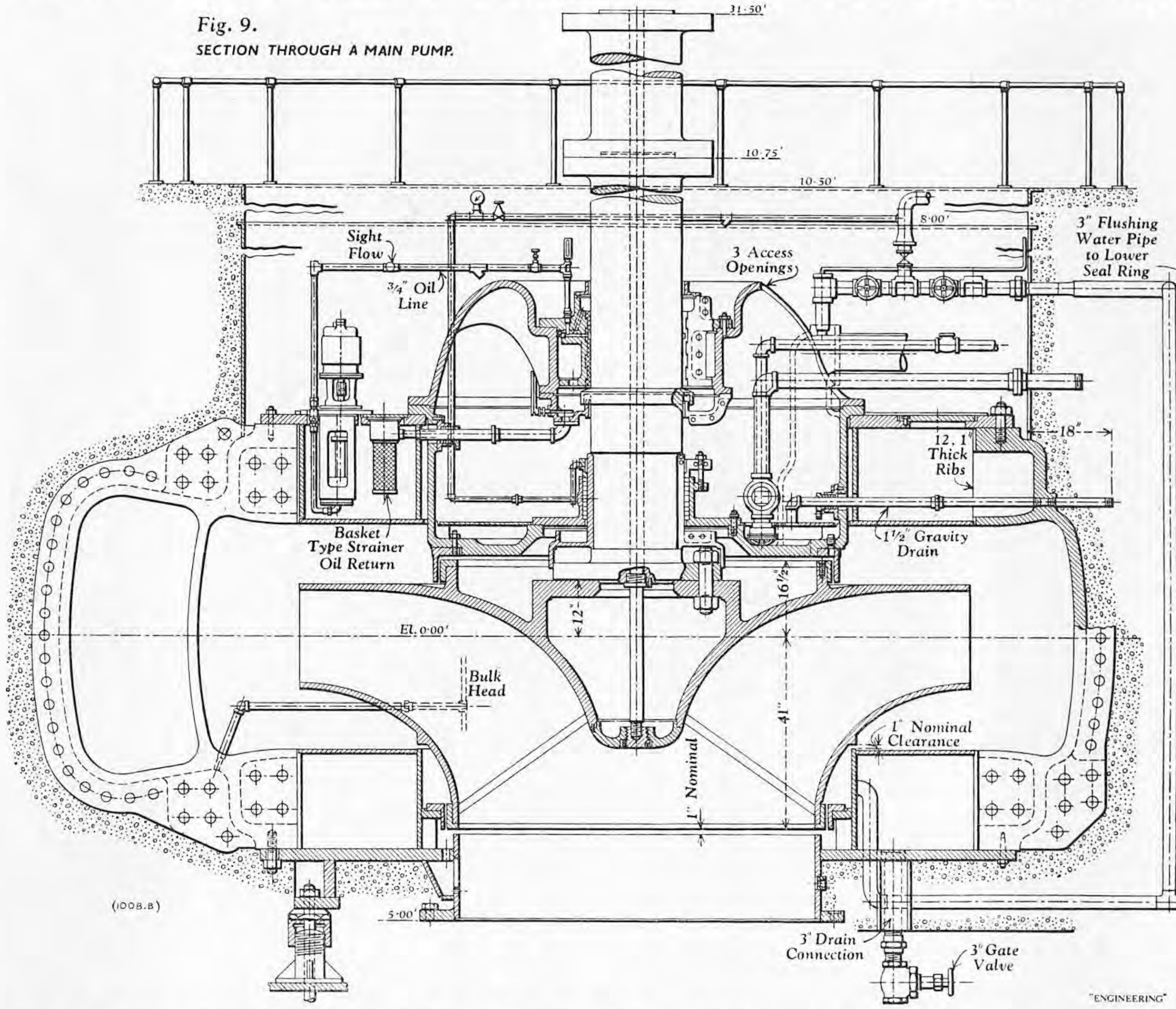


Fig. 9. SECTION THROUGH A MAIN PUMP.

is provided with a forced-air ventilating system. There is also, naturally, much auxiliary plant such as dewatering and sump pumps and oil-purifying equipment. A chlorinating and softening plant is installed to deal with the domestic water supply.

The switchyard, of which a general view is given in Fig. 18, opposite, not only contains the transforming and regulating plant for the pumping station supply, but serves as the key control point of the whole Central Valley electricity network. As will be seen from the map forming Fig. 1, on page 4, *ante*, the Tracy Plant is geographically situated at about the middle point of the whole scheme. The yard is served by two 230-kV transmission lines from the power station at the Shasta Dam and one transmission line of the same voltage from the Keswick Dam power station. As explained in our earlier article, and as shown on the map, both these stations are situated on the Sacramento River. From the yard, various outgoing lines serve Bakersfield, in the extreme south of the area, and other places, and include lines to the Pacific Gas and Electric Company which interconnect with the developed network of that company. The main sources of power are the 375 000-kVA station at Shasta, and the 75,000-kVA station at the Keswick Dam. As explained in our earlier article, and as indicated in Fig. 1, on page 4, *ante*, power stations from which the output will ultimately be available are being built at Folsom and Nimbus, on the American River; the respective capacities of these will be 180,000 kVA and 15,000 kVA.

The switchyard contains gear operating at four different voltages. The incoming 230-kV lines are connected to a 'bus structure 84 ft. high and having a length of 52 ft. for each section. Each line has a disconnecting single-throw air-break switch and a 1,000-ampere oil circuit-breaker, with an interrupting time of 3 cycles and an interrupting capacity of 10,000,000 kVA. The periodicity is 60 cycles per second. The reclosing line is 20 cycles. This gear controls 230-kV outgoing lines to the Pacific Gas and Electric Company and the 230-kV sides of seven oil-immersed transformers; one of these serves as a spare. They are rated at 33,333 kVA and step down from 230 kV to 115 kV; in addition, they have 13·8-kV tertiary windings. The primary winding is tapped so that the 115-13·8-kV voltages can be varied plus or minus 5 per cent. The three phases of the three-phase transformers are separate units. In addition, there are two voltage-regulating 75,000-kVA oil-immersed three-phase transformers. They operate in series with the 115-kV 'bus-bars and are excited by the 13·8-kV supply. They provide a plus or minus 10 per cent. regulation.

The 115-kV supply from the primary gear is connected to a 'bus-bar structure 61 ft. high and with a bay length of 32 ft. The 115-kV lines are connected through disconnecting air-break switches and five 1,200-ampere oil-break switches rated at 5,000,000 kVA. The interrupting and reclosing times are the same as for the 230-kV gear. There are four oil-immersed auto-transformers each rated at 15,000 kVA and providing a secondary voltage of 69 kV. They have tertiary 13·8-kV windings. The 115-kV primary winding is tapped so that the 69-kV output can be varied plus or minus 5 per cent. Outgoing lines connecting to less distant points will in the future be supplied from the 115-kV gear.

The 69-kV section of the yard has a double-'bus structure 46 ft. high and with a bay length of 24 ft. It controls the output from the 69-kV side of the 115/69-kV transformers. Each line passes through a 600-ampere air-break disconnecting switch and an oil circuit-breaker with an interrupting capacity of 1,500,000 kVA, an interrupting time of eight cycles and a reclosing time of 20 cycles. Transmission lines to still nearer points of utilisation are supplied at 69 kV; this applies to Contra Costa, which is in the neighbourhood of San Francisco.

As mentioned earlier, the Tracy pumping plant is supplied at 13·8 kV. This voltage is available from both the 230-kV and 115-kV primary-voltage transformers. The switchgear consists of a single 'bus structure 20 ft. 6 in. high and with a bay length of 18 ft.; it has a total length of 252 ft. The various circuits are connected through air-break disconnecting switches of various types and sizes, depending on the rating of the oil-circuit breakers the connection to which they control. Some of the switches are of the three-pole single-throw type and others single-pole; there are 2,000, 3,000 and 4,000-ampere ratings. The capacities of the oil circuit-breakers are similar. The reason for the

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

(*For Description, see Page* 463.)

Fig. 10. Pump Impeller.

Fig. 11. Kingsbury Thrust Bearing.

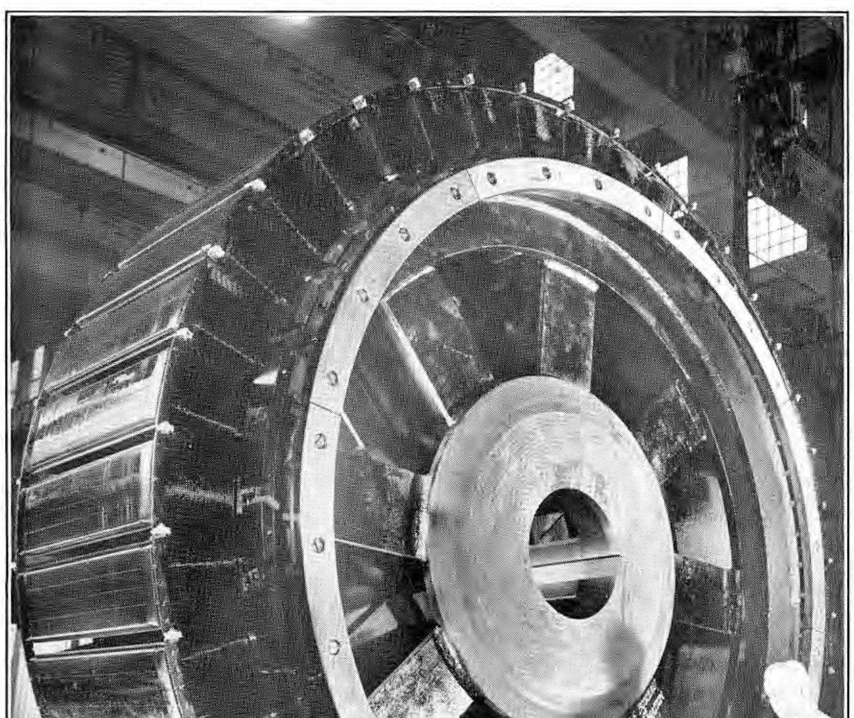


Fig. 12. Completed Rotor for Motor.

Fig. 13. Jacking Frame Handling Pump Impeller.

(*To face page* 464.)

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

(*For Description, see Page* 463.)

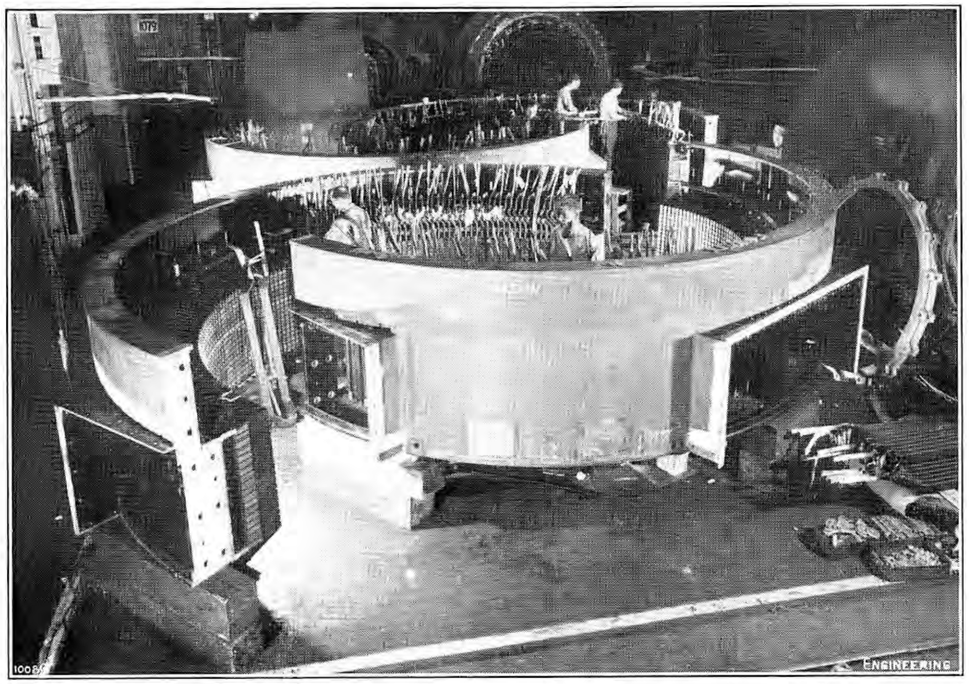


Fig. 14. Stator Winding in Progress.

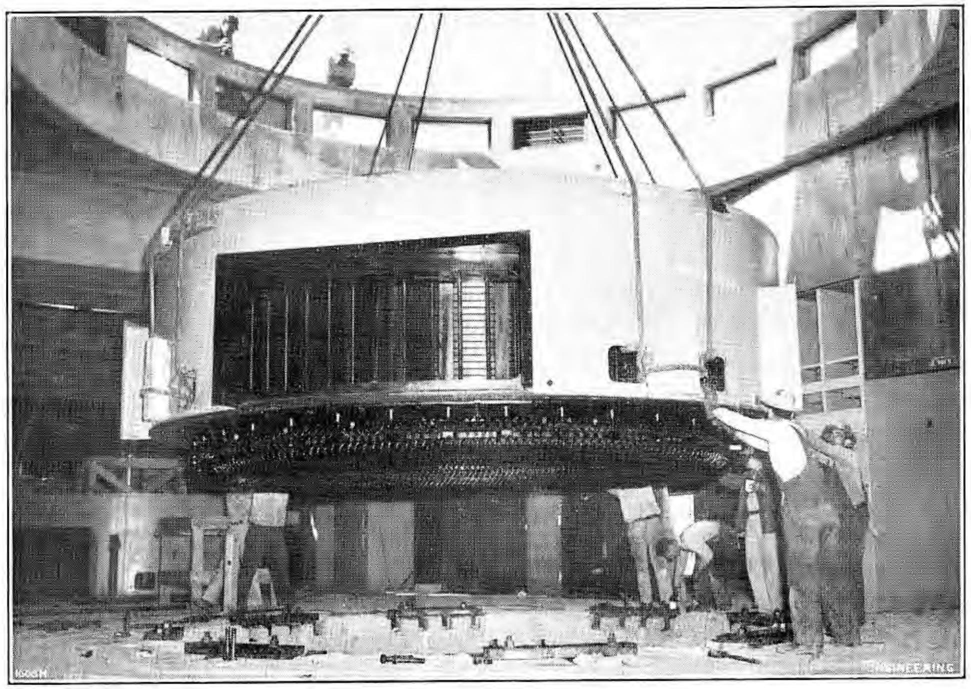


Fig. 15. Stator being Lowered into Position.

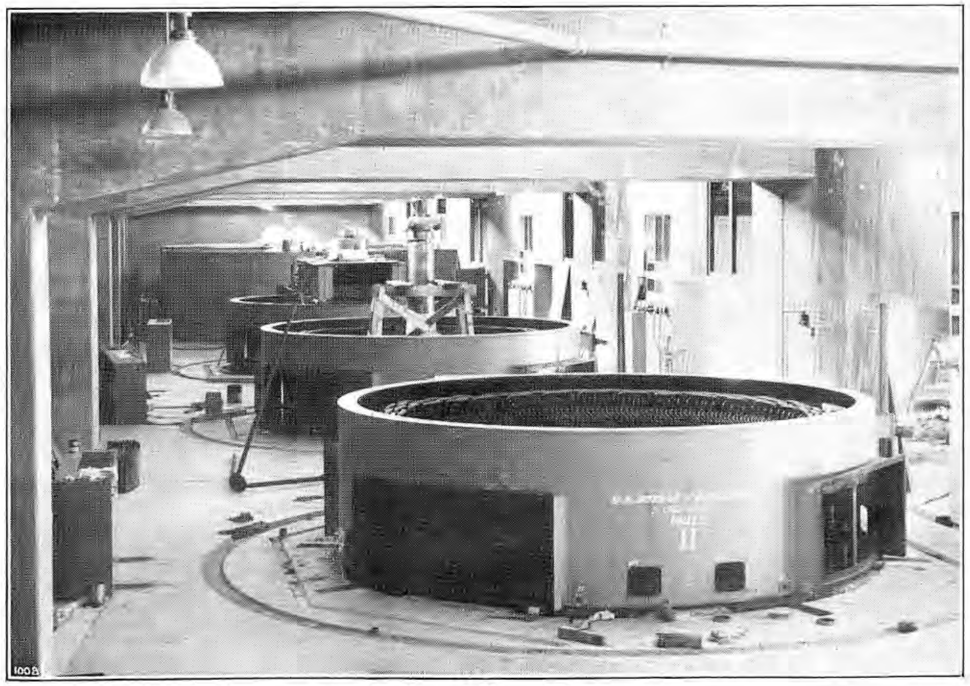


Fig. 16. First Three Motors during Erection.

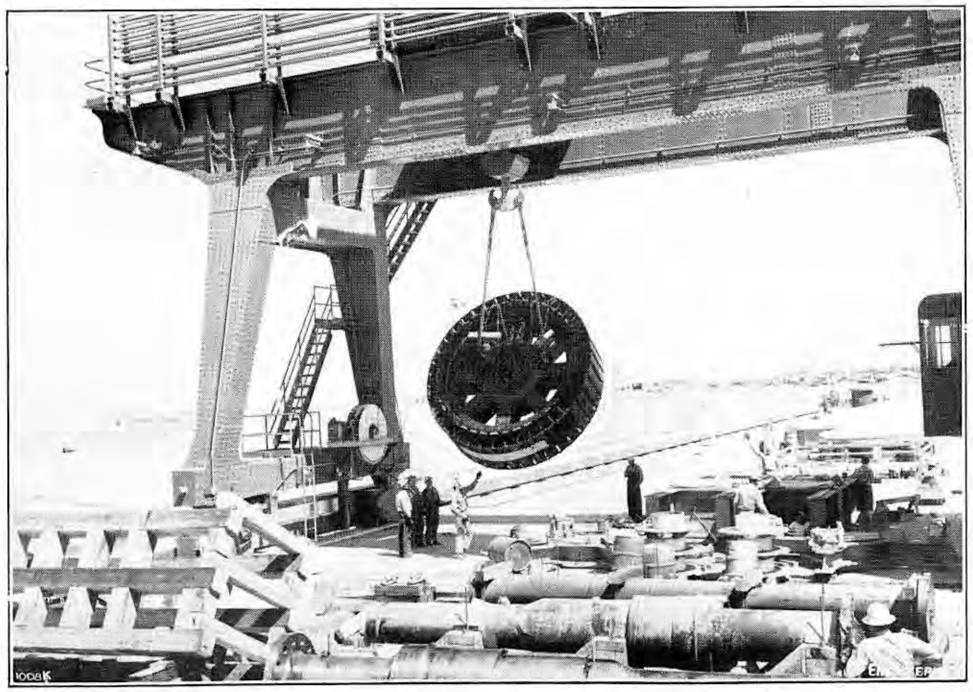


Fig. 17. Gantry Crane handling Motor Rotor.

(*To face page* 465.)

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

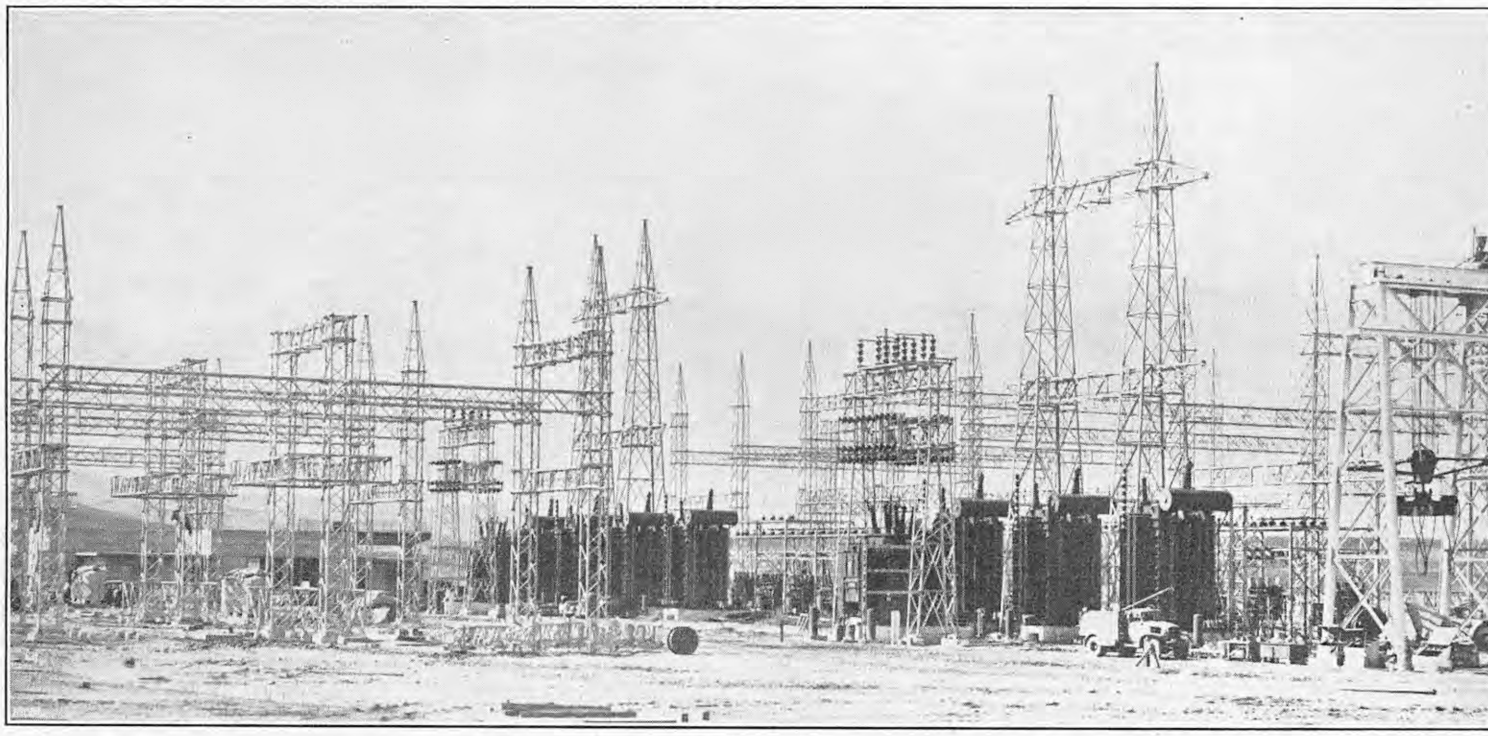


FIG. 18. TRACY SWITCHYARD: KEY CONTROL POINT FOR CENTRAL VALLEY NETWORK.

different ratings of the breakers is that, in addition to the pumping plant supply, the 13·8-kV switches also control a number of transformers stepping down to 480 volts, for pumping plant in the switchyard and auxiliary plant of various kinds in the Tracy workshops and pump house. The 13·8-kV 'bus-bars are fitted with three single-phase current-limiting reactors. They are of the air-cooled type and are rated at 840 kVA per phase.

The switchyard also contains a 50,000-kVA, 13·8-kV hydrogen-cooled synchronous condenser. It is installed out of doors on a platform at the north end of the reinforced-concrete building which houses the control boards. The condenser is a 12-pole unit running at 600 r.p.m., and has a 230-kW, 250-volt, 6-pole direct-current exciter. The condenser is provided with a starting auto-transformer supplied at 13·8 kV and giving output at 3·45, 4·14, 4·83, 5·52 and 6·21 kV. Installed between the condenser terminals and the ground, there is a 72,200-kVA neutral reactor at 60 seconds rating. The drop is 3·8 kV at 19,000 amperes and 0·20 ohms. A 15-kV circuit-breaker with an interrupting capacity of 19,000 amperes is installed in connection with the reactor.

The switchyard contains oil-storage tanks and other necessary auxiliary plant, and near at hand there is a 100,000-gallon water tank, 188 ft. high, for storing water from the canal for fire protection at the pumping plant and switchyard and, after purification, for domestic use. The Tracy pumping plant was designed in the Denver, Colorado, office of the Bureau of Reclamation, and the Tracy switchyard partly in that office and partly in the Regional Director's office at Sacramento. The main contractors for the construction of the building and installation of the machinery were the Duncan-son-Harrelson Company, of Oakland, California.

STELLA POWER STATIONS.—The new power stations being erected at Stella North and Stella South near Newcastle-on-Tyne, at a cost of 30,000,000*l*., are expected to be completed in about three years' time. About 600 men are working on the projects, and, during the past 12 months, railway sidings to accommodate 2,800 wagons have been built and earth excavated for the foundations of the main power houses. Work has also commenced on two 400-ft. chimneys.

THE INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING.

THE autumn meeting of the Institution of Naval architects, which has been held in Italy by invitation of the Associazione Italiana di Technica Navale, opened in the afternoon of Thursday, September 25, in Genoa, where the members taking part had arrived by train in the morning. The party, numbering between 50 and 60, including a number of ladies, was headed by the President of the Institution, Viscount Runciman of Doxford.

The first function was a visit to the Instituti di Architettura e di Construzione Navale, which forms part of the Universita degli Studi, and is housed in the Villa Cambiaso, formerly the home of a Genoese noble family. The party was received by the Rector of the University (Professor Carlo Ceretti), and the President of the Faculty of Engineering, Professor Dott. Ing. Agostino Capocaccia, who expressed their gratification that the Institution of Naval Architects, which last visited Italy in 1929, had decided to do so again. Professor Capocaccia then gave an outline of the courses provided and the work done in his faculty, the excellent quality of which the members were enabled to examine later, as an exhibition of the students' design work had been arranged in an adjoining room.

Lord Runciman having acknowledged the welcome of the Rector and Professor Capocaccia, Colonel Dott. Ing. Luigi Tursini, a member of the committee who had been responsible, earlier in the year, for the arrangements made to celebrate the 500th anniversary of the birth of Leonardo da Vinci, gave an illustrated address on those of Leonardo's many drawings which had a direct bearing on naval architecture. Most of these were already familiar to his audience as a result of the commemorative exhibition, etc., held in London in collaboration with the Italian committee, but Colonel Tursini's explanatory notes will, no doubt, form a useful commentary on the published and exhibited drawings when they appear in the *Transactions*.

Following Colonel Tursini's lecture, the members proceeded to the building in which is housed the Institute's ship-model tanks. These are two in number, one being of conventional type, with an electrically-operated towing carriage and wave-making apparatus, and the other a closed-circuit tank in which a stationary model is held in the stream of water circulated round the channel. An interesting addition to this latter tank is a large wind-trunk, constructed above the tank, through which a flow of air can be directed on to the sails of yacht models so that they are caused to heel, yaw, etc., while undergoing tests. The tank is, perhaps, rather small to afford very precise measurements, because of the difficulty of ensuring that the water is flowing uniformly in the immediate vicinity of the model; but its design and construction reflect great credit on the staff of the Institute, in view of the post-war problems of obtaining the necessary financial support for the development.

From the Institute the party proceeded in motor coaches to the Palazzo Tursi, the town hall of the city of Genoa, where they were received by the Deputy Mayor, Signor Venturini, on behalf of the Mayor and the City Council and entertained with light refreshments while they explored the historic rooms of the municipal headquarters and studied the many fine paintings on the walls. The thanks of the Institution were expressed by Lord Runciman, and of Italian Association by their President, Dott. Ing. Alberto Della Ragione, who also took the opportunity to express the hopes of his society—usually referred to as "Atena"—that the joint meeting would prove both enjoyable and technically fruitful.

OPENING SESSION.

The proceedings of Thursday afternoon and evening had been arranged largely to enable the members of the two societies to become acquainted, the first formal session being that held on the morning of Friday, September 26, in the Palazzo San Giorgio. Unfortunately, Lord Runciman was unwell and could not take the chair as had been intended; but his duties were ably shared by Professor Della Ragione and Mr. E. L. Champness (vice-president of the Institution of Naval Architects). The proceedings opened with short speeches of welcome by Professor Capocaccia of the Engineering University, and Professor Della Ragione. Mr. Champness, in reply, regretted his inability to do so in Italian—the only appropriate language, he felt, in which to express the warm appreciation of the Institution of Naval Architects of the arrangements made and the hospitality extended to them. Such conferences as they were holding were not only valuable because of the exchange of scientific knowledge, but because of the advantages they afforded for the members to establish personal contacts. He regretted exceedingly that rising costs, all over the world, made it so difficult for the younger men to participate more freely and so to gain those advantages that it was so necessary they should enjoy. The Institution of Naval Architects possessed a gold medal which had been presented to them in 1913 by Signor Orlando on behalf of their Italian confreres: they treasured it as a token of the regard which the present meeting was enabling them to renew.

The Longitudinal Strength of Ships.

Mr. E. L. Champness, M.B.E., M.Sc., then took the chair and invited Mr. James Turnbull, O.B.E., to present his paper on "Longitudinal Strength: A Review of Some Recent Developments." which we commenced to print on page 449, *ante*, and conclude on page 483 of this issue. Although, he said, the longitudinal strength of ships had been constantly under review since naval architects first appreciated that a ship was merely a large girder, it was true that the longitudinal scantlings of ships were still based mainly on the records of service behaviour of earlier ships. The failure of several welded ships in 1942-43 had shown, however, that new problems had arisen, and almost simultaneously, in the United Kingdom and the United States, research committees had been set up to investigate the matter. Under the direction of the Admiralty Ship Welding Committee, a comparison was made of the welded tanker Neverita and the riveted sister ship Newcombia, under hogging and sagging bending moments applied in still water, but no important difference was revealed. Similar still-water comparison of the welded Ocean Vulcan and the riveted Clan Alpine, sister dry-cargo ships, showed slight differences in behaviour. The Ocean Vulcan was then fitted with instruments to record the behaviour at sea, when much valuable information was gained, including photographic evidence that waves at sea were seldom regular, though in severe storms they tended to resemble closely the trochoidal form. Reviewing the accumulated data, Mr. Turnbull thought it likely that the standard longitudinal bending-moment calculation would be superseded by a simplified still-water bending-moment calculation, to which would be added an estimate of the effects due to dynamic action. Perhaps the most outstanding deduction from the tests was the superiority in welded construction of longitudinal framing over transverse framing for the bottom and for the strength deck amidships. The danger of excessively high stresses at sea could be greatly reduced by arranging the fore and aft distribution of the cargo loading so as to maintain the still-water bending moment as near as possible to the neutral condition; and, to minimise the effects of slamming, the draught forward, in the ballast condition, should be kept as great as possible, consistent with other requirements, such as adequate immersion of the propeller.

The Chairman, observing that Mr. Turnbull's paper, though short, summarised an immense amount of full-scale experimental work carried out during the past 20 years, called on Mr. H. E. Steel to open the discussion.

Discussion.

Mr. Steel thought that Mr. Turnbull was to be congratulated on having merged the essentials of his recent work into a brief but accurate survey of the hull strength problem as it was known to date. If time had permitted, the paper could have been usefully amplified, point by point, from experience in order to avoid leaving impressions which, he was sure, Mr. Turnbull did not wish to convey; for instance, he (Mr. Steel) recalled two cases of rivet slip in shearstrake butts—admittedly, in locally highly stressed areas—but the paper suggested that rivet slip was unknown. He would say emphatically that hundreds of fatigue fractures had occurred in all parts of ships' hulls; it would be curious if it were otherwise, since such failures were so familiar to bridge, railway and mechanical engineers. This did not conflict with the useful data given in the section of the paper headed "Frequency of Stress Ranges Experienced at Sea." The trouble arose where these normal stress ranges were amplified at flexing areas or by discontinuities, and by whipping and vibratory ranges of high frequency superimposed upon them.

At the moment, Mr. Steel continued, we were preoccupied in preventing brittle fractures in welded ships, chiefly because their high rate of propagation was so dangerous. It was not enough to strive to eliminate the use of steel susceptible to brittle fracture. If we did not also eliminate, as far as practicable, the sources of such fractures, we might be troubled in both riveted and welded ships with fatigue cracks originating at some of the same sources. Fortunately, they extended slowly, as a rule. Although he agreed that fatigue fractures had not, in general, been considered an important factor in the longitudinal strength of ships, there had been a number of cases where they caused considerable anxiety, especially in large ships, not only because of the cost of repairs, but mainly because of the great difficulty in making effective repairs. There was reason for thinking that satisfactory fatigue strength was of greater significance than increased tensile strength in the attempt to provide against fatigue fractures.

Dr. Giuseppe Fusini, who was the next speaker, suggested that, as the block coefficients of the tankers and cargo vessels tested by the Admiralty Ship Welding Committee were considerably greater than that of a Liberty ship, this might have some bearing on the largely negative results of the tests. Starting, however, from the same considerations as Mr. Turnbull, concerning hogging stresses in cargo ships with the machinery amidships, when fully loaded, and sagging stresses when in ballast with deep tanks amidships; sagging stresses in tankers when fully loaded; and modern cargo ships with finer hulls than those of the past, he suggested that future cargo ships should have their machinery aft, cargo holds extending from the machinery bulkhead to the collision bulkhead, a double bottom forward from amidships to facilitate ballasting and trimming when loaded, and continuous strong girders connecting all longitudinal sides of hatchways, to improve the longitudinal strength of the ship. Placing the machinery aft would reduce the length of shafting, and also the troubles associated with shafting; but it would be necessary to avoid raising the strength deck too high above the water-line. A ship so constructed, however, should offer advantages in cargo-handling.

Mr. J. M. Murray, M.B.E., said that the paper gave a very concise account of the present state of knowledge of the stresses sustained by a cargo ship of about 400 ft. length, of which a large number were built during the war. The information contained in it must be comforting to naval architects, for it showed that the classical method of carrying out strength calculations, initiated by William John in 1874, gave not only comparative, but also reasonably absolute, stresses for that type of ship. The deduction that, by using the L/20 wave without the Smith correction, the theoretical bending moment amidship would approximate to the actual bending moment experienced in severe storm conditions by ships of about 400 ft. length, might, perhaps, be extended. It had been shown on several occasions that the bending moment could be divided conveniently into two components—that due to the passage of the wave, which depended purely on the geometric characteristics of the ship, and that due to the bending moment in still water, which was a function of the distribution of loading. The effect of the Smith correction was reduced at draughts less than the load draught, and therefore at the ballast draught it would appear that, allowing for the different geometrical characteristics of the ship at that draught, the wave component of the bending moment would be about the same as the wave component of the load draught. If so, it appeared that bending-moment calculations might be further simplified by adopting the same wave component at all draughts and adding it to the appropriate still-water moment. He had advocated that method of approach to bending moments on several occasions, and long experience had convinced him of its value.

The author's statement that, in longer ships, the stresses derived from the classical theoretical calculations would, of course, be higher, and, in shorter ships, lower than those actually experienced, needed some qualification. It might be true for ships of the same form and speed/length ratio, but, in his opinion, it would be dangerous to assume that it applied generally. There was some evidence to show that the effect of speed must be taken into account. In the modern fast cargo liner, which might be driven hard in heavy weather, it was probable that the chance of high bending moments occurring was increased. The highest stresses recorded on the San Francisco in 1934 occurred when the ship was hove to; had engine power been available or had conditions necessitated driving the ship in that weather, probably even higher stresses would have been recorded.

The diagram in the paper showing maximum wave heights for various lengths was interesting, but the envelope curve seems to require justification at the higher lengths. In a recent paper in the *Transactions* of the American Society of Naval Architects and Marine Engineers, on the motions of ships at sea, there was a curve, prepared from observations made in the North Pacific Ocean, giving certain values for most extreme conditions over a long period of time. They showed that, in round figures, the ratio of length to height reached a maximum of 12 at about 460 ft., and thereafter declined to about 20 at 750 ft. That curve, perhaps, would provide a suitable envelope. At present, it was not certain whether the damage to a ship was done by an isolated wave of great magnitude or by a series of waves of slightly smaller size. It could be shown that a wave of the same length as the ship did not necessarily induce the most severe conditions; a static calculation would show that there was little difference when the length of wave varied from 1 to 1·3 times the length of the ship. For this reason, therefore, any attempt to relate the chances of excessive stresses to the length of ship and to the most likely length of wave encountered must be treated in a broad sense. In his opinion, the most promising line of investigation, would be to fit statistical strain gauges on a number of ships of various sizes and speeds so that the range of stress induced by the wave could be determined for a variety of types.

Mr. Turnbull's demonstration of the superiority in welded construction of longitudinal framing over transverse framing for bottom and strength deck amidships could not be too strongly endorsed. The distribution of longitudinal stresses over the bottom shell plating of the welded ship, as illustrated in the paper, was typical of the effects of the transverse form of construction. Experiments made by Lloyd's Register, under the ægis of the British Shipbuilding Research Association, on an element of a double bottom of a ship under compression produced similar stress patterns to those given in the paper. The experiments were made on specimens of riveted and welded construction, and the difference between the behaviour of the two forms of construction was very marked.

(*To be continued.*)

NATIONAL SCIENCE CENTRE.

On page 411 of our 170th volume (1950) we recorded that agreement to the establishment of a national science centre in London had been reached in principle, although it was not expected that actual building would be started for some time. A further step forward has, however, been taken this week when the London County Council at their meeting on Tuesday, October 7, adopted a recommendation of their Town Planning Committee that a site of some 35 acres on the south bank of the Thames between Waterloo Bridge and Broad Walk, and with a river frontage of a quarter of a mile, should be purchased from the Duchy of Cornwall. It was also agreed that five acres of this site adjacent to Waterloo Bridge should be reserved for the erection of the Science Centre and that on it a building should be erected for the accommodation of the Royal Society and other leading scientific bodies with their libraries, as well as for the Patent Office Library, for the Department of Scientific and Industrial Research and other Government scientific organisations. Before building can begin it may, however, be necessary to extend the new river wall downstream beyond Waterloo Bridge. As has already been announced the centre is intended to improve contacts between scientists and users of science both in this country and abroad and, when completed, should do much to remove the handicaps under which the Royal Society in particular has suffered.

EXHIBIT AT COMMERCIAL MOTOR SHOW.

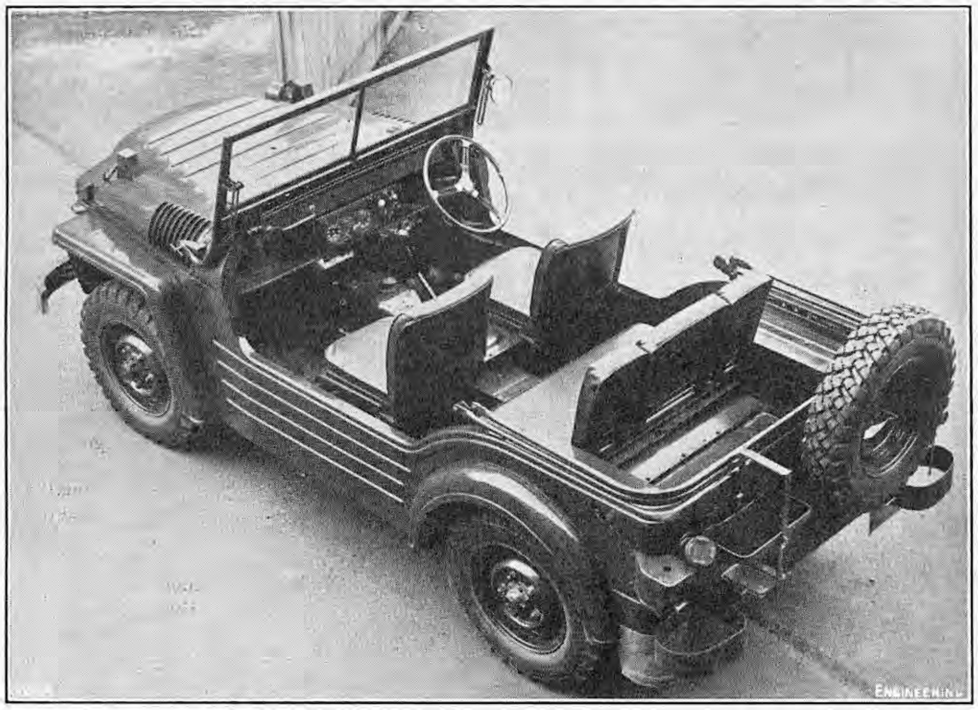


Fig. 12. Four-Wheel Drive Personnel Carrier; Austin Motor Co., Ltd.

INTERNATIONAL COMMERCIAL MOTOR SHOW.

(*Continued from page* 437.)

Four-Wheel Drive Personnel Carrier.

Considerable progress has been made with the production of four-wheel drive vehicles. Originally, these were produced for the Services only, but several manufacturers have now reached a position in which they are able to offer a limited number for civilian use overseas. The Austin Motor Company, Limited, Longbridge, Birmingham, for example, were exhibiting two such vehicles, limited quantities of which are available for export, namely, a personnel carrier, and a 1-ton load carrier. The personnel carrier, which is known as the Champ, is illustrated in Fig. 12, on this page. It was developed for the British Armed Services and will shortly be available for export. It is of exceptionally robust construction, having been designed for severe cross-country work and apart from its application to military service is eminently suitable for police, forestry and farming purposes. Three distinct versions of the Champ will be available for world markets, namely, the military version fitted with a Rolls-Royce engine, the military version fitted with a special Austin engine, and a civilian version fitted with a standard Austin 2,660 c.c. engine. Apart from the engine, the chief differences between the military and civilian versions are that the former is "tropicalised," radio suppressed, waterproofed and fitted with special wading equipment which is not included in the latter. The military version also has 24-volt electrical equipment, whereas the civilian model is fitted with a normal 12-volt system.

The model shown at Earls Court was the military version fitted with the Austin special engine. This has four cylinders with a bore of 3·4375 in. and a stroke of 4·375 in., and is capable of developing 78 brake horse-power at a speed of 3,750 r.p.m. and a maximum torque of 140 lb.-ft. at 2,000 r.p.m. The cylinders are cast integrally with the crankcase, the casting being designed so that the water jackets extend the full length of the bores. A cast-iron cylinder is employed and this is fitted with the overhead valve gear operated in the usual manner through push-rods and rocking levers. Large inlet valves are fitted and these are made from silicon-chromium alloy, the exhaust valves, on the other hand, are made from "X B" steel, so as to resist corrosion from leaded fuels, and operate on Stellite valve-seat inserts. Aluminium-alloy pistons of the split-skirt type are used and each is fitted with three compression rings and one oil-control ring. The pistons operate in dry-type cylinder liners and are connected to the crankshaft through forged steel rods provided with steel-backed whitemetal-lined big-end bearings. A nitride-hardened crankshaft is fitted and this is supported by three main bearings of the same type as used for the big ends. The camshaft is driven through a duplex roller chain and, like the crankshaft, is supported by three whitemetal-lined bearings. The main, big-end, camshaft and valve-rocker bearings are pressure lubricated, the oil being supplied by a gear-type pump. A full-flow filter is incorporated in the lubricating system and holes in the big-end bearings provide for jet lubrication of the cylinder walls. The coolant is circulated by a centrifugal pump, cooling being assisted by an engine-driven fan. The temperature of the engine is regulated by a thermostatic control and the radiator is designed so that there is no loss of coolant through expansion.

The drive is transmitted to the transmission group through a single-plate dry-type Borg and Beck clutch, the operating pedal for which is mounted on the chassis frame and isolated from engine movement by an adjustable linkage. The gearbox forms a single unit with the clutch and engine. There are five forward speeds with synchromesh engagement of all speeds, the control lever being mounted directly on the gearbox. The reverse gear is situated in the transfer-gear casing and is selected by a lever having three positions, namely, forward, reverse or winch: there are, therefore, five reverse speeds. The drive can be transmitted to the rear wheels only or to all four wheels at once, a single Hardy-Spicer open propeller shaft conveying the drive from the gearbox to the rear axle. A second shaft drives the front axle from the rear-axle transfer case and runs idly when the front-wheel drive is not in use. The final drive assembly for the front wheels consists of a hypoid bevel gear and pinion and a straight-tooth bevel-type differential, the complete assembly being housed in a cast-aluminium case. Tracta constant-velocity universal joints are incorporated in the half shafts to give freedom for steering and to accommodate spring deflection. The rear axle is similar to the front axle but, as already indicated, has a transfer-gear casing installed at the front of the main casing, the former casing also incorporating the winch and power take-off drives. As in the case of the front axles the drive is transmitted to the road wheels through Tracta constant-velocity joints, the joints, together with the differential assemblies being interchangeable between front and rear axles.

Independent suspension is provided for all four wheels, the springs consisting of tension bars connected to the wheels through wishbone arms. The tension bars are disposed longitudinally and are interchangeable between all four positions, it being possible to remove any one bar without disturbing the others. A progressive rubber buffer provides a gradually increasing resistance, being designed to function as a part of the normal suspension system and telescopic dampers are fitted at the front and rear. Helical rack-and-pinion steering gear is employed, the half-track rods being tubular thus providing oil reservoirs for the ball joints. Girling hydraulically-operated brakes are fitted to all four wheels, the front brakes being of the two leading-shoe type. The handbrake lever applies the rear brakes only, all bearings in the linkage being of the bronze oil-impregnated type sealed against entry of dirt and water. The body is of semi-integral construction, the dash, floor, front wheel-arches, seat supports, etc., being welded to a box-section cruciform chassis frame, the rear cross member of which forms the rear body panel and incorporates suitable reinforcements for accommodating the winch gear. The approximate weight of the vehicle unladen is 3,470 lb. and the load capacity is a driver and three passengers or a driver and 560 lb.

Four-Wheel Drive One-Ton Truck.

The Austin Motor Company, Limited, were also showing a four-wheel drive lorry designed to military specification and capable of transporting a load of 1 ton. This vehicle, which is illustrated in Fig. 13, page 468, is of a somewhat different layout to the personnel carrier just described. Rigid axles are employed, for example, and the suspension system follows traditional lines in that semi-elliptical leaf springs are fitted to the front and rear axles. It is powered by a six-cylinder version of the engine installed in the personnel carrier, the output in this case being 90 brake horse-power at 3,000 r.p.m., and the maximum torque developed being 190 lb.-ft. at 1,300 r.p.m. A Borg and Beck 11-in. diameter single dry-plate clutch is used to transmit the drive to the gearbox, the engine, clutch housing, clutch and gearbox forming a single unit. The gearbox gives four forward speeds and a reverse speed and is connected by an open tubular-type propeller shaft to an auxiliary gearbox mounted separately on cross members mid-way along the chassis. This auxiliary gearbox is known as the transfer box and provides the option of a high-ratio drive to the rear axle only for normal road work or a low-ratio drive to both front and rear axles for rough work, the drive being transmitted to each axle through open Hardy-Spicer propeller joints. A fully-floating rear axle with straddle-mounted spiral-bevel pinion is used the design being such that the half shafts transmit torque only and carry no other load; furthermore, they can be dismantled, together with the differential assembly, without removing the wheels. The axle casing is built up from steel tubes and a cast-steel centre case. The spiral-bevel drive assembly and the centre casing of the front axle are identical with those of the rear axle and these parts are interchangeable. The drive, however, is transferred to the road wheels through Tracta constant-velocity universal joints, the stubs of which are flanged and held to the hubs by studs. Lockheed hydraulic brakes are fitted to all four wheels, the front brakes being of the two leading-shoe type. The frame is of convential design, consisting of channel side members reinforced by pressed-steel cross members.

Four-Wheel-Drive $1\frac{1}{2}$-Ton Load Carrier.

A four-wheel-drive lorry was also shown by Morris Commercial Cars, Limited, Adderley Park, Birmingham. This vehicle, which is illustrated in Fig. 14, on page 468, has been designed to meet almost any eventuality, either on roads or over rough ground, and is equipped with a flexibly-mounted six-cylinder petrol engine having overhead valves and developing 72 brake horse-power at 2,750 r.p.m. The main gearbox provides four forward speeds and a reverse speed and works in conjunction with an auxiliary, or transfer, box, which gives a high ratio of 1 to 1 for either two-wheel or four-wheel drive or a low ratio of 2 to 1 for four-wheel drive only. The front and rear axles incorporate spiral-bevel final drive assemblies and both axles are connected to the chassis through semi-elliptical leaf-type springs, the rear springs having auxiliary leaves. A general-service body is fitted as standard, and this has a length of 7 ft. 11 in., a width of 6 ft., and a side height of 2 ft. $1\frac{1}{2}$ in. It is largely of steel construction and is equipped with tubular-steel hoopsticks and a canvas sheet arranged to give protection to the cargo, or to personnel, when carried. Other types of body, however, can be fitted. A towing attachment is provided. The overall dimensions of the complete vehicle are: length, 17 ft. 8 in.; width, 6 ft. $7\frac{1}{2}$ in.; and height, to top of cab, 7 ft. 9 in.

Forward-Control 5-Ton Load Carrier.

Other new vehicles on the stand of Morris Commercial Cars were a $1\frac{1}{2}$-ton forward-control van and a 5-ton forward-control load carrier. The chassis for the latter vehicle, which is known as the FVS 12/5 five-tonner, is illustrated in Fig. 15, on page 472. It is fitted with a six-cylinder overhead valve petrol engine having a bore and stroke of 88 mm. and 115 mm., respectively, and developing 100 brake horse-power at 3,200 r.p.m. A Diesel engine, manufactured by Morris Commercial Cars, Limited, to Saurer patents, can, however, be installed as an alternative. This unit has a capacity of 4,459 c.c. and develops 70 brake horse-power at 2,400 r.p.m. In each case, the power unit is supported by heavy-duty flexible mountings, those used in connection with the petrol engine being visible in Fig. 16, on page 472, which shows the unit installed in the chassis. In general, the design of the chassis follows conventional lines. There is a four-speed gearbox, which forms a single unit with the engine and the drive is transmitted to the rear axle through open tubular propeller shafts provided with a centre bearing. A spiral-bevel final drive with four star-wheel differential is incorporated in the rear axle and both axles are connected to the chassis through progressive-type semi-elliptical springs, those at the rear being provided with helper springs. Lockheed two leading-shoe brakes are fitted to all four wheels, application being assisted by a vacuum-servo unit. The frame is built up from pressed-steel channel-section side members reinforced by triangulated cross-bracing and five channel-section cross-members. The wheelbase is 12 ft. 6 in., the overall length of the chassis, 20 ft. $7\frac{1}{2}$ in., and the overall width just over 7 ft. With standard tyres, the maximum permissible gross weight is 18,480 lb.

8-Ton Logging Arch.

An unusual exhibit on the stand of R. A. Dyson and Company, Limited, 76-80, Grafton-street, Liverpool, was the 8-ton logging arch illustrated in Fig. 17, on page 472. This unit has been designed for use with track-laying tractors and is intended for handling tree trunks after they have been felled and trimmed. When in use, the drawbar is connected to the tractor and the rope from the tractor winch is passed through the guides and over the roller at the top of the arch; a heavy log can then be lifted by means of the tractor winch and subsequently towed through the forest to the dispatching point. The arch is fitted with two giant 18-in. by 24-in. low-pressure Goodyear tyres which are protected to a certain extent by "wings" situated just in front of the wheels.

40-Ton Convertible Trailer.

R. A. Dyson and Company, Limited, showed the convertible trailer illustrated in Fig. 18, page 472. This unit is capable of carrying loads up to a maximum of 40 tons and can be used either as a semi-trailer or, by the fitting of a fore-carriage, as a full trailer. As will be seen from the illustration, it is of the cranked pattern, a design that gives a low platform height and renders the unit suitable for transporting machinery, etc., which can be loaded from the rear or sides on steel skids. Heavy-duty supporting legs are provided; these are operated by screws and are located at the crank, one each side of the chassis. Each leg is provided with a wheel and they are designed to take the full laden weight of the semi-trailer when the tractor is uncoupled. Removable elephant feet are also provided for use when ground conditions are not suitable for the supporting legs. The rear bogie is of the makers' twin rocker-beam type in which two longitudinal beams pivot about a transverse shaft. Each beam, in turn, is equipped with two short axles, one at each end, and each axle is fitted with two pairs of twin 36-in. by 8-in. tyres. With this arrangement, the longitudinal beams are free to pivot the transverse shaft and the axles, in turn, about the ends of the beams, thus permitting free articulation. When travelling over very rough ground, the plates forming the deck over the rear wheels are removed to give extra clearance. All the rear wheels are fitted with Girling $16\frac{1}{2}$-in. by 5-in. brakes operated by the Clayton-Dewandre two-line air-pressure system.

(To be continued.)

Advisory Service on Flexible Tubing.—The Compoflex Co., Ltd., have opened new showrooms at 26, Grosvenor-gardens, London, S.W.1, at which samples of their flexible tubing and hoses and photographs of a number of methods of installation will be displayed. Representatives will also be available to advise manufacturers.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

Fig. 13. 1-Ton Four-Wheel-Drive Vehicle; Austin Motor Co., Ltd.

Fig. 14. $1\frac{1}{2}$-Ton Four-Wheel-Drive Lorry; Morris Commercial Cars, Ltd.

MOBILE TENDER FOR ROAD PROVING OF VEHICLES

The proving section of the Nuffield Engineering Division has always regarded a final run of ten thousand miles in ten days as an indispensable test for any new model about to be made available to the public. Conditions on the roads, however, which are now carrying more traffic than ever before, have made this final test difficult to execute without inconvenience to other road users. Accordingly, the Nuffield Engineering Division came to the conclusion that the only method of overcoming the difficulties was to carry out the test on a closed circuit such as a disused aerodrome. At the same time, they decided to complete the test without a single stop, and to make this possible they designed and constructed a special vehicle to enable crew changes on the test car to be accomplished and, at the same time, permit scientific observations to be made, with the car continually under power. Furthermore, the special vehicle, or tender, as it is more commonly referred to, carries technicians and mechanics who not only replenish the fuel tank, lubricants, etc., but change the road wheels during the course of the ten-thousand miles run.

MOBILE TENDER FOR VEHICLE ROAD PROVING.

Fig. 1. Vehicle Entering Tender.

Fig. 2. Changing Near-Side Rear Wheel on the Move.

Fig. 3. General View of Tender With Test Vehicle In Servicing Position.

The tender was designed and built by the Nuffield Engineering Division in the remarkably short time of five weeks and is already in use at Goodwood motor-racing circuit, where a Morris Minor four-door saloon fitted with a new overhead-valve engine is undergoing the final test. This engine, it may be added, is the first standard product of the recently-formed British Motors Corporation. A general view of the tender is given in Fig. 3, on this page, from which it will be seen that it takes the form of an articulated vehicle. The prime mover is a suitably modified Morris half-ton van chassis and the trailer, in plan view, is in the form of a U with the two arms trailing. The tender forms a mobile floorless bay into which the car under test may be driven. Once inside the bay, the car is located front and rear by pins passed through special brackets incorporated in the bumpers. The front pin is spring-loaded and, by acting through a strain-gauge type of dynamometer, gives a continuous reading of the thrust exerted by the car under test; in this way, it is possible to ensure that the car is continually under power.

In general, the prime mover is of conventional construction but the trailer coupling is of interest. Clamped to the underside of the forward portion of the trailer is an ordinary road wheel, inner tube and outer cover assembly, and on the tractor there is the corresponding stub axle arranged to point upwards and complete with its normal hub shell and bearings. To attach the trailer to its prime mover, the road wheel is lowered on to its studs and the usual road-wheel nuts fitted, the resulting coupling being flexible, shock absorbing and silent, contact between the trailer and tractor being made solely through the inflated outer cover. A superstructure made from steel tubes is carried on that part of the trailer which forms the bay and forward of this, that is, on the raised or cranked portion, is the cabin for the vehicle controller. Also housed in this section are the recording instruments, etc.

When it is required, for example, to change over crews, change the rear tyres and replenish the engine oil, the tender, complete with the necessary supplies and a fresh crew, proceeds on to the track and the test car advised by two-way radio. As the car approaches the tender, the hinged crossmember at the rear is raised, after which the car drives in between the two arms of the trailer as shown in Fig. 1, herewith. The hinged crossmember is then replaced and the front and rear locating pins inserted, the driver being advised whether or not the test car is exerting the correct thrust by a system of coloured signal lights. When the hand throttle has been set to give the required minimum, he hands over to the next driver. Meanwhile, mechanics make the necessary connections to the engine and, by means of a double-acting pump, draw the used oil from the sump and simultaneously pump in fresh oil. A chain hoist is used when changing the wheels, the hoist being suspended from the tubular superstructure and the hook connected to one side of the bumper. A check strap is used to prevent the axle dropping in relation to the body as the latter is raised, and when the wheel is clear of the ground, the handbrake is applied, the linkage having been modified so that one wheel can be braked at a time. The car is then driven by one road wheel only through the differential, and the wheel which is now out of commission is changed in the normal manner, a small derrick being provided to assist in handling the wheels as they are removed from and replaced on the hub. The derrick can be seen in Fig. 2, herewith.

It should, perhaps, be emphasised that the research tender is by no means a "stunt" vehicle. It is an honest, and so far as can be seen, successful attempt to solve the problems of present-day road proving and at the same time provide a means for carrying out scientific tests which hitherto have been confined to the laboratory. Its use is by no means confined to prolonged road trials, as the design is such that the behaviour and performance of steering and suspension units, for example, can be assessed, vibration and stress surveys of the complete structure of the car driven at varying speeds and on different surfaces carried out, and the effect of such variables as humidity on performance determined.

Various preliminary trials were run on the Goodwood circuit in order to ascertain the effect of running on a continuous circuit. The course is 2·38 miles long and consists of a 90-deg. left-hand bend taken at 40 miles an hour, a 150-deg. left-hand bend which is taken at 30 miles an hour, followed by a rising right-hand bend of 80 deg. the remainder consisting of a progressive left-hand bend. The centripetal acceleration of the vehicle when driven to maintain a mean speed of 45 miles an hour varies from $0 \cdot 25g$ to $0 \cdot 4g$, and this in turn is resisted by a vehicle-to-course slip coefficient of between 0·6 and 0·57. The petrol consumption was checked on a similar vehicle both on the course and on a straight track, and it was found that when running on the course, the consumption was increased to the extent of 7·6 miles per gallon, which can be equated to being proportional to 1·7 h.p. used in negotiating the course, that is, in overcoming the circuit thrust. This thrust is resisted, of course, by the tyres and leads to excessive wear; at the test speed of 45 miles an hour the wear rate on the front tyres is 250 miles per millimetre of tread depth. When the course is negotiated at the maximum speed of the vehicle, namely, 59 miles an hour, the wear rate increases to 37·7 miles per millimetre of tread depth. On normal A and B class roads at a mean speed of 45 miles an hour, the wear rate on the front tyre is 1,500 miles per millimetre of tread depth.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Glasgow Scrap Drive Week.—In an effort to help supplies of raw materials for steelmaking, Glasgow is holding a Scrap Drive Week, which began on Monday, October 6, when the heavy type of household scrap, such as old bedsteads, firegrates, mangles, etc., will be particularly sought. The City Cleansing Department have undertaken to collect such material as is notified to them.

The Late Sir Hector McNeill.—Sir Hector McNeill, Lord Provost of Glasgow from 1945 to 1949, and chairman of the Development Corporation for the new town at Glen-Rothes, Fife, died in a Glasgow infirmary on September 28. An engineer by training, Sir Hector was a native of Glasgow and was born in 1892; he eventually became a company representative. At one time he held an executive position in the Amalgamated Society of Engineers. He was created a knight in 1946.

The Late Mr. W. Logan.—Mr. William Logan, vice-chairman of William Baird & Co., Ltd., and a director of Bairds and Scottish Steel, Ltd., and the Sierra Leone Development Co., Ltd., died suddenly in Glasgow on September 27. Mr. Logan was chairman of the Scottish Ironmasters' Association. He had been connected with the Bairds undertakings for about 50 years, and had at one time looked after their interests in Spain. He was 70 years of age.

Scottish Coal for Italy.—The largest single export cargo of coal shipped from Scotland since the war was loaded last week at Methil in the vessel Bonitas for Italian ports. It consisted of some 8,500 tons of industrial grades.

Business Efficiency Exhibition, Glasgow.—More than 60 firms will be represented at the Business Efficiency Exhibition which will open in the Kelvin Hall, Glasgow, on November 4. The exhibition, the largest to be held in Scotland, is to be opened by the Earl of Home, Minister of State, Scottish Office. Thousands of overseas visitors are expected.

Prestressed Concrete Water Tank.—Plans for the erection of a 2,000,000-gallon water tank of prestressed concrete were passed on October 1 by the Painsley Dean of Guild Court. The tank will cost about 35,000*l*. It was stated that the walls would be only 9 in. thick compared with 15 in. for normal reinforced concrete.

CLEVELAND AND THE NORTHERN COUNTIES.

Productivity Exhibition, Newcastle.—Mr. Duncan Sandys, Minister of Supply, will perform the opening ceremony at a productivity exhibition to be held at Newcastle-upon-Tyne from October 30 to November 6. About 100 firms in the north are taking part in the exhibition, which is intended to show how good planning, efficient methods, and co-operation between employees and managements can increase output. Mr. R. W. Mann, chairman of Victor Products, Ltd., Wallsend, and chairman of the exhibition planning committee, stated at a Newcastle Press conference that he believed output could be raised by 25 per cent. through team work between men and management. The exhibition is to cost 7,000*l*., which is being borne by local industry, the Information Division of the Treasury, and the Mutual Security Agency.

Parsons Works Extensions.—Newcastle-upon-Tyne City Council is to lease nearly 33,000 sq. yd. of land between Back Shields-road and the Fossway to C. A. Parsons & Co. Ltd., for proposed works extensions. Parsons have agreed to erect factory buildings within ten years. When completed, the extensions are expected to provide work for about 2,000 men.

Driving of New Drift Mine.—It has been announced that the Northern (Northumbrian and Cumberland) Division of the National Coal Board will commence work shortly on the driving of a new drift mine between Longhirst and Ulgham, which will have an output of about 250,000 tons per annum. The drift will have a "life" of about 20 years. It is understood that the Coal Board is considering the sinking of another drift mine near by. There are eight seams of coal to be worked, ranging from 2 ft. to 3 ft. in thickness.

Workington Bessemer-Steel Production.—It has been announced by the Workington Iron and Steel Co. Ltd. that, during the year ended September 30, 1952, the works' output of Bessemer-steel ingots reached the all-time record of 242,230 tons. In the same period, the output of electric-furnace ingots totalled 18,823 tons.

THE MIDLANDS.

Centenary of Snow Hill Railway Station, Birmingham.—October 1 marked the centenary of the opening of the passenger station at Snow Hill, Birmingham, on what is now the Western Region of British Railways. The Birmingham and Oxford Junction Railway Act, of 1846, authorised the construction of a line from a junction with the London and North Western Railway, near the centre of Birmingham, to a junction with the Oxford and Rugby Railway at Fenny Compton. Construction began in 1847, the engineer being I. K. Brunel, and while the work was proceeding negotiations were started with the L.N.W.R. for a joint station in Birmingham. Agreement on this matter was not reached, and an extension of the new line was built to Snow Hill, where the construction of a station was commenced in January, 1852. The first train from London, via Oxford, entered Snow Hill station on October 1, 1952. Some fairly extensive engineering works were involved in the building of the new line, including a cutting 110 ft. deep and half a mile long at Harbury, near Leamington; a viaduct of 58 brick arches at Bordesley, Birmingham; and a tunnel at the approach to Snow Hill station.

Large Traffic Island.—A traffic island measuring 200 ft. by 150 ft., at Dudley, Worcestershire, was formally "opened" on September 26, by Lt.-Commdr. J. Gurney Braithwaite, M.P., Parliamentary Secretary to the Minister of Transport. The island is at a junction of the main trunk road from Birmingham to Wolverhampton, and of three other roads which carry a heavy local traffic. The cost, 30,000*l*., has been met by the Ministry of Transport.

Sewer Tunnel under Railway.—The work of excavating a sewer tunnel 208 ft. long under a railway at Ettingshall, Bilston, Staffordshire, is now practically complete. The tunnel passes under the main Birmingham-Wolverhampton line of the Western Region of British Railways, and has had to be excavated without any stoppage of railway traffic. A speed limit of 5 m.p.h. was imposed on trains while tunnelling was actually in progress under the tracks. The top of the tunnel is only 4 ft. 6 in. from the tracks, which were reinforced before the work of excavation started.

Record Furnace Output.—A record is claimed for the output of a medium-sized open-hearth steel furnace at the Bilston Steelworks of Stewarts and Lloyds, Ltd. The furnace, of 50 tons capacity, is producing basic steel for tube-making, and has worked 27 heats in a normal week of 168 hours. The production during the period was 1,500 tons.

Demonstration of Process Control Instruments.—"Nullmatic" process control instruments will be demonstrated by Sunvic Controls, Ltd., 10, Essex-street, London, W.C.2, at the Grand Hotel, Birmingham, on Wednesday and Thursday, November 12 and 13. Tickets of admission may be obtained on application to the company.

Open-Hearth Steel-Furnace Firing.—About 4,000 tons of steel a month have been produced at the Appleby-Frodingham Steelworks, Scunthorpe, Lincolnshire, by using a new type of firing in the steel furnaces. Production was stepped up to 79,929, in four weeks, from 75,682 tons, which was the previous best over a similar period. In the new method, a mixture of cold coke-oven gas and pitch creosote is used on four of the furnaces. This type of firing has replaced the mixture of blast-furnace and coke-oven gas which is still used on some of the steel furnaces.

LANCASHIRE AND SOUTH YORKSHIRE.

North Western Gas Board Extension.—It is expected that the new gas-producing and compressor plant now being installed at the Partington works of the North Western Gas Board will be completed in November. It has cost 675,000*l*. and will be the centre of a gas-grid system supplying 45 towns in Lancashire and Cheshire. In due course, the grid will be linked with a second grid, based on Liverpool and now serving seven towns on the western side of the area. A battery of seven compressors capable of handling 500,000 cub. ft. of gas an hour will pump gas from Partington to towns as far distant as Northwich and Tyldesley.

Sheffield's Water Stocks.—In eight days Sheffield's water stocks have risen by the equivalent of 20 days' supply. The reservoirs on October 3 held enough to meet all demands for 100 days, compared with an 80 days' supply the week before. In the first two days of October the rainfall on the gathering grounds amounted to more than an inch, or about a quarter of the average for a whole month. The rainfall in September was more than $4\frac{1}{2}$ in., compared with an average of about $2\frac{3}{4}$ in.

Connecting Four Collieries.—Approaching completion is the first stage of a 4,000,000*l*. centralisation scheme in South Yorkshire, which will link the pits of Manvers Main, Barnburgh Main, Wath Main and Kilnhurst. Coal from Wath Main is to be drawn into Manvers Main through a specially constructed haulage road nearly a mile long and some 15 ft. wide. This is the first stage and others will follow immediately.

Process Control Demonstration.—Sunvic Controls, Ltd., 10, Essex-street, London, W.C.2, are to demonstrate their "Nullmatic" process control instruments at the Queen's Hotel, Manchester, on Tuesday, Wednesday and Thursday, October 28, 29 and 30. Tickets of admission may be obtained on application to the company.

SOUTH-WEST ENGLAND AND SOUTH WALES.

South-Western Coal Output.—Up till September, the coal output from the South-Western Division of the National Coal Board increased by about 500,000 tons over the figure for last year, and, had it not been for the stoppage in August, it would have been far higher still. This was announced by Mr. D. M. Rees, chairman of the Divisional Board, at the annual dinner of the South Wales branch of the National Association of Colliery Managers at Cardiff. The increase in the output was the second highest in the country, and he hoped that, by the end of the year, the Division would be approaching the top.

Admiralty Contracts in Wales.—During the past two years the Admiralty have placed some 690 direct contracts in Wales valued at about 6,000,000*l*. and spread over 160 firms. This was stated by Captain R. P. Selby, reporting for the Admiralty at a meeting of the Welsh Board for Industry at Cardiff. The defence contracts placed include orders for chain and cable gear with two South Wales makers and electric equipment worth 67,000*l*. with a North Wales firm.

Pembroke Dock.—R. S. Hayes (Pembroke Dock) Ltd., dry-dock owners and ship repairers, have entered into a long-term lease for the use of the Admiralty base at Pembroke Dock, and they have also acquired the machinery at the base. The firm have been using the base for the past five years under a short-term agreement.

Ystrad Limestone Quarry.—Preparations are being made by Richard Thomas and Baldwins Ltd. to open a new and extensive limestone quarry at Ystrad about $2\frac{1}{2}$ miles to the north of their existing Blaen Duffryn and Trevil workings. It is reported that the new quarry will cost about 500,000*l*. to develop. It will give the company three large quarries for the supply of limestone to their extensive Ebbw Vale works, where the erection of a new blast furnace, a battery of coke ovens, engineering shops and open-hearth furnaces is planned over the next few years at a cost of more than 6,000,000*l*.

Steel Sheets for Australia.—The Abbey Works, Margam, have produced some special steel sheets for shipment to Brisbane, for the construction of motor-car bodies. The sheets measure 12 ft. by 6 ft. and are packed in bundles weighing 2 tons and 3 tons each.

New Railway Facilities for Newport Power Station.—Extensive engineering works have been completed by British Railways, Western Region, to provide adequate rail access for the new power station at Uskmouth, Newport (Mon.), and for other and future plants along the branch line. Three miles of single track have been converted into double track, which has involved the widening of several bridges. Two new signal boxes have been built, one at Corporation Road Bridge and the other controlling access to the sidings of the British Electricity Authority. Additional loop lines at Corporation Road will allow traffic for other plants along the branch line to be handled while coal trains to and from the power station are passing. The siding accommodation at East Usk Junction marshalling yard is also being increased.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—*Western Centre:* Monday, October 13, 6 p.m., Offices of the South Western Electricity Board, Colston-avenue, Bristol. Chairman's Address, by Mr. A. C. Warren. *North-Eastern Centre:* Monday, October 13, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. Chairman's Address, by Mr. H. Leyburn. *District Meeting:* Monday, October 13, 7 p.m., Offices of the Southern Electricity Board, Market-place, Reading. "Safety Aspects of Domestic Electrical Installations," by Mr. H. W. Swann. *London Students' Section:* Monday, October 13, 7 p.m., Victoria-embankment, W.C.2. Chairman's Address, on "The Protection of Running Buses," by Mr. B. L. A. Ellings. *Education Discussion Circle:* Tuesday, October 14, 6 p.m., Victoria-embankment, W.C.2. Discussion on "Teaching Chemistry to Engineers," opened by Dr. J. E. Garside. *North Midland Centre:* Tuesday, October 14, 6.30 p.m., College of Technology, Leeds. Discussion on "Training for Management," opened by Mr. R. Shilton. *Radio Section:* Wednesday, October 15, 5.30 p.m., Victoria-embankment, W.C.2. Chairman's Address, by Dr. E. C. S. Megaw. *Southern Centre:* Wednesday, October 15, 6.30 p.m., 17, New Canal, Salisbury. "Electricity Supply Industry," by Mr. E. A. Logan.

ILLUMINATING ENGINEERING SOCIETY.—*Sheffield Centre:* Monday, October 13, 6.30 p.m., University, Western Bank, Sheffield. "Hospital Lighting," by Mr. M. W. Peirce and Mr. D. J. Reed. *Institution:* Tuesday, October 14, 6 p.m. Royal Institution, Albemarle-street, W.1. Presidential Address, by Dr. W. J. Wellwood Ferguson.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section:* Monday, October 13, 7 p.m., 16, St. Mary's Parsonage, Manchester. Presidential Address on "Engineering Reminiscences," by Mr. R. O. Harper. *Sheffield Section:* Monday, October 13, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. Annual Meeting. Chairman's Address on "Rolling of Steel Sections," by Mr. W. H. Bailey. *Institution:* Friday, October 17, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Water Divining," by Colonel K. W. Merrylees.

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Section:* Monday, October 13, 7 p.m., Hotel Metropole, Leeds. "The Study of Working Methods," by Mr. A. B. Armstrong. *Stoke-on-Trent Section:* Monday, October 13, 7.15 p.m., North Staffordshire Technical College, Stoke-on-Trent. "The Engineers' Part in the Production of Pottery," by Mr. J. Robinson. *Birmingham Section:* Wednesday, October 15, 7 p.m., James Watt Memorial Institute, Birmingham. "Standardisation," by Dr. H. E. Merritt. *South Essex Section:* Wednesday, October 15, 7.30 p.m., Mid-Essex Technical College, Chelmsford. "Dimensional Control in Production," by Mr. E. Clarke. *Southern Section:* Thursday, October 16, 7 p.m., Polygon Hotel, Southampton. "The Comet," by Mr. H. Povey.

INCORPORATED PLANT ENGINEERS.—*Dundee Branch:* Monday, October 13, 7.30 p.m., Mathers Hotel, Dundee. "Safety First," by Mr. W. B. S. McLean. *Edinburgh Branch:* Tuesday, October 14, 7 p.m., 25, Charlotte-square, Edinburgh. Discussion on "Insulation." *East Lancashire Branch:* Tuesday, October 14, 7.15 p.m., Engineers' Club, Manchester. "Power Factor Correction," by Mr. C. W. Sutcliffe. *Kent Branch:* Wednesday, October 15, 7 p.m., The Bull Hotel, Rochester. "Foundations," by Mr. C. R. Glover.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS.—Tuesday, October 14, 2.15 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. "Problems of the Development Worker," by Mr. F. W. McConnel.

INSTITUTION OF CIVIL ENGINEERS.—*Airport Engineering Division:* Tuesday, October 14, 5.30 p.m., Great George-street, S.W.1. "Organisation of Airport Construction," by Mr. E. A. Palmer. *Midlands Association:* Thursday, October 16, 6.30 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address, by Mr. C. A. Risbridger.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, October 14, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Pneumatic Conveying, Part I," by Mr. D. M. Newitt and others. *North-Western Branch:* Saturday, October 18, 3 p.m., College of Technology, Manchester. "The Further Training of the Chemical Engineer," by Mr. Stanley Robson. *Midlands Branch:* Saturday, October 18, 3 p.m., The University, Birmingham. "Handling of Phosphorus," by Mr. H. D. Anderson. *Graduates' and Students' Section—North-West Centre:* Thursday, October 16, 7 p.m., Queen Hotel, Chester. "Chemical Engineering Theory and Practice in the United States," by Mr. A. F. Thompson. *London Centre:* Friday, October 17, 6.30 p.m., Caxton Hall, Victoria-street, S.W.1. Conversazione on "The Development of a Chemical-Engineering Project."

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 14, 5.30 p.m., 85, Minories, E.C.3. "Strength of Large Bolts Subjected to Cyclic Loading," by Mr. B. Taylor.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Tuesday, October 14, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Chairman's Address, by Mr. W. F. Cartwright. *East Midlands Branch:* Wednesday, October 15, 7.30 p.m., Technical College, Lincoln. "Mechanical Handling," by Mr. A. Roebuck, Mr. H. S. Carnegie and Mr. E. G. Taylor. *Institution:* Friday, October 17, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Presidential Address on "The Art of the Practical Engineer," by Sir David Pye, F.R.S.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 14, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Presidential Address, by Sir William Wallace.

INSTITUTION OF WORKS MANAGERS. — *Merseyside Branch:* Tuesday, October 14, 6.30 p.m., Adelphi Hotel, Liverpool. Three short papers. *Preston Branch:* Tuesday, October 14, 7.30 p.m., Starkie House, Starkie-street, Preston. "The System of Scheduled Maintenance," by Mr. J. D. Prior. *Tees-Side Branch:* Tuesday, October 14, 7.30 p.m., Vane Arms Hotel, Stockton-on-Tees. "A Day's Work," by Mr. W. G. Hiscock.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*South-Western Branch:* Tuesday, October 14, 6.30 p.m., R.W.A. School of Architecture, Bristol. Annual Meeting and Film Display. *Liverpool Branch:* Wednesday, October 15, 6.30 p.m., Radiant House, Bold-street, Liverpool. "Pipe Sizing for Gravity Circulation," by T. H. F. Holman. *Birmingham Branch:* Wednesday, October 15, 6.30 p.m., Imperial Hotel, Birmingham. "Practical Aspects of Heating and Ventilating," by Mr. J. H. Evans and Mr. T. Cornwell.

SHEFFIELD METALLURGICAL ASSOCIATION.—*Refractories Group:* Tuesday, October 14, 7 p.m., Grand Hotel, Sheffield. "Determination of Alumina and Other Constituents in Refractory Materials," by Mr. G. Padget.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, October 14, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Air and Oil Filters," by Mr. E. A. Stokes. *East Midlands Centre:* Wednesday, October 15, 7.30 p.m., Mechanics' Institute, Nottingham. Annual Meeting. *North-East Centre:* Thursday, October 16, 7.30 p.m., Hotel Metropole, Leeds. "Machining and Inspecting Methods in Manufacture of Heavy Commercial Vehicles," by Mr. E. I. Perry.

INSTITUTE OF FUEL.—*North-Western Section:* Wednesday, October 15, 2 p.m., Engineers' Club, Manchester. "House Heating," by Dr. J. C. Weston. (Luncheon, 1 p.m.)

ROYAL SANITARY INSTITUTE.—Wednesday, October 15, 2.30 p.m., 90, Buckingham Palace-road, S.W.1. "Efficiency of Domestic Solid-Fuel Appliances," by Mr. W. F. B. Shaw. Thursday, October 16, 10 a.m., Guildhall, Exeter. (i) "Re-Development Works in Exeter," by Mr. John Brierley. (ii) "Noise and the Public Health," by Mr. F. G. Davies.

NEWCOMEN SOCIETY.—Wednesday, October 15, 6.30 p.m., 10, Blackfriars-street, Manchester, 3. "James Hargraves and the Invention of the Spinning Jenny," by Mr. W. A. Hunter.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Wednesday, October 15, 7 p.m., Victoria Hall, Hanley, Stoke-on-Trent. "Locomotive Development," by Sir W. A. Stanier, F.R.S.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Wednesday, October 15, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Control Chart Techniques," by Dr. B. P. Dudding.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, October 16, 2.30 p.m., Caxton Hall, Victoria-street, S.W.1. Presidential Address on "Diesel Digestion," by Mr. Gerald B. Fox.

INSTITUTION OF MINING AND METALLURGY.—Thursday, October 16, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. (i) "Graduates in Metal Mining: Notes on Their Status, Training and Vocation," by Mr. J. B. Richardson. (ii) "Recovering a Flooded Shaft" by Mr. R. S. Cooke.

SOCIETY OF CHEMICAL INDUSTRY.—*Road and Building Materials Group:* Thursday, October 16, 6 p.m., Building Centre, Store-street, W.C.1. "Road Problems Arising from Snow and Ice," by Dr. A. C. Whiffin and Mr. W. I. J. Price.

INSTITUTE OF WELDING.—*South London Branch:* Thursday, October 16, 6.30 p.m., Institute of Marine Engineers, 85, Minories, E.C.3. "New Ideas on the Welding of Aluminium," by Mr. P. T. Houldcroft.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 17, 6.45 p.m., Engineers' Club, Manchester. "Electronics in Engineering," by Mr. F. C. Robinson.

PERSONAL.

MR. ALAN P. GOOD has felt obliged, on medical advice, to reduce his heavy business commitments and ask the directors of the Brush Electrical Engineering Company, Ltd., to allow him to relinquish his responsibilities as managing director. He is, however, remaining a director and deputy chairman of the company. He is succeeded by MR. MILES BEEVOR, who has been deputy managing director since early in 1951, and MR. IAN T. MORROW becomes deputy managing director. Mr. Good is retaining the chairmanship of Associated British Engineering, Ltd., of which MR. LAWRENCE W. ROBSON has been made deputy chairman.

LIEUT.-COL. J. A. S. RITSON, O.B.E., D.S.O., M.C., Professor of Mining at the Royal School of Mines, Imperial College, University of London, has been elected President of the Institution of Mining and Metallurgy and will take office at the Institution's meeting on May 28, 1953. He was elected to the Institution in 1936 and has served on the Council since 1940. He is a past-President of the Institution of Mining Engineers.

At the annual general meeting of Sheepbridge Engineering, Limited, Chesterfield, held on October 1, the chairman, LORD ABERCONWAY, C.B.E., LL.D., D.Sc., said that owing to the many calls on his time, he proposed to relinquish his chairmanship after the meeting, but would remain a director. He added that the board had expressed its intention of electing MR. A. V. NICOLLE as chairman. Mr. Nicolle would resign his joint managing directorship, leaving MR. TOM BROWN as sole managing director.

SIR NOEL ASHBRIDGE, B.Sc., M.I.C.E., M.I.E.E., F.K.C., F.I.R.E., who was appointed director of technical services, British Broadcasting Corporation, in 1948 and retired in July of this year, has joined the boards of Marconi's Wireless Telegraph Co. Ltd., the Marconi International Marine Communication Co. Ltd., Marconi Instruments Ltd., and the English Electric Valve Co. Ltd.

It is also announced that Marconi's Wireless Telegraph Co. Ltd., have expanded and reorganised their Aeronautical Division into three sections, namely, technical, sales and contracts. DR. B. J. O'KANE, B.Eng., A.M.I.E.E., joined the company on October 1 as chief air radio engineer. MR. R. R. STANFORD-TUCK, D.S.O., D.F.C., has been made sales manager of the Division, and MR. F. WHEELER has been appointed contracts manager.

MR. T. H. SUMMERSON, chairman and joint managing director of Thomas Summerson & Sons, Ltd., Albert Hill Foundry, Darlington, has been elected chairman of the North-East Development Association, Newcastle-upon-Tyne, in succession to LORD RIDLEY, who has resigned owing to ill-health. Lord Ridley has been elected President of the Association and SIR MARK HODGSON, chairman of the Northern Regional Board for Industry, vice-president.

MR. M. T. TUDSBERY, C.B.E., M.I.C.E., who joined the British Broadcasting Corporation as its first civil engineer in January, 1926, retired under the age limit on October 4. He is being retained temporarily, however, as consulting civil engineer.

MR. L. MCEWAN, naval architect to the Cunard Steam-Ship Co. Ltd., Liverpool, retired on September 30. He has been succeeded by MR. R. K. WOOD, B.Sc., M.I.N.A., who has been assistant naval architect to the company since 1951.

MR. HENRY F. SPENCER, assistant managing director of Richard Thomas and Baldwins, Ltd., 47, Park-street, London, W.1, has been appointed a managing director of the company.

MR. J. T. RYMER has relinquished his position as managing director of Mirrlees, Bickerton and Day, Ltd., Stockport, a member company of the British ABOE Group. Mr. Rymer has been granted leave of absence for the remainder of the present year. MR. C. F. BARNARD, at present assistant managing director of the firm, has been appointed general manager.

MR. SYDNEY F. SMITH, development engineer, Dunlop Rubber Co. Ltd., Fort Dunlop, has succeeded MAJOR F. MONK as the company's chief safety officer for Great Britain.

MR. JOHN WALMSLEY, A.M.I.Mech.E., "Greenways," Two Gates, Tamworth, Staffordshire, has been appointed, as from October 1, resident representative of the Visco Engineering Co. Ltd., Stafford-road, Croydon, for the counties of Derby, Leicester, Northampton, Nottingham, Shropshire, Stafford, Warwick and Worcester.

MR. C. T. M. BAGNALL, publicity manager, the English Electric Co. Ltd., and MR. S. H. PRYOR, publicity manager, Igranic Electric Co. Ltd., have been appointed members of the publicity committee of the British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2.

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

(*For Description, see Page* 467.)

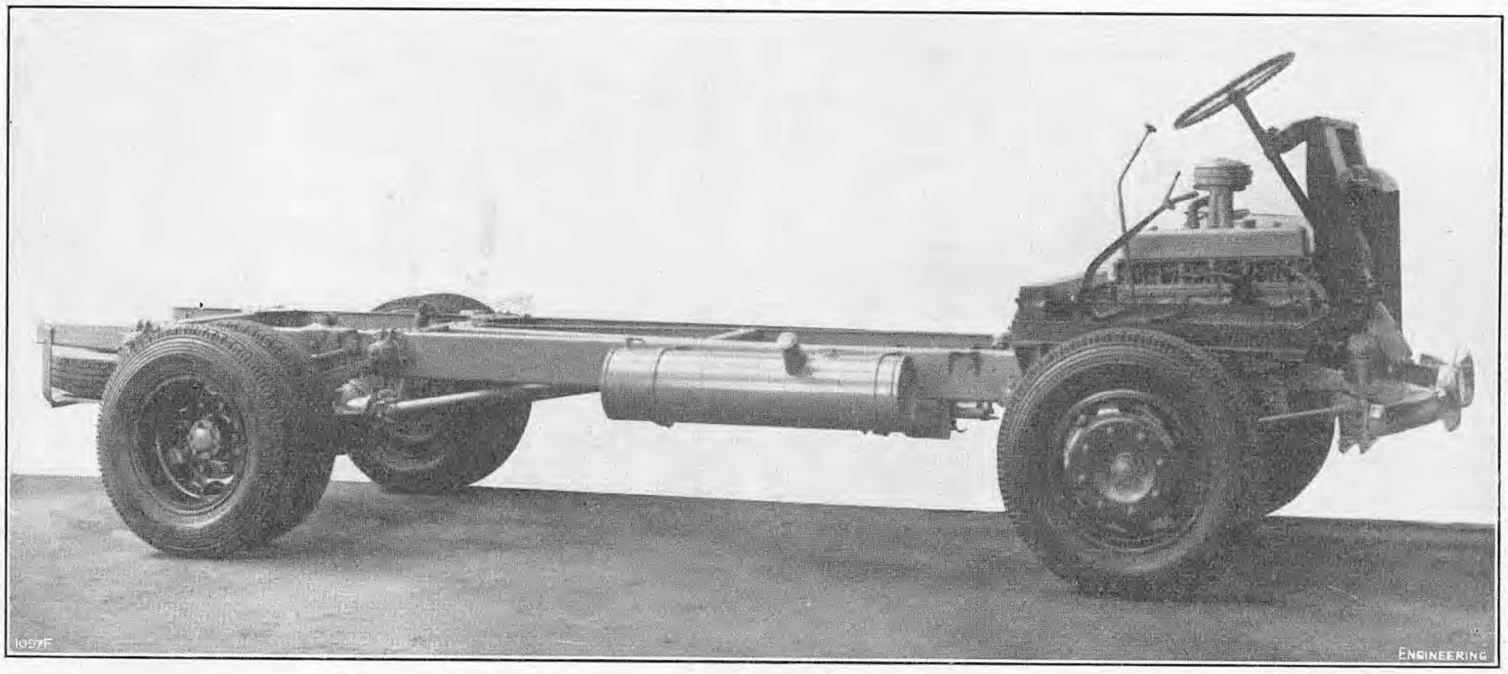


FIG. 15. FORWARD CONTROL CHASSIS FOR 5-TON LOADS; MORRIS COMMERCIAL CARS, LTD.

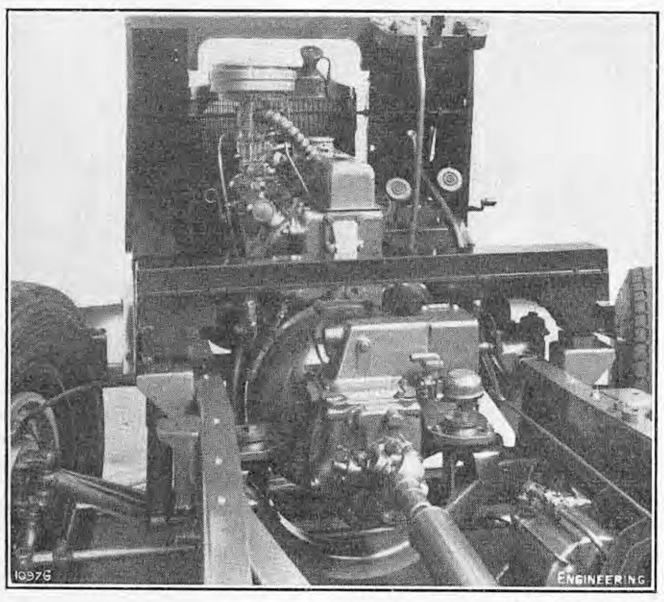


FIG. 16. REAR ENGINE SUPPORTS; MORRIS 5-TON CHASSIS.

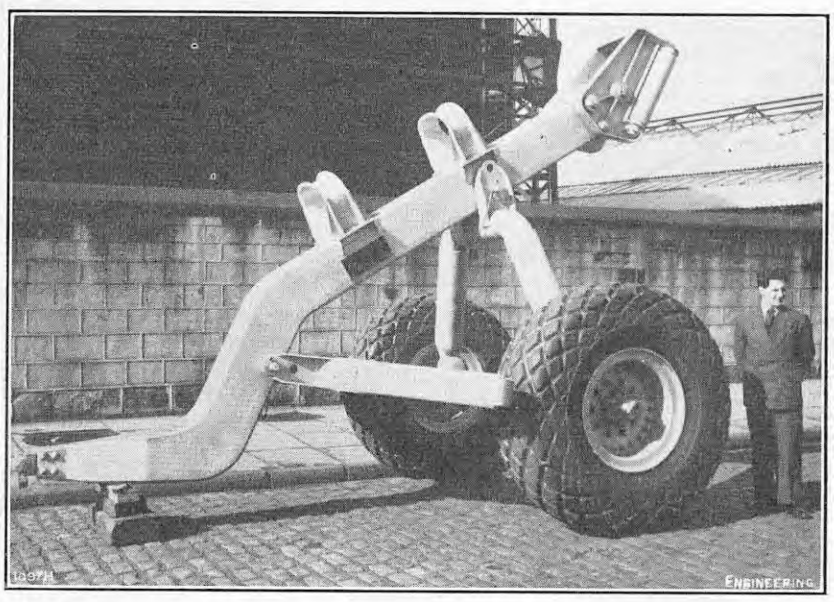


FIG. 17. LOGGING ARCH; R. A. DYSON & CO., LTD.

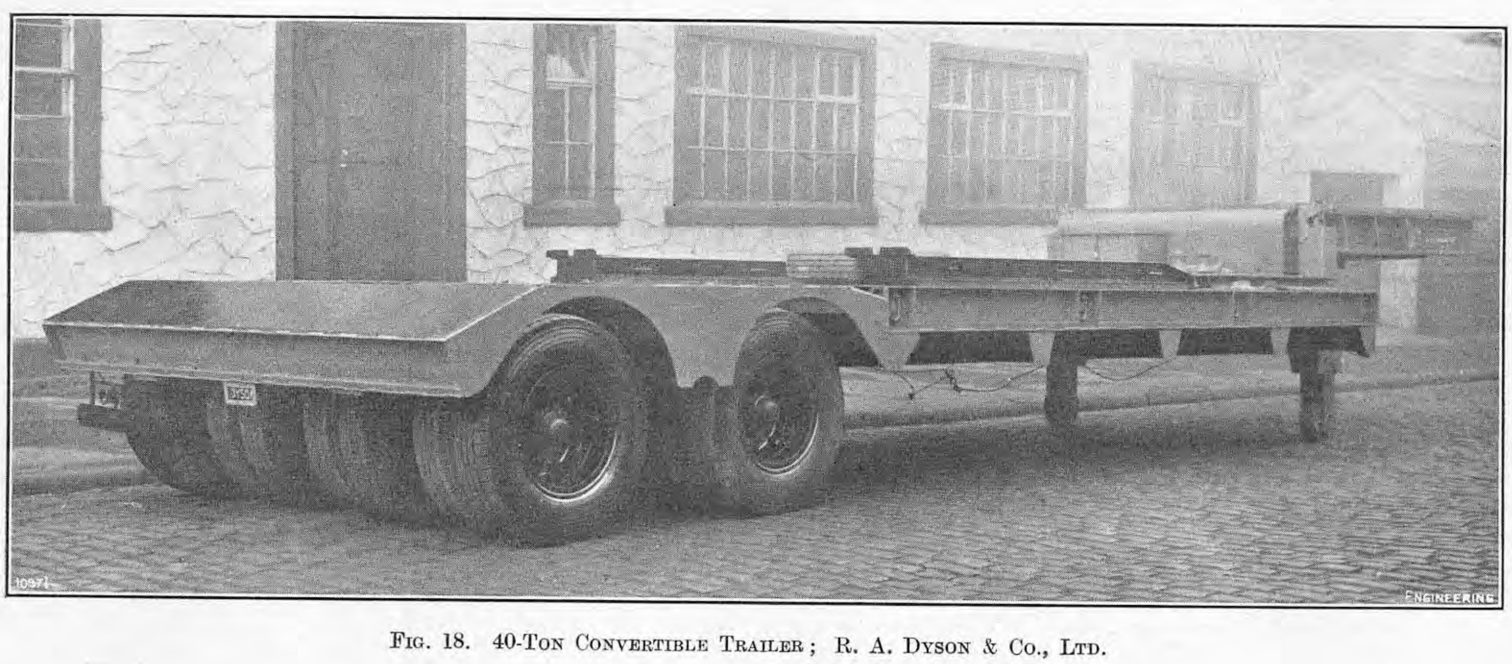


FIG. 18. 40-TON CONVERTIBLE TRAILER; R. A. DYSON & CO., LTD.

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Telephone Numbers :

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

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

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ENGINEERING

FRIDAY, OCTOBER 10, 1952.

Vol. 174. No. 4524.

NATIONAL ELECTRICITY SUPPLY.

When the Labour Government of this country nationalised a number of our basic industries it did so for reasons which, though mainly political, were not all economically unsound. It was not realised, however (and it is a point worth emphasising at a time when further extensions of this policy are being advocated) that it would have been wiser to delay the necessary changes until the possible results had been thoroughly considered and weighed. We are confirmed in this opinion by a statement of Mr. Shinwell at the recent conference of the Labour Party to the effect that, in the cases of the mining and electricity supply industries the change was made without "any blueprints whatever"; and that, while "there had been generalisation . . . very little consideration had been given to the actual details of nationalisation." As Mr. Shinwell was the Minister responsible for piloting the Bills implementing these developments through Parliament, this is a confession which, to say the least of it, is worthy of note. It adds interest, too, to a perusal of the fourth annual report* of the British Electricity Authority for the year ended March 31, 1952, which was published by H.M. Stationery Office this week.

In examining the present state of the electricity supply industry, as disclosed in this document, it must be remembered that it was enjoying a fair degree of prosperity when reorganisation took place. Any progress which has since been made has, therefore, stemmed from a higher level than it would have done in the case of, say, coal or railways; and can, therefore, less justly be credited entirely to the new ownership. On the other hand, any falling off might, with some fairness, be ascribed to the protagonists of the new system. Bearing these facts in mind, it may be recorded that 59,250 million kilowatt-hours were generated during the year ended March 31, 1952. This was an increase of 6·6 per cent. over the figure for the previous year, and of 41·7 per cent. over that for 1947–48, the year before nationalisation. Sales exceeded 50,400 million kilowatt-hours, an increase of 8·2 per cent.; and the number of consumers rose by about 426,000 to $13\frac{1}{2}$ million. About half the sales were to industry and were nearly 10 per cent. higher than in the previous year. Farm consumption increased by 18 per cent., domestic by 7 per cent. and commercial by 6·5 per cent. All these rates, however, show a decreasing tendency, as more recent figures have also indicated. In fact, the actual demand was 300 MW less than was expected. The average price received was 1·22*d.* per kilowatt-hour, which was an increase of 3·3 per cent. over that of 1950-51 and of 16·2 per cent. over that of 1938–39. This increase was, however, very much less than those in the costs of coal, plant, equipment, civil engineering works and goods of all kinds during the same period. In fact, owing to the rising price of coal, and in spite of improved efficiency, the average cost of generation rose from 0·4869*d.* to 0·5274*d.* per kilowatt-hour. Nevertheless, on the basis of these figures taken as a whole, nationalisation has been successful.

On the other hand, the overall financial surplus was only 2·92*l.* million, compared with 6·33*l.* million in 1950-51, and with 7·16*l.* million in 1949-50; and the 14 Area Boards showed a deficit of about 1·33*l.* million, compared with a surplus of 3·7*l.* million in 1950-51. This is a startling change in twelve months, which is ascribed to the higher charges made by the Authority for energy, as a result of increased fuel costs, and to the framing of standardised tariffs. Although, therefore, the industry is not yet "in the red," its financial position can hardly be said to be improving, even where it is admitted to be partly due to a deliberate policy. Careful consideration, followed by such action as may be necessary, is therefore essential and will, we hope, be given. In this connection, we suggest that one remedy is to be found in a reorganisation of administrative methods and a pruning of staff, where this can be carried out without affecting efficiency. There must also be a resistance to exaggerated wages claims. We fear, however, that, even if all these courses are followed, it will be necessary, for reasons over which the Authority has little control, to increase prices to the consumers.

As in previous reports, a considerable amount of space is devoted to accounts of the engineering and utilisation problems which have had to be faced; some of which have lost any bloom of novelty. Of these, the principal, as in former years, was how to provide plant to meet the increasing demand. At the date of the report the Authority owned 293 power stations with a total installed capacity of nearly 15,800 MW, a net increase of just over 1,000 MW during the year. This was, in fact, more than has been added in any previous twelve months. A distressingly large amount of the plant in service, in fact nearly 15 per cent. of the total generating capacity, was, however, old, small and expensive

* *British Electricity Authority. Fourth Report and Statement of Accounts for the year ended March* 31, 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 10s.]

to operate; and, although 41 new stations and 37 extensions with a total capacity of 6,276 MW, were under construction, or are planned, it will be four years at least before the plant in them will be in full operation. Even this consummation, it is reiterated, depends upon the amount of plant the manufacturers can supply and upon Government policy, which, it is pointed out, is still limiting annual addition to 1,550 MW. If, as unfortunately seems likely, this limit continues to be imposed, it will be impossible to meet demands, if they increase at the normal rate. It is to be hoped, therefore, that these restrictions will be removed without delay, since failure to do so might easily imperil the country's industrial prosperity. The position may be illustrated in another way by saying that shortage of plant again necessitated load shedding, although the number of occasions on which this occurred was only 79, compared with 101 in 1950-51. This reduction was, in great part, due to the mild winter months during which only six disconnections took place.

On the transmission side, 145 route miles of 132-kV lines and some 218 route miles of the new 275-kV supergrid were being added to the grid. It is expected that the first part of the system operating at 275 kV will be completed in 1955. The total transformer capacity, which was installed in 284 substations, was nearly 17,000 MVA. This represented an increase of only 610 MVA during the year, owing to about 1,600 MVA of plant for 66 kV or some lower voltage being taken out of service. Technically, therefore, it is a little difficult to see how matters could have been improved, if Mr. Shinwell had provided a full set of blue prints. This opinion is reinforced by a study of the extensive programme of research which is being undertaken into such matters as the use of low-grade fuels, the extraction of pyrites from coal in pulverising mills, and the development of special instruments, by the use of which it is hoped that the operation of steam turbine plant will be improved. That these and other activities of the same kind are beginning to yield results is shown by the fact that while the amount of electricity generated during the year was 6·6 per cent. in excess of that in 1950-51, the increase in coal consumption was only 4·5 per cent. It is also shown by the fact that the average overall thermal efficiency of the Authority's steam stations increased during the year to 22·04 per cent., compared with 21·54 per cent. in 1950-51 and 20·86 per cent. in 1947-48.

Unfortunately, the financial outlook, as we have already indicated, is not similarly favourable, owing to increasing prices. Even in 1948 the average cost of new generating plant and buildings was between two and three times as great as before the war. Since then further large increases in wages and in the cost of materials have taken place. As a result a 120-MW power station, the construction of which was begun in 1948 at an initial contract price of 6*l*. million, will probably cost from 500,000*l*. to 750,000*l*. more to complete, while a station of similar capacity begun in 1952 will cost at least 1½*l*. to 2*l*. million more than if it had been built at 1948 prices. When it is stated that the power station capital contracts approved in 1951-52 amounted to 89*l*. million, it requires little imagination to envisage the heavy burden of capital costs both the Authority and the Area Boards have to bear. This burden is further increased by the present high rates of interest on loans. Operating and administrative costs have also been adversely affected, particularly by increases in fuel prices and transport rates and in salaries and wages. This additional expenditure more than offsets the operating economies that have been achieved in various ways; and indicates that the future will not be without its difficulties, both for the Authority itself and for the consumer.

HUMAN RELATIONS.

THIS article is not concerned with questions of consanguinity; its subject is the relations necessarily established between individuals in everyday human intercourse. The "principles" of such relations, as set forth in Professor Maier's book,* appear to be that if harmony and common understanding are to be established between two people forming a pair, one of them must be endowed with a sympathy for, and an understanding of, the point of view of the other. The second book, by Dr. Scott, the title of which is also given below, if it does not specifically state the same thing, certainly implies it. As will be clear from their titles, both books are concerned with the relations existing between management and workpeople in industry. As Professor Maier deals with conditions in America, where organised labour is sympathetic to innovation and new methods, his proposals and arguments may not always be directly applicable to this country, but the large number of specific examples of the handling of difficult individuals, or situations, by supervisors will be of instructive value to all concerned with factory administration.

Although the books are broadly concerned with a common subject, there is little resemblance between them. Dr. Scott gives an account of an investigation into the labour conditions, both in the past and existing, in a seed-crushing firm now employing 3,500 workpeople; an establishment producing rayon yarn, with 2,500 employees; and a printing firm with 900 workpeople. Professor Maier is concerned rather with an analysis of the mental equipment necessary in supervisors and managers if harmony is to rule in a factory and the workpeople are to give of their best. The many examples of negotiations between workpeople and what he terms "counselors," which may be read as personnel managers, are mainly concerned with individual workers, not with groups.

What is common between the two authors is that they both stress the importance of the mental, and what may even be called the emotional, equipment of supervisors and managers. Dr. Scott writes: "it is, however, supervisory behaviour . . . that is so important in determining the attitudes and morale of rank-and-file employees." In a sense, this is the whole subject of Professor Maier's book. He is Professor of Psychology at the University of Michigan, and his recipe for the production of satisfactory supervisors and managers is training in psychology. They should acquire "skill in democratic leadership and a good understanding and appreciation of the subjects of attitudes and frustration." In everyday language, this means that they should be broad-minded, sympathetic and able to appreciate the point of view of the individuals they control.

The value of sympathy and understanding in those set in authority is not, however, a discovery by either Dr. Scott or Professor Maier. It has been known for more than two thousand years. In *The Republic of Plato*, it is specified that among the qualities desirable in the Guardians who are to administer the ideal state are justice, gentleness and quick apprehension. These two latter terms may be held to cover sympathy, which is the master quality, added to quick apprehension, which the two authors specify. Plato, like Professor Maier, laid down rules for training these administrators, although he did not describe the understanding to which the training should lead as a knowledge of "psychology."

Among the many case histories related by Professor Maier is that of Miss Everett. It concerns a woman who had been employed for 15 years and had become dissatisfied with her pay increases and her status in the firm by which she was employed. Conversations between her and the head of her department are reported in detail, with comments pointing out that instead of treating her with sympathy and listening to her frequently unreasonable complaints, the interviewer might, to put it briefly, have told her to go back to work and not be silly. Tolerant handling induced a more reasonable frame of mind in Miss Everett and she settled down. Part of her trouble was apparently an unsatisfactory home background. This story is given as an example of applied psychology to reinforce the contention that personnel managers and others should have a psychological training. There is no objection to calling this sort of thing applied psychology, if that gives any satisfaction, but it might equally be described as the exercise of a little patience and common sense in dealing with a discontented woman.

Although Dr. Scott has little to say about psychology, in a sense his book reinforces Professor Maier's plea. At one place, he writes, "there is need for a modification of the attitudes of intermediate and higher management if consultative relationships are to be realised at the shop-floor level." This phrase summarises much that has gone before it. The point is that foremen, charge hands and under-managers are likely to treat those whom they control in the same way as they are treated by the officials set above them. Dr. Scott refers to a "chain reaction down the line." He states that "the signal weakness of most supervisory training programmes" is that the behaviour of a supervisor is not likely to be modified by re-training at his level alone; "the procedures he has learnt are seldom evinced in his superior's relationships with him." This is a contention that the quality of mind and manner which Professor Maier considers will be induced by training in psychology, must be possessed by every supervisory grade if industrial harmony is to reign. It must be admitted that managing directors are not likely to go to school to learn psychology except in Utopia, or possibly Russia, but none the less, chief executives are likely to profit from a study of the factual data assembled by Dr. Scott.

There is a consideration, at least in British industry, which dominates this whole matter. Much is now heard about joint consultation and works councils. Specific and detailed information about the operation of such councils, in the three firms with which he is concerned, is given by Dr. Scott. Many of the difficulties which have been experienced are due to trade-union activity or interest. Workmen elected to a works council will frequently, or usually, be trade unionists, and apart from the fact that the interests of different unions may clash, the individual may, and often will, find himself in an invidious position. He is faced with conflicting loyalties, one to his union, the other to his workmates. This matter is dealt with at some length by Dr. Scott. It would not be realistic to pretend that the setting-up of a works council will eliminate the possibility of difference between the interests of a union and those of a firm, or even of its employees. Dr. Scott considers that "the attitude and behaviour of management . . . play a major part in determining the success of any reconciliation of the Union and Council approaches." This is no doubt true, but it is to be feared that the most enlightened attitude and behaviour will not eliminate all future trouble. In the meantime, his careful account of what actually happened in three firms may be studied with profit.

* *Principles of Human Relations. Applications to Management.* By Professor Norman R. F. Maier. John Wiley and Sons, Inc., 440, 4th Avenue, New York 16, N.Y., U.S.A. [Price 6 dols.] Chapman and Hall, Ltd., 37, Essex-street, London, W.C.2. [Price 48*s*. net.] *Industrial Leadership and Joint Consultation. A Study of Human Relations in Three Merseyside Firms.* By Dr. W. H. Scott, B.A. The University Press of Liverpool, Liverpool, 3. [Price 12*s*. 6*d*.]

NOTES.

WORLD POWER CONFERENCE.

THE annual meeting of the International Executive Council of the World Power Conference, which was held in Chicago on Thursday, September 4, 1952, was attended by 33 delegates from 17 countries and included an unusually large number of representatives from the United States and Canada. Among the matters discussed was the technical programme of the sectional meeting of the conference which is to be held in Rio de Janeiro from July 25 to August 8, 1954. The theme of this conference will be the energy problems of tropical and subtropical countries. It was announced that the French National Committee expected to issue a formal invitation for the fifth Plenary Conference, to be held in Paris in 1956; and it was intimated that if this invitation was not confirmed it would be replaced by one from the National Committee of the German Federal Republic. Notice was also given that the Canadian National Committee would invite the Conference to a sectional meeting in Canada in 1958, and it was decided to hold the 1953 meeting of the International Executive Council in Germany. At the annual executive meeting of the International Commission on Large Dams of the World Power Conference, which took place in Chicago on Friday, September 5, an invitation to hold the fifth Congress on Large Dams in Paris in 1955 was accepted, and Mr. G. A. Hathaway (United States) was elected president. Preliminary notice was given by the United States National Committee of their intention to issue an invitation for the sixth Congress, to take place in the United States in 1958. A new edition of the list of National Committees and representatives of the World Power Conference has been issued and copies can be obtained from the offices of the British National Committee, 201, Grand Buildings, Trafalgar-square, London, W.C.2, at the price of 1*s.* 6*d.*

THE SOCIETY OF ENGINEERS: AWARD TO SIR FRANK WHITTLE.

The Society of Engineers have instituted a new medal to be known, with the approval of Mr. Winston Churchill, as the Churchill Gold Medal; the purpose of the medal is to commemorate the close war-time association between Mr. Churchill and engineers that ultimately resulted in the planning and execution of the Mulberry harbours for the Normandy landings in 1944. The award of the medal is to be made every two years for a noteworthy contribution to contemporary engineering, the recipient to be selected by the Honorary Fellows and Past-Presidents of the Society. With the approval of Mr. Churchill, who is an Honorary Fellow of the Society, the first recipient is Air Commodore Sir Frank Whittle, K.B.E., C.B., F.R.S., and the award is made for his outstanding work on the internal-combustion turbine and its use for aircraft propulsion. The formal presentation was made at an ordinary meeting of the Society at Burlington House, Piccadilly, London, on Monday, October 6, by the President, Mr. R. S. V. Barber, B.Sc.

RAMSAY CENTENARY EXHIBITION.

An exhibition designed to mark the centenary of the birth and to commemorate the work of the late Sir William Ramsay, K.C.B., F.R.S., celebrated for his discovery of the rare gases of the atmosphere, was opened at the Science Museum, South Kensington, London, S.W.7, on Thursday, October 2, by the Lord President of the Council, Lord Woolton. The exhibition, admission to which is free, has been arranged by the Science Museum in collaboration with University College, London, where Ramsay was professor of chemistry for many years. It will remain open until January 3, 1953. The element argon, of which the atmosphere contains nearly 1 per cent., was isolated independently and almost simultaneously by Ramsay and by the third Baron Rayleigh in 1894, their results being published jointly. Helium, known previously only from its occurrence in the sun, was isolated by Ramsay in the following year and the remaining inert atmospheric gases, neon, krypton and xenon, were discovered by him in collaboration with M. W. Travers in 1898. In 1902, Rutherford and Soddy discovered that the gaseous emanation from radium, known as radon, was also chemically inert, and in 1911 Ramsay and R. Whytlaw-Gray, after experimenting with minute quantities of the gas, reported that it was the sixth member of the newly discovered group of inert gaseous elements. The exhibits fall into three main classes. The first includes books, documents, portraits and general biographical material relating to Ramsay and his associates. Of particular interest are the originals of his letters to Rayleigh, giving an account of his isolation of argon. In the second group of exhibits may be seen some of the actual apparatus used by Ramsay and his collaborators in their researches. In this early work, undertaken while he was professor of chemistry at University College, Bristol, Ramsay was mainly concerned with investigating the equilibrium relations of solid, liquid and gaseous systems, and verifying conclusions arrived at previously on thermodynamic grounds. Starting with these early experiments, the exhibits go on to illustrate the discovery of the inert gases, the history of which is traced back to an experiment and observation made by Henry Cavendish in 1785, fully a century before. One of the earliest machines used by Ramsay to liquefy air has been re-erected within the exhibition hall. The exhibits also include the delicate micro-balance which he used to weigh minute bubbles of radon. The third group of exhibits illustrates modern applications of inert gases. Gas-filled discharge tubes, operated by means of push-buttons, show the use of these gases in illumination. A colour film, taken with the aid of a high-speed camera, and shown in slow motion, depicts the argon-arc welding process, and working demonstrations of argon-arc welding are given periodically. A full-size figure of a diver wearing his diving equipment illustrates how helium admixed with oxygen may be used instead of air in the breathing apparatus to avoid the harmful effects of nitrogen in deep-sea diving operations. William Ramsay was born in Glasgow on October 2, 1852, and, during his lifetime of 64 years, received many honours both in his own country and abroad. Not the least interesting among the exhibits at the Science Museum is a large volume containing the originals of scrolls testifying to the distinctions conferred on him by universities and scientific academies, and a show-case displaying his medals and insignia. There are also two fine portraits of Ramsay and a number of contemporary photographs. In opening the exhibition, Lord Woolton made a plea for the establishment, in Britain, of Universities of Technology having the same status as the existing universities. Such universities, he suggested, were essential if Britain was to benefit fully from the discoveries made by her scientists.

THE GAUGE AND TOOL MAKERS' ASSOCIATION.

Mr. F. W. Halliwell, M.I.Mech.E., M.I.Prod.E., President of the Gauge and Tool Makers' Association, said last week that he hoped there would be, in years to come, sufficient recipients of the Association's awards for craftsmanship and draughtsmanship for them to form a guild of their own. Some two dozen awards have been made this year, and the prizes and certificates were presented by Mr. Halliwell and the chairman, Mr. H. S. Holden, M.I.Prod.E., to the successful apprentices and learners at a luncheon of the Association at the Savoy Hotel, London, on September 29. The annual report of the Association, which was presented at the tenth annual general meeting, after the luncheon, was the subject of a note in these columns in our issue of September 19; it revealed that the number of member firms has risen from 16 to over 250. Participation in the competitions in craftsmanship and draughtsmanship is confined to apprentices and learners attached to firms which are members of the Association. To qualify for the Certificate of Craftsmanship, an applicant has to satisfy the education and apprenticeship committee and the Council of the Association that he has served a *bona-fide* apprenticeship in the craft of toolmaking and has passed the final examination in machine shop engineering of the City and Guilds of London Institute. Following the presentations, Mr. B. C. Lucia, B.Sc., deputy-director of the Department of Technology, City and Guilds of London Institute, gave a short address on the work of the Institute, particularly in relation to the gauge and tool industry. He recalled the history of the development of craftsmanship and technical education in this country from the days of the Guilds. The Department of Technology of the Institute, he explained, did not provide courses of instruction but draughted syllabuses and examinations that corresponded to the needs of the various industries. For every subject there was an advisory committee composed of representatives from the production side of the industry. The department was a mediator between industry and the technical colleges.

INTERNATIONAL EXCHANGE OF ELECTRIC POWER IN EUROPE.

A report recently issued in Geneva by the Committee on Electric Power of the United Nations Economic Commission for Europe points out that the consumption of electricity on that Continent increased from 49,000 million kWh in 1920 to 288,000 million kWh in 1950, and is doubling every ten years. There is, however, a lack of coincidence between sources of production and centres of consumption, so that while some areas are exhausting their natural resources others possess important reserves. A number of schemes for the international transfer of power are therefore suggested, including exports from Norway to Sweden and Denmark, from Yugoslavia to Italy, Austria, Albania, Greece and Hungary and from Czechoslovakia, Poland and Germany. Various proposals for "periodic exchanges" are also made as a means of reducing power losses and improving the utilisation of available plant. These include the proposal to lay a submarine cable between this country and France. As regards the use of water power, it is estimated that even if all the countries pooled their resources they would be exhausted in a little over 20 years, assuming that the same proportion of electricity was then produced by this means as it is at present. In fact, Italy has already developed 48 per cent. of her water power, although in the case of Yugoslavia and Austria the figures are only 2 per cent. and 17 per cent., respectively. On the other hand, the European reserves of coal, lignite and peat could support European solid-fuel production at its present level for more than 1,000 years. Thermal electric power generators, 90 per cent. of which at present burn hard coal, are, however, already using one-fifth of all the solid fuels produced and the demand is increasing more rapidly than the coal output. Increased transmission of electric power to consuming centres should therefore be made from stations situated on the brown coalfields, the transport of this type of fuel not being economically justifiable.

TRAINING FOR IRONFOUNDING.

On May 31, 1950, the number of boys employed in the metal manufacturing group of industries in Great Britain, including ironfounding, was 17,960. This number represented 3·8 per cent. of the total number of male persons aged 15 years and over engaged in these industries. In engineering and shipbuilding, however, the proportion was 5 per cent.; in vehicle construction it was 5·7 per cent.; in building and contracting, 6·6 per cent.; in agriculture, forestry and fishing, 7·3 per cent.; and in paper and printing, 7·9 per cent. These figures were quoted by Mr. F. Holmes, regional youth employment officer, Ministry of Labour and National Service, at a conference on "Training for Ironfounding" held by the Council of Ironfoundry Associations, at Ashorne-hill, Leamington, in March of this year. The report of the conference has now been published and is available, price 3*s.* 6*d.*, post free, from the Council's offices, Crusader House, 14, Pall Mall, London, S.W.1. The report shows that, generally speaking, the flow of boys into the ironfounding industry is insufficient to replace the wastage from sickness, death and retirement. Much, however, is being done by joint foundry recruitment and training committees of employers and trade-union representatives, set up in various part of the Midlands, and also by several prominent firms which have established well thought-out training schemes, to dispel the prejudice among some parents and teachers that foundries are dirty and unhealthy places in which to work. In addition to the training of moulders and similar employees working on the foundry floor, the conference dealt with the foundry technician, the foreman, and the junior executive officer. The work of the National Foundry College and other establishments in training suitable men as foundry managers and executive officers was discussed in detail, as were also training schemes for foremen both within the industry and in technical colleges and similar institutions.

LETTER TO THE EDITOR.

PRODUCTION OF COMBUSTIBLE AND FERTILISING SLUDGE AT MAPLE LODGE SEWAGE WORKS.

To the Editor of Engineering.

Sir,—I have read and appreciated the letter from Messrs. Sandford Fawcett and Partners, in your issue of September 19, dealing with the suggestion I made of spreading sludge on fields in the aqueous state rather than drying it. Obviously, if weed seeds, grease, disease germs, etc., are present, digestion is essential. Regarding the smell, dwellers in the country, like myself, who are faced with the smell of hen manure from batteries, ensilage, pig manure, and other aromatic substances, could, I fancy, take the sewage in our stride.

I ought to have made it clearer that I envisaged distribution by tanker, and in this connection I suggest that, great as an annual tonnage of 300,000 sounds, it is probably comparable with the tonnage of ground lime applied to fields in most districts by means of road transport, direct from the quarry to the soil. The low manurial value is one point, but, on the other hand, what is the humus content? In any case, a low manurial value means that a heavy dressing could be applied—a useful feature since the amount to be disposed of is large. The point I have in mind is raising the fertility of infertile ground by heavy applications, rather than the manuring of soil in good condition; for example, the thin soils over chalk and the huge acreages of well-nigh desert in the Aldershot area and parts of Norfolk and Suffolk.

It will, I think, be necessary for the people of this country to pay less attention to making a profit from the sale of sewage works' by-products and more to the need to raise the fertility of every acre of ground in these islands. Having regard to this fact, it seems to me that, in the first place, finance free of interest should be found for the construction of such works as Maple Lodge, and in the second place the by-product—in this case digested sludge—should be considered less as a manure in competition with other manures, and more as a means of improving infertile or poor soil.

Yours faithfully,
Kyrle W. Willans.

Rose Cottage,
All Cannings, Devizes,
Wiltshire.
October 2, 1952.

Steel and Iron Production in September.—There has been a record production of steel in September, at an annual rate of 17,141,000 tons. The previous highest September figure was achieved in 1950, at a rate of 16,964,000 tons. In September, 1951, the rate was 15,749,000 tons. This is the result of an expansion in pig-iron production; four new blast furnaces have come into operation during the past few months. The production of pig iron in September achieved an annual rate of 10,845,000 tons. The previous peak rate, reached in August this year, was 10,498,000 tons.

The Manufacture of Aluminium-Sheathed Electric Cables: Erratum.—In the article on "The Manufacture of Aluminium-Sheathed Electric Cables," which appeared on page 404 of our issue of September 26, there was a reference to the difficulty of making soldered or sweated joints with that metal. Messrs. Johnson and Phillips, Ltd., however, point out that this difficulty has been overcome for some time and that satisfactory wiped joints are now in use on cables sheathed with aluminium in place of the mechanical type of union, which was previously advocated.

OBITUARY.

PROFESSOR F. C. LEA.

By the death of Professor F. C. Lea, which, we regret to record, occurred on September 30, the engineering profession has lost a prominent figure to whom many engineers now practising owe much for the inspiration and advice he imparted during their early years.

Frederick Charles Lea commenced life in an engineering atmosphere, having been born in the great railway centre of Crewe on June 25, 1871; he had, therefore, just passed his 81st birthday at the time of his death. His technical education was first acquired in the Crewe Mechanics Institution and subsequently at Owen's College, Manchester, and the Royal College of Science, London. He served an apprenticeship of seven years, from 1885 to 1892, in the London and North Western Railway shops at Crewe, under the late F. W. Webb, part of his term being spent in the locomotive, millwrights, hydraulic machinery and electrical departments of the works. He also spent three years in the civil

The Late Professor F. C. Lea.

engineering department of the company, in whose service he remained in various capacities for about 16 years in all. He gained a Whitworth Exhibition in 1891 and a Whitworth Scholarship in 1896, while engaged with the railway company.

His connection with technical education may be said to have commenced in 1899, when he was appointed chief assistant to Professor W. C. Unwin at the City and Guilds College, London, where he remained until 1911 when he became engineering inspector to the Board of Education in charge of the West Central District. Two years later, he was appointed Professor of Civil Engineering in Birmingham University, and in this capacity was largely concerned during the first World War with metal materials for aircraft construction. On relinquishing this appointment in 1924 he was appointed Professor of Engineering in Sheffield University and became Dean of the Faculty of Engineering. He retired from this position in 1936 and was appointed Emeritus Professor. At about this time he joined the board of directors of Messrs. Edgar Allen and Company, Limited, Sheffield.

Professor Lea was elected a member of the Institution of Mechanical Engineers in 1921 and served as chairman of the Yorkshire Branch for the session 1928-29. He was Chairman of the Education Committee for several years, and became a Member of Council in 1930, and vice-President in 1939. He occupied the Presidential Chair for the 1943-44 session and delivered a notable address, for which he used as text the very appropriate words of Pasteur, "Remember the Past and look to the Future." He continued to serve on the Council as past-President until 1948. The extent and value of his services to the Institution were acknowledged by admitting him to Honorary Membership in January, 1949.

In addition to the distinguished service Professor Lea rendered to the Institution of Mechanical Engineers, he was a member of the Institution of Civil Engineers and acted as President of both the Birmingham and District Association and the Yorkshire Association. He attended the meetings of the British Association for the Advancement of Science for many years and frequently contributed to the discussions of the Engineering Section; he was President of the Section during the visit of the Association to South Africa in 1929. He was also a member of the Institute of Metals and the Institution of Structural Engineers.

He naturally contributed numerous addresses and other communications to the various institutions and societies with which he was connected, but one of his best-known publications was the text-book on *Hydraulics*, first published in 1908, which many of the older engineers will remember with gratitude. Professor Lea gained several academic distinctions, including the Associateship of the Royal College of Science, and the degrees of Doctor of Science of London University and Master of Science of Birmingham University.

MR. HARRY CUNNINGHAM.

Mr. Harry Cunningham, whose death at Bearsden, Dumbartonshire, on October 5, we also record with regret, was chairman and managing director of Sir William Arrol and Company, Limited, Glasgow. Having served the company since 1906, and the Caledonian Railway Company before that, he figured in some of the most notable civil engineering contracts of the past 50 years. During the second World War, he was chairman of the British Constructional Steelwork Association.

Harry Cunningham was born on May 15, 1877, and received his early education at Spiers School, Beith, Ayrshire, and at Glasgow University. He was articled to Messrs. Crouch and Hogg, consulting civil engineers in Glasgow, from 1895 to 1899, gaining experience in the design of bridges, on surveys, and the preparation of contracts. His initial training over, he joined the staff of the chief engineer of the Caledonian Railway Company, where he was engaged successively on designs in connection with Glasgow Central Station, as assistant resident engineer on the Clyde Bridge contract of the station extension, as resident engineer on other contracts associated with the extension, and as designer of the Bridge-street station reconstruction. Meanwhile, from 1894 to 1901, he studied at Glasgow Technical College.

It was while he was working on Clyde Bridge that he attracted the attention of Sir William Arrol, who had the contract for the steelwork, and on joining Sir William's staff he became resident engineer for the early stages of the Walney Bridge, Barrow-in-Furness, and, later, for the widening of Blackfriars Bridge, London. His subsequent work for the company included Newport Dock gates and a deep-water berth at Barrow, and in 1912 he visited Japan to report on the site conditions for the design of a long-span railway bridge. He was elected to the board of the company in 1913, and among the major works with which he was connected were H.M. Dockyard, Rosyth; wharves for Messrs. John Brown and Company, Limited, Clydebank; the central power station at Barrow; and the Royal Albert Dock extension. He succeeded the late Sir John Hunter as chairman of the company in 1935. During the second World War, as chairman of the B.C.S.A., he was largely responsible for arrangements to co-ordinate the resources of the structural steelwork industry as applied to the construction of landing craft, components for the Mulberry harbours, etc.

Mr. Cunningham served as chairman of a large number of trade associations, and was a director of the North-West Rivet, Bolt and Nut Factory, Limited, the Rivet, Bolt and Nut Factory, Limited, and the Power and Traction Finance Company, Limited. He was elected an associate member of the Institution of Civil Engineers in 1903 and a member in 1920.

SIR ARCHIBALD McKINSTRY.

We also regret to record the sudden death of Sir Archibald McKinstry, which occurred in London on Monday, October 6, at the age of 75 years. Archibald McKinstry was born in Co. Antrim on November 3, 1877, and was educated at Queen's College, Belfast, and at the Royal University of Ireland, where he took honours courses in mathematics and mathematical physics. He graduated in 1898, receiving an exhibition for the results of his final examination, as well as a post-graduate scholarship. He then joined the British Westinghouse Electrical and Manufacturing Company as junior engineer and served with them for nearly 30 years, during which period he occupied numerous positions of increasing responsibility. Towards the latter part of his time with this concern, when it had become the Metropolitan-Vickers Electrical Company, Limited, he acted as chairman of its subsidiary, the Metropolitan-Vickers Electrical Export Company, and also as a director of the parent organisation. During the latter part of the 1914-18 war, became Director of Munitions to the Commonwealth Government of Australia and Electricity Commissioner to the State of Victoria.

The Late Sir Archibald McKinstry.

In 1922 he became one of the first directors of the British Broadcasting Company, which, it may be recalled, was formed by a number of electrical firms to develop this form of communication. He remained director until 1927, when the Company was merged in the present organisation. In 1931 he became a director of Messrs. Babcock and Wilcox, Limited, and about two years later was appointed managing director, becoming deputy chairman in 1937. He resigned his position as managing director in 1944 and retired from the Board in January, 1951.

During the 1939-45 war, he served as a member of the industrial panel of the Ministry of Production, and as representative of the Ministry of Supply on the munitions management and labour efficiency committees of the former Ministry. He was appointed a member of the Royal Commission on Awards to Inventors in 1947 and had attended a meeting of that body as recently as last week.

McKinstry received the honour of knighthood for his services in 1943 and was also the recipient of the honorary degree of Doctor of Science from the University of Melbourne. He became a member of the Institution of Mechanical Engineers in 1934, and of the Institution of Electrical Engineers in 1914.

THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION.

The British Hydromechanics Research Association was formed in 1947 by makers of hydraulic machinery under the presidency of Sir John Anderson (now Lord Waverley). In the early stages the resources were concentrated on the provision of a technical information service, but this was supplemented in 1951 by the opening of the laboratory at Nettlesford-road, Harlow, Essex, where the staff are now carrying out a research programme of direct interest to members. The Association comprises ordinary members, who are manufacturers or users of fluid machinery or equipment, and associate members, who are either engineering consultants or university teachers. The present rate of expenditure is about 25,000*l*. per annum and the income is derived from members' subscriptions, from a proportionate Government grant and from individual charges made for special investigations. The main purpose of the Association is to provide members with the latest known information relevant to their technical problems and, when this is inadequate, to undertake the appropriate research.

During the past year the major effort of the staff of the Association has been devoted to equipping the laboratory to carry out the research projects previously decided on by the various committees set up to direct the work of the laboratory. No capital grant was raised for this purpose and most of the test rigs have been constructed in the workshop of the laboratory, although this work has been supplemented by a number of gifts from members. On September 24 and 25, open days were held at the laboratory, when visitors were able to examine the apparatus, workshops and library, and to discuss with the members of the staff the problems being investigated. A description of some of the exhibits is given below. Of particular note was the considerable use that has been made of Perspex, or other transparent windows, at critical sections in the hydraulic circuits so that direct observations can be made on the phenomena occurring within the apparatus.

The first exhibit that visitors were invited to inspect was an apparatus that has been installed to investigate the several factors—particle size, shape, density, fluid head and pipe diameter—involved in the problem of the fluid transport of solids. The transport of large quantities of granular solids by hydraulic conveyance in pipe lines has been practised successfully for many years, but many of the existing installations are of short length only, where power costs are not excessive and where the advantages of hydraulic "loading and unloading" make this method more economical and preferable to other transport systems. There is, however, considerable interest being shown in this country to-day in the possibilities of hydraulic transport of large-size solids over long distances. The magnitude of the hydraulic friction then becomes a deciding factor and the Association have conducted a full survey into existing data before commencing their own experimental investigation. Some success has been achieved in correlating available published data on friction losses of mixtures of liquids and solids of less than 0·2 in. particle size, and the Association's experiments will be directed mainly at providing data for larger particles and densities other than that of sands. The apparatus consists of a 4-in. centrifugal pump which forces the water-borne solids through a pipe circuit 70 ft. long, which includes 10 ft. of horizontal and 10 ft. of vertical transparent pipe. The flow and concentration are measured by collecting the delivery for a known time in a calibrated tank. The concentration in the pump suction tank is maintained uniform by an auxiliary mixing pump, and the concentration of solids in the circulating system may be changed by diverting solids into, and out of, a large elevated tank. A measurement of the mean particle size is obtained by determining the settling velocity of the material down a vertical glass pipe, 15 ft. long; such a measurement does to some extent involve the surface texture of the particles, although entrapped boundary fluid will tend to minimise this effect. The size variation of the sample is obtained by the continuous weighing of the solids as they reach the bottom of the pipe where they fall on to a scale pan. An initial observation has shown that, while there is continuous regular flow, loss of particle speed with respect to the speed of the transporting fluid is independent of particle size, the various contributing factors tending to have a cancelling effect. The trouble of scour in the pipe is minimised as long as a fluid velocity can be maintained that will keep the particles in suspension.

An adjacent exhibit illustrated an investigation, now completed, on models of bell-mouthed spillways for reservoir schemes. The model experiments had shown the great advantages that accrued from substituting a curved connection for the rectangular elbow originally proposed between the vertical spillway and the main trunk conduit. From the experiments it had also been thought advisable to induce a hydraulic "jump" in the conduit to break an air lock that could form at the bottom of the spillway funnel and so achieve maximum flow. Without the jump it was possible for a resistance head to be developed in the funnel that would cause flood water to pile up above the level of the spillway, with a consequent risk of damage to the banks of the reservoir. The desirability of incorporating a baffle ring at the bottom of the spillway funnel had also been observed in the experiments. Under a free flow, the water poured down the sides of the funnel and hit the invert of the conduit as a high-velocity jet of restricted area; in practice, this jet could have given rise to serious erosion. The incorporation of the baffle ring diverted the water streams so that they met—and gave up their kinetic energy on mutual impact—a few feet above the invert, on to which the water finally fell under a small head and over a relatively large area, so minimising the possibility of erosion.

The Association have also been studying the characteristics of various types of seals and gland packings, with the dual object of determining their actual performance rating and discovering the fundamental processes involved in their operation. A small exhibit enabled visitors to demonstrate the stability—or lack of stability—of three characteristic disc valves. Small jets of water, contained within a transparent tank, could be sealed by the finger-operation of the sample discs; on account of the differing flow patterns under the discs—one was convex, one plane and the third concave with respect to the jet—the concave disc was found to be self-centring and easy to control, in contrast with the convex disc, which was unstable and difficult to place in position.

An experimental reciprocating-ram pump has been installed with valve boxes specially designed so that observation can be kept on the flow and the movements of the valves, with the object of determining the factors controlling the stability of self-acting valves. The faulty action of this type of valve is at present the feature that restricts the speed, and therefore the capacity, of reciprocating pumps. The delivery of the experimental pump is at present throttled and returned to the suction tank, but at a future date will be passed through a regenerative cylinder to allow the use of higher delivery pressures without excessive power consumption. A maximum pump speed of 230 r.p.m. is available and the stroke may be adjusted by increments of one inch over a range of one to 12 inches. Provision has also been made for fitting rams of 4 in. and $3\frac{1}{4}$ in. in diameter, in place of the existing $2\frac{1}{2}$-in. diameter ram.

Problems related to the operation of centrifugal pumps are being examined in two pieces of apparatus. In order to study flow patterns through the impeller and to determine the impeller characteristics independently of the influence of the casing, a test rig has been erected in which a transparent impeller can be rotated inside a large cylindrical tank fitted with observation windows at the top and bottom. Impellers of up to 16 in. in diameter by about 5 in. overall width can be accommodated and driven at speeds up to 400 r.p.m. When data in respect of the impeller flow have been obtained and studied, restrictions representing the casing of the pump will be progressively added and their effect in modifying the flow observed.

In commercial pump testing it is common practice to make the suction and delivery connections at the pump flanges with either bends or taper pieces, and if pressure measurements are taken at these points erroneous observations may be obtained due to the effects of both curvature and rotation of flow. In addition to these effects, however, considerable errors in the apparent suction head, at flows less than half normal, can be caused by the impeller setting up a back-swirl for considerable distances along the suction pipe. A 6-in. pipe, with a straight length of Perspex pipe connected to the suction flange, has been set up for observing the back-swirl or pre-rotation at sub-normal speeds and its effect on suction-head measurement. This investigation is to be extended to cover various forms of pipe layout so as to obtain information from which the most suitable locations for pressure tappings can be selected in the case of pump tests where the pipe layout is difficult.

As a prelude to much of the work already described, an investigation is also being conducted into the response of manometers to fluctuating pressures. Preliminary work on the measurement of pulsating flow has led to the conclusion that most of the errors are due to false indications given by certain conventional types of manometer when subjected to pressure fluctuations. The performance of manometers is therefore being studied, as a separate problem, on an installation which consists of a closed hydraulic system that includes an input pump, of variable stroke and speed, to apply an impulse and a damping air lock. The manometers can therefore be connected to a hydraulic system in which there is a known static pressure with a superimposed pressure fluctuation. At present the tests are being made to determine the effects of diameter and length of pressure connections on the accuracy of a simple mercury U-tube manometer.

The effect of breakdown in pumping and the pressure surges that may be set up are being investigated in a model installation consisting of a small pump which delivers from a sump into a closed hydraulic system. At the highest point in the system, near to the pump, a length of transparent pipe has been fitted so that cavitation, should it occur, may be observed and photographed. The pump itself is fitted with a powerful brake so that it can be stopped in a fraction of the pipe-surge reflection period. Two possible forms of the resultant breakdown of flow have been mooted: first, complete cavitation, which would be followed by an immediate collapse giving rise to dangerous repercussions, or, secondly, a less complete rupture made up of a multitude of isolated bubbles which will tend to cushion the resultant shock wave. The efficiency of a by-pass around the pump, and of other devices for mitigating pressure surges, will be investigated by making instantaneous recordings of the pressure and flow at the time of braking the pump. At a later date the additional effects of side connections from the main ring pipe will be studied.

The library and information services have recently been extended and visitors to the Association's premises were able to inspect the facilities provided and to see a selection of the several publications that members of the staff have so far compiled. An abstract bulletin, published every second month contains critical reviews of current papers and books, of world-wide origin, on topics relevant to the work of the Association.

Withdrawal of Midland Railway Locomotives.—The last of two classes of 4-4-0 passenger engines designed by S. W. Johnson for the former Midland Railway have recently been withdrawn from stock for breaking up. They are No. 40383, one of the non-superheated class-2 locomotives, and No. 40726, one of the class-3P locomotives. No. 40383 was built in 1888 and was one of a batch of ten. Its working pressure was raised from 160 to 175 lb. per square inch in 1904 when a larger boiler was fitted, and all ten were subsequently rebuilt by Sir Henry Fowler. The total mileage run by No. 40383 was 1,604,149, and latterly it was used for pulling the Derby district engineer's saloon on his inspections. Class-3P locomotive No. 40726 was 50 years old on withdrawal and was one of 80 which first appeared in 1900.

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

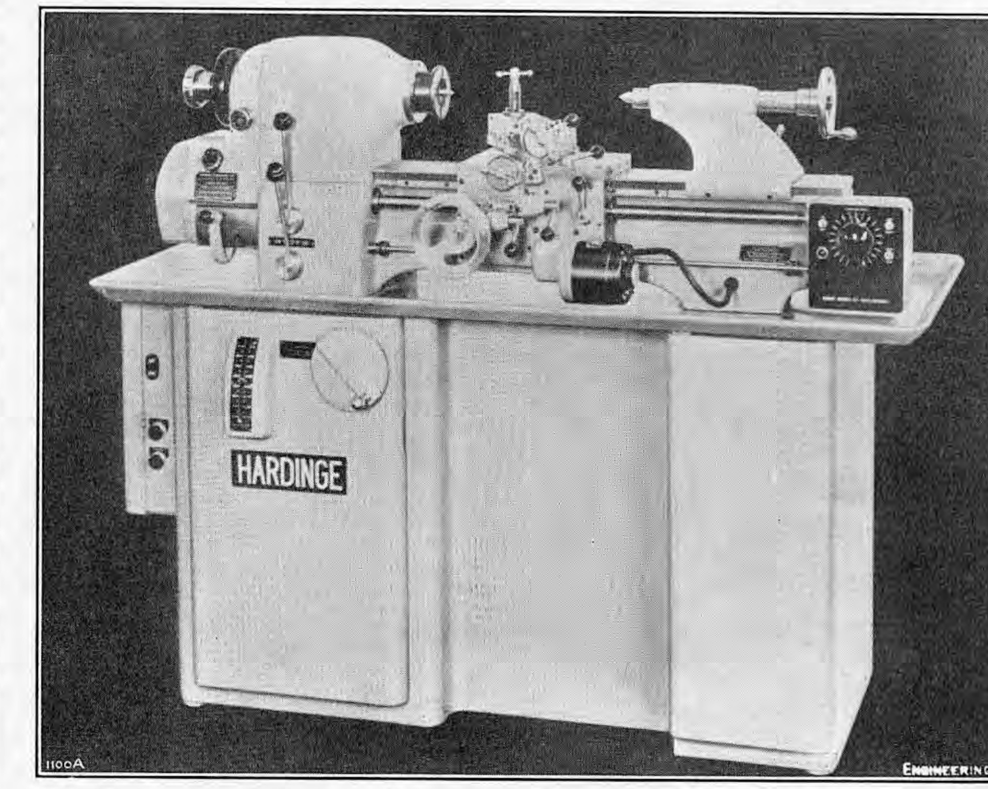


Fig. 112. 11-In. Swing Centre Lathe; Hardinge Machine Tools, Ltd.

THE INTERNATIONAL MACHINE TOOL EXHIBITION AT OLYMPIA.

(*Continued from page* 435.)

11-In. Swing Centre Lathe.

The exhibits on the stand of Hardinge Machine Tools, Limited, Feltham, Middlesex, included a new 11-in. swing lathe known as the HLV, designed to bridge the gap between plain precision bench lathes and heavy-duty engine lathes. An outstanding feature of this machine is the provision of an independent electrically-driven variable feed for the carriage and cross slide, thus enabling the rate of feed to be changed instantly without having to stop the machine and shift the gears. These two movements are driven by a separate variable-speed electric motor mounted on the carriage, and when the machine is in use it is only necessary to vary the motor speed to alter the rate of feed. A solid dovetail bed is used. The spindle is mounted in preloaded ball bearings and is driven from a two-speed motor through a variable-speed device arranged to give an infinite number of speeds between the limits 125 r.p.m. and 3,000 r.p.m. There is a $1\frac{1}{4}$-in. diameter hole through the centre of the spindle for bar work, and round collets up to a maximum diameter of 1 in. can be fitted. The lead screw is used for thread-cutting only, the number of changes in the gearbox being 27 and the thread range extending from 11 threads per inch to 108 threads per inch; this covers all standard threads in the British systems. The swing over the bed is 11 in., over the carriage 9 in., and over the cross slide $5\frac{3}{4}$ in. With the tailstock flush with the end of the bed, the distance between centres is 18 in., but by overhanging the tailstock, this dimension can be increased to 20 in. The power-feed range is infinitely variable between the limits of $\frac{1}{4}$ in. and 7 in. per minute and the maximum compound-rest travel available is 3 in. A quick-acting mechanism fitted to the tool-post slide enables the tool to be brought into the work and withdrawn rapidly when threading, and an automatic lead-screw stop with adjustable stop collars is provided. Additional equipment available with the machine includes a taper-turning attachment, follower and steady rests, step chucks, a radius turning attachment and an automatically-indexing square turret for the compound rest.

Precision Profile Grinder.

The exhibits on the stand of A. A. Jones and Shipman, Limited, Narborough-road South, Leicester, included a selection from their range of precision grinders. This firm also showed a number of Ex-Cell-O machines for milling, polishing and grinding gas-turbine blades, an Ex-Cell-O fine-boring machine and two micromatic honing machines. One of the grinding machines for dealing with gas-turbine blades, namely, the Ex-Cell-O precision profile grinder No. 87, is illustrated in Fig. 113, on Plate XL. This machine is intended for grinding the complete aerofoil form, including the leading and trailing edges. It is completely automatic in operation except, of course, for loading and unloading the workpieces, a master cam made according to the form desired ensuring accuracy. Each blade is located from the finished root form at one end and from a centre at the other end, and the work is rotated and traversed across the grinding wheel. A two-speed drive rotates the part at high speed when the grinding wheel engages the thin edges of the blade, that is, where the area of contact is small, but slows down when the wheel cuts the sides of the blades where the area of contact is much larger. The two different work speeds, therefore, are each used twice during each revolution of the blade, the finish, as a consequence, being of a uniform nature.

In operation, the part is first loaded and the starting button then pressed. This starts the grinding-wheel motor and the supply of coolant, and at the same time the work is lowered at a controlled rate of feed to the grinding position. As the work contacts the wheel, the work-drive motor starts and the part moves to the right to grind the fillet of the root, an end cam controlling the lateral position of the blade root in relation to the grinding wheel to generate the fillet parallel to the root platform as the part makes one complete revolution. As rotation continues the work starts to feed from right to left at a controlled rate of feed to grind the remainder of the blade. At the end of this stroke, the work stops turning and is raised to the loading position, subsequently returning rapidly to the left as the coolant valve is closed and the grinding wheel stopped. The maximum width of profile that can be handled is 2 in. with the standard machine and 3 in. with a special machine. The length of profile that can be ground depends on the size of the grinding wheel and the end-cam rise,

(To face page 478.)

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 478.)

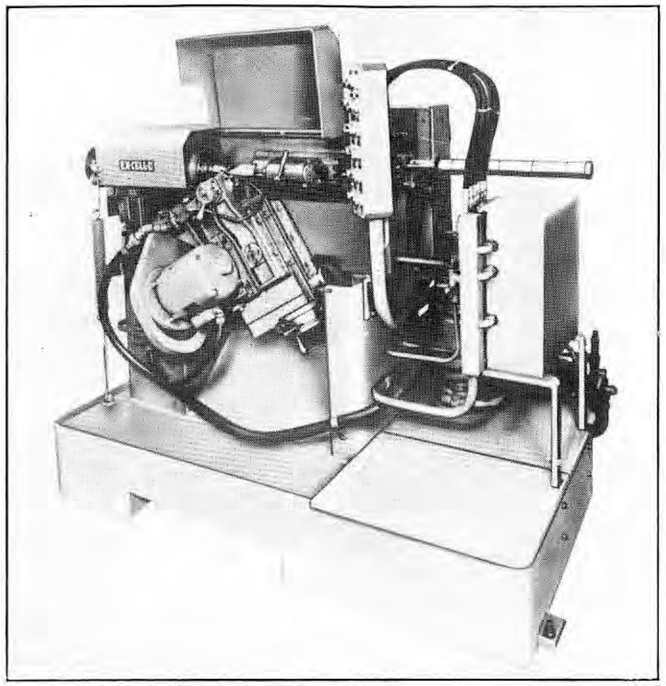


FIG. 113. PRECISION PROFILE GRINDER; A. A. JONES & SHIPMAN, LTD.

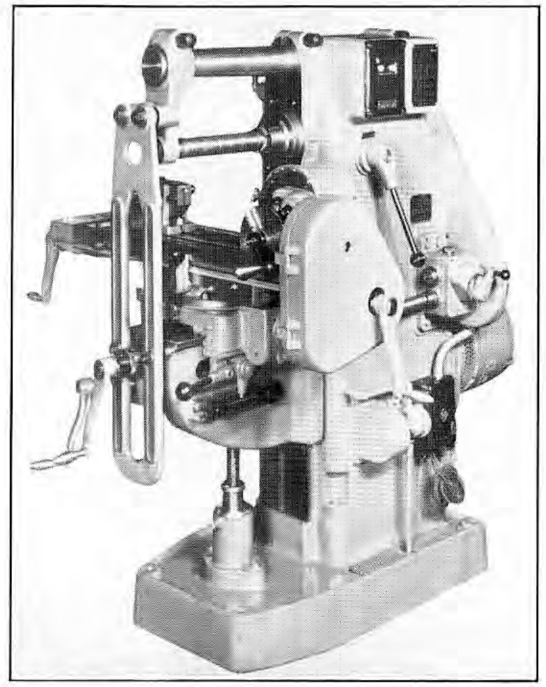


FIG. 114. UNIVERSAL MILLING MACHINE; MIDGLEY & SUTCLIFFE, LTD.

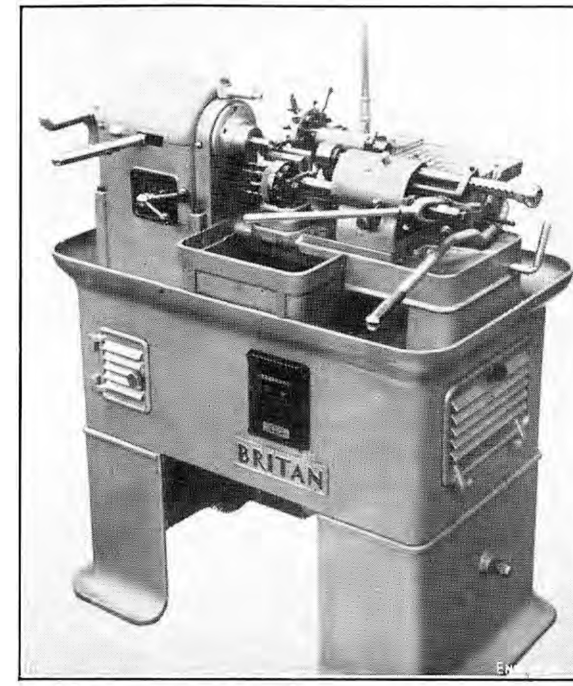


FIG 115. "BRITAN" REPETITION LATHE; KERRY'S (GREAT BRITAIN), LTD.

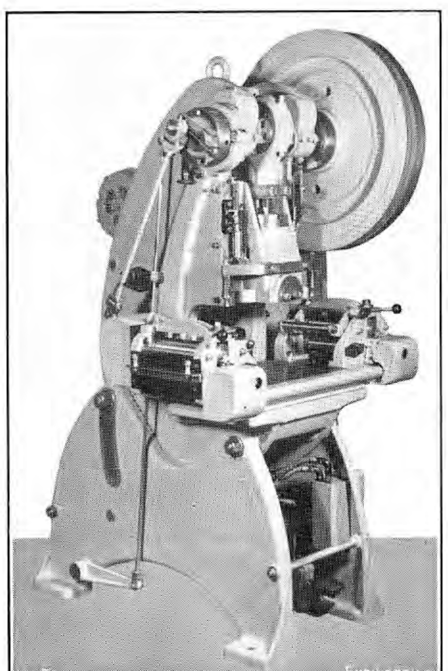


FIG. 116. 20-TON INCLINABLE CRANK PRESS; HUMPHRIS & SONS, LTD.

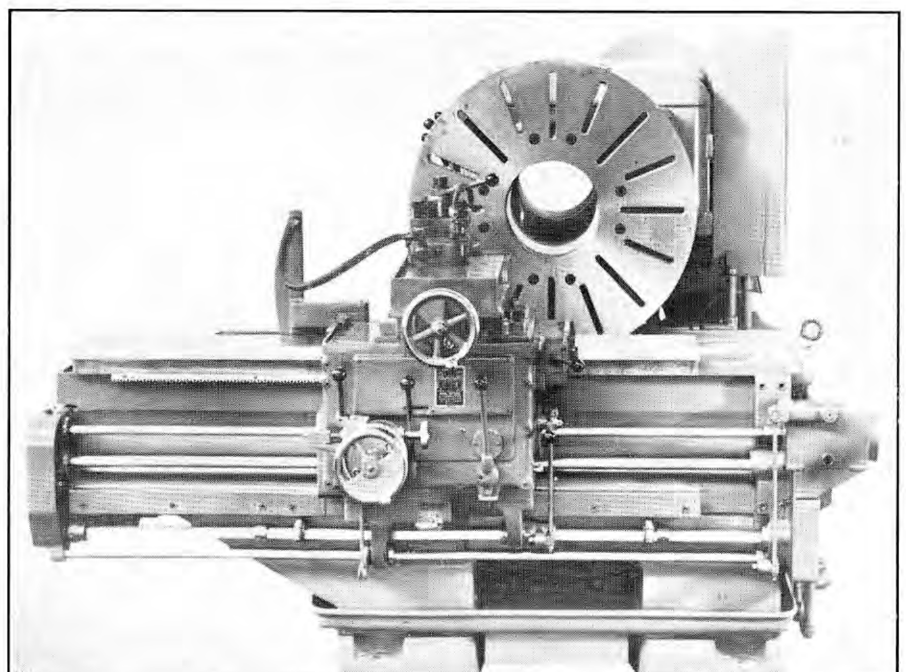


FIG. 117. LODGE & SHIPLEY RIGHT-ANGLE CHUCKING LATHE; E. H. JONES (MACHINE TOOLS), LTD.

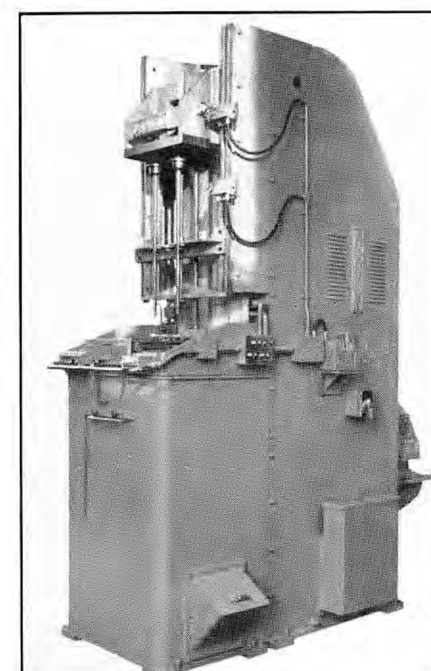


FIG. 118. VERTICAL HYDRAULIC BROACHING MACHINE; LAPOINTE MACHINE TOOL CO., LTD.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 478.)

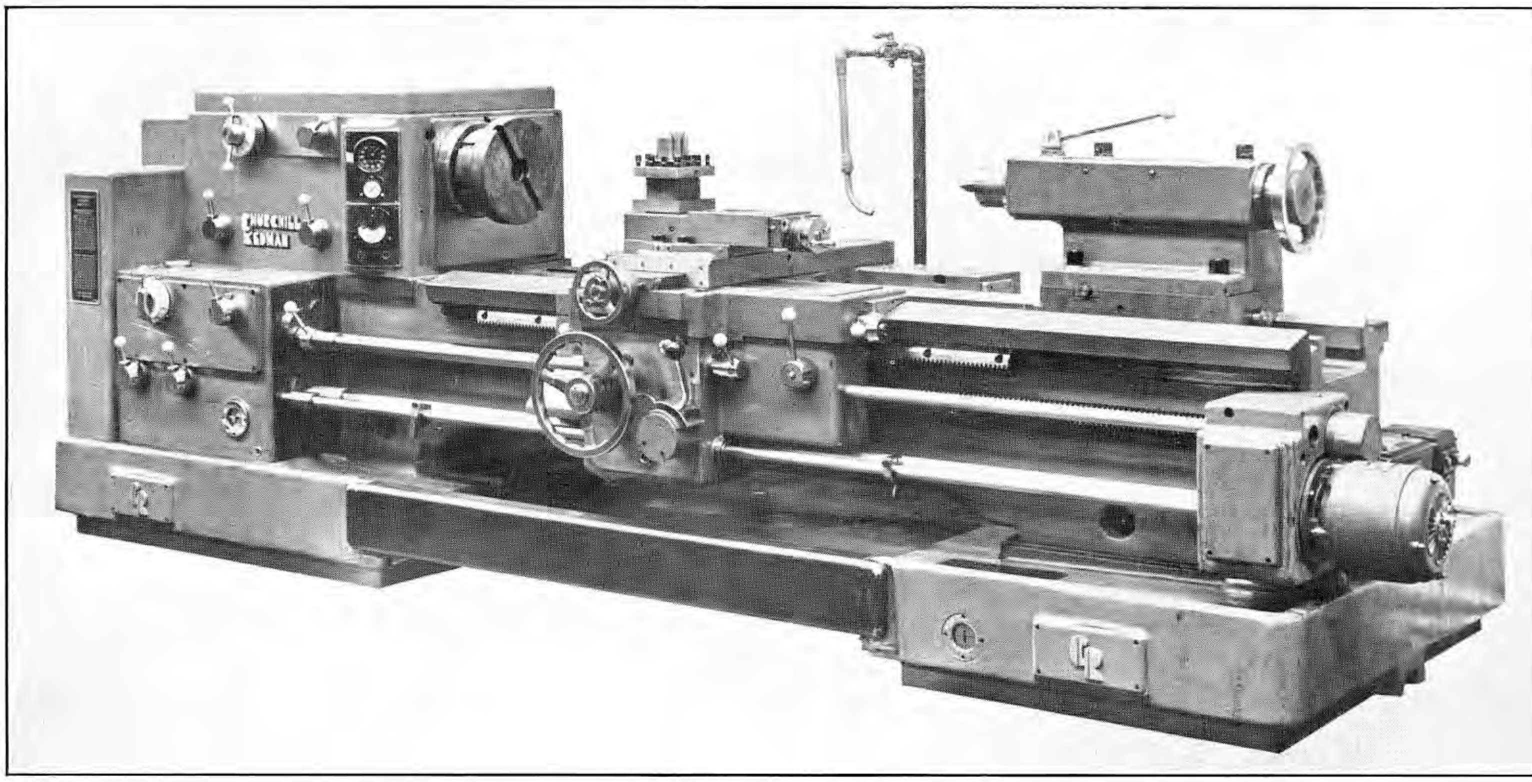


Fig. 119. 23-In. Swing Centre Lathe; Charles Churchill & Co., Ltd.

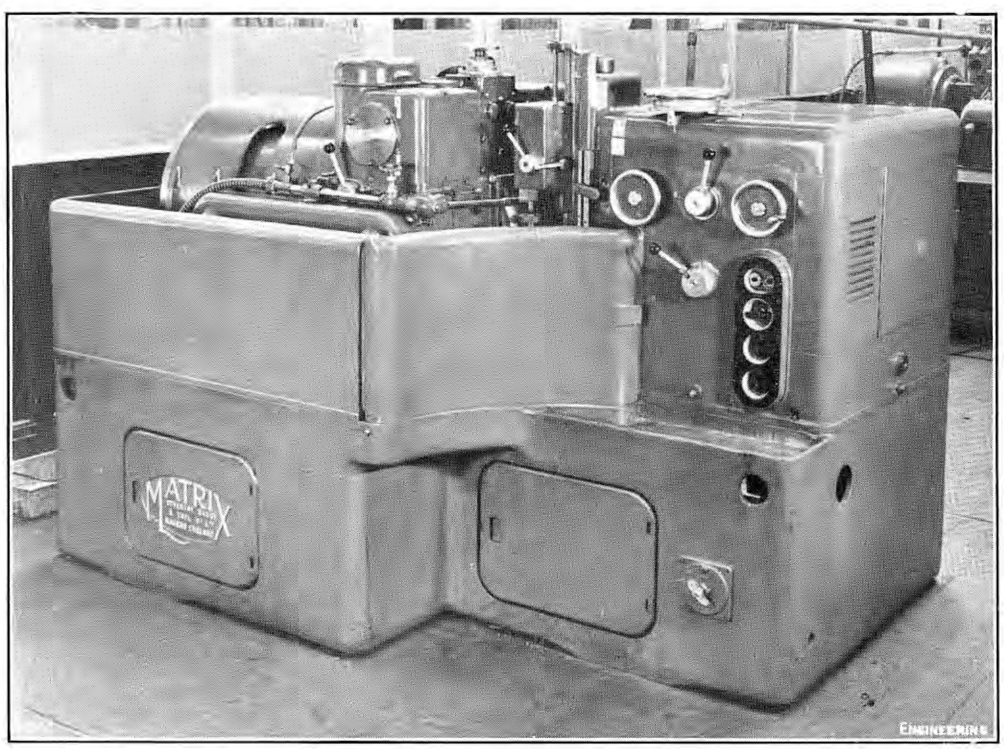


Fig. 120. High-Speed Gear Grinding Machine; Coventry Gauge & Tool Co., Ltd.

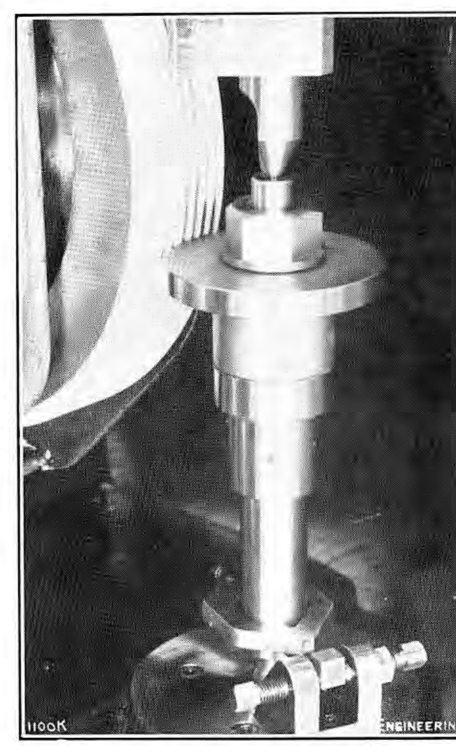


Fig. 121. Gear Blank Set for Grinding.

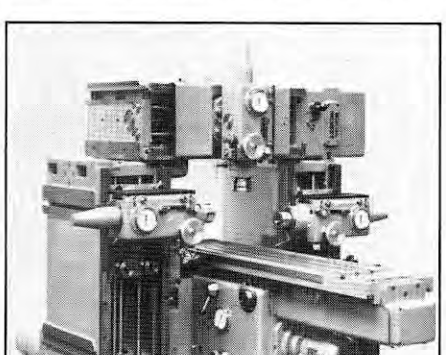


Fig. 122. M.V.A. Production Milling Machine; Modern Machine Tools, Ltd.

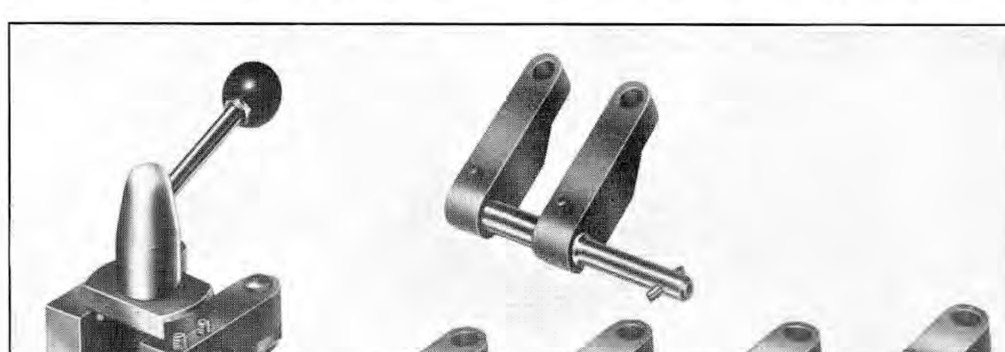


Fig. 123. Tool Post with Interchangeable Holders; F. Burnerd & Co., Ltd.

(*To face page* 479.)

but with a $3\frac{1}{2}$-in. diameter wheel and no end-cam rise it is $8\frac{1}{2}$ in. The grinding wheel is driven by a 1-h.p. motor operating at 3,600 r.p.m., the wheel speeds available extending from 6,800 r.p.m. to 14,600 r.p.m. The work-drive motor runs at 450 r.p.m. and 900 r.p.m. and the standard work-spindle speeds are 13 r.p.m. and 26 r.p.m.

Universal Milling Machine.

The exhibits on the stand of Midgley and Sutcliffe, Limited, Hillidge Works, Hunslet, Leeds, included the universal milling machine illustrated in Fig. 114, on Plate XL. This unit has a table with a working surface of 30 in. by 8 in., longitudinal and cross feeds of 18 in. and 6 in., respectively, and a vertical feed of 16 in. In general, the design follows that of the makers' O 1-type milling machines but the drive has been redesigned to simplify belt changing. The body and base are made from close-grained iron castings suitably ribbed to resist vibration, and the over-arm from a solid steel bar, the latter being fitted with an end-stay for supporting the arbor; a cast-iron brace is also supplied for tying the mandrel steady to the knee bracket. The spindle is made from alloy steel, hardened at the nose, and is supported at the front by a pair of Timken opposed taper-roller bearings and at the rear by a roller journal bearing. Automatic feed is provided for the table longitudinal and cross movements, and six rates of feed are available extending from 0·005 in. to 0·048 in. per revolution of the spindle. There are six spindle speeds, the range being from 34 r.p.m. to 400 r.p.m. This machine is available in two types, namely, type 1 and type 2, the latter being substantially the same as type 1 but provided with a two-speed motor, thus giving twelve speeds with a maximum of 600 r.p.m.

Repetition Lathe.

Kerry's (Great Britain), Limited, Warton-road, London, E.15, and Messrs. Henry Broadbent, Limited, Sowerby Bridge, Yorkshire, were showing a number of exhibits, including a Broadbent 10 in. by 10 ft. lathe, a range of Kerry drilling machines, power hacksaw machines and double-ended grinding machines, and a Britan repetition lathe. The last named item is illustrated in Fig. 115, on Plate XL; it is manufactured by the Britan Manufacturing Company, Limited, Cambridge, for whom Kerry's (Great Britain), Limited, act as sole distributors. It is capable of giving a high rate of production, for as many as 15 tooling stations are incorporated in the design. The capstan unit is, possibly, the most interesting feature of the machine, the turret of which is mounted in the vertical plane and carries six tools. It operates at right angles to the work through a compound slide controlled by two hand levers, which provide the longitudinal and cross movements and tool indexing. Standard $\frac{5}{16}$-in. square cutter bits are used and, when at work, the cutters are supported by a hardened track arranged close to the cutting points, an arrangement which permits heavy cuts to be made. For taper turning, the complete capstan unit is swung horizontally through an arc, up to 10 deg. of movement being available.

The tailstock has two guideways which accommodate tool-holding shafts that swing into position as required, a locking device holding them separately in line with the headstock spindle. The tool-holding shafts are arranged to take inset tools for boring, screwing and other operations and are designed to accept standard Britan accessory shanks; thus, collets, threading-tool holders, etc., are readily fitted, being drawn into position by the use of lock bolts. As a supplement to the main turret on the capstan unit, an eight-station turret can be fitted to the standard tailstock shaft, thereby permitting as many as 15 tools to be used in any one set up.

The headstock is contained in one casting in which is fitted the spindle, chuck-operating mechanism and a two-speed reversing controller. The spindle runs in ball and roller bearings and has eight speeds in both directions of rotation ranging from 358 r.p.m. to 4,414 r.p.m. The chucking mechanism is operated by a lever, and spring collets suitable for use with round, square and hexagonal stock are available; eccentric and second-operation collets for short-work lengths or large diameters can also be supplied. The maximum diameter of the stock which can be passed through the collet is $\frac{5}{8}$ in., but second-operation work up to $1\frac{3}{4}$ in. can be accommodated. The maximum turning length is 5 in. A pneumatically-operated work-feed is employed.

20-Ton Inclinable Crank Press.

A new 20-ton inclinable crank press was included in the exhibits of Messrs. Humphris and Sons, Limited, Park-road, Parkstone, Dorsetshire. This machine, which is illustrated in Fig. 116, on Plate XL, gives greater tool space than normally available on presses of this capacity and is conservatively rated to ensure that maximum pressure is always available. The body of the press is built up from close-grained iron castings and the crankshaft is machined from a nickel-chromium-molybdenum alloy steel. The clutch is of the rolling-key type in which all components subjected to impact loadings are made from heat-treated 100-ton steel. A ball and buttress threaded Pitman arm is used, and to avoid any possibility of the ram tilting the slides are unusually long. Phosphor-bronze is used for the bearings, which are lubricated by grease supplied under pressure. It operates at 100 strokes per minute and the stroke can be varied from a minimum of $\frac{1}{2}$ in. to a maximum of 3 in. The overall bed dimensions are 26 in. by 16 in., and the hole in the bed measures 11 in. right to left and $9\frac{1}{4}$ in. front to back. The press can be fitted with the maker's own design of universal roll feed and is shown so equipped in the illustration. This unit is driven by means of an eccentric fitted to the end of the press crankshaft, the link motion being transmitted to the feed rolls through a friction roller clutch.

Right-Angle Chucking Lathe.

The most interesting machine shown by E. H. Jones (Machine Tools), Limited, Garantools House, Portslade, Brighton, Sussex, was, possibly, the right-angle chucking lathe illustrated in Fig. 117, on Plate XL. This machine was developed by the Lodge and Shipley Company, Cincinnati 25, Ohio, U.S.A., for facing, turning and boring thin-walled section work of large diameter and short length. The bed is in the shape of a T with the section carrying the carriage set at right angles to the centre line of the headstock. Facing at right angles to the centre line is accomplished by movement of the carriage in the normal manner and the top slide can be set at any angle so that taper boring or turning can be carried out. The machine is arranged so that it can be controlled for contour facing by the makers' Copymatic tracer-control mechanism, and has been designed so that a variable-speed driving gear can be applied to give a constant cutting speed. The spindle is hollow so that work with an extension can be accommodated, the bore in the spindle of the standard machine being $11\frac{1}{2}$ in. The machine can also be supplied with a spindle having a $2\frac{1}{2}$-in. bore. There are 24 spindle speeds, the standard range extending from 4 r.p.m. to 225 r.p.m. for the $11\frac{1}{2}$-in. bore spindle and from 6 r.p.m. to 338 r.p.m. for the $2\frac{1}{2}$-in. bore spindle; the latter range, however, can, if required, be applied to the $11\frac{1}{2}$-in. bore spindle. The carriage and compound rest are power driven, the number of feeds available being 55 with a range of from 0·001 in to 0·064 in. per revolution. A rapid power traverse is built into the machine and is capable of moving the carriage in either direction at 10 ft. per minute. The maximum swing over the bed is 60 in. and the surfacing and boring travels are 37 in. and 16 in. respectively.

Vertical Hydraulic Broaching Machine.

All the exhibits on the stand of the Lapointe Machine Tool Company, Limited, Otterspool, Watford By-pass, Watford, Hertfordshire, were of British manufacture and included a selection of broaching work and associated broaches and two machines, namely, a 5-ton, 30-in. stroke, horizontal machine and their V.3 vertical automatic internal pull-down machine. The latter machine is illustrated in Fig. 118, on Plate XL; it has a 42-in. stroke with a pulling capacity of 15 tons and is representative of a range of eight similar models having capacities of from 5 tons with a 36-in. stroke to 50 tons with a 60-in. stroke. The V.3 machine illustrated, like all Lapointe broaching machines, is hydraulically operated, fluid under pressure being supplied by a pump driven at 1,000 r.p.m. by a 30-h.p. electric motor. In accordance with the maker's normal practice, the main frame is of welded steel construction, the structure being stress-relieved after fabrication. The maximum travel of the slide, which operates within hardened and ground steel ways, is 42 in. Cutting speeds are variable up to a maximum of 21 ft. per minute with a return speed of 42 ft. per minute. The platen on which the work-pieces are located is of heavy semi-steel construction and reciprocates to and from the broaching position to facilitate loading and unloading of the components. An automatic broach-lifting mechanism is provided to eliminate handling of the broaches during the operating cycle, and the work-pieces can, therefore, be loaded and unloaded during the automatic return cycle of the broaches.

23-in Swing Centre Lathe.

The lathes being shown by Charles Churchill and Company, Limited, Coventry-road, South Yardley, Birmingham, included that illustrated in Fig. 119, on Plate XLI. This machine, which is known as the Churchill-Redman 22 × 60 lathe, is a new model, and, as its type designation infers, the height of the centres is 11 in. and it admits work between centres up to 5 ft. in length. The swing over the bed is 23 in. and over the saddle, $13\frac{1}{2}$ in., but a gap-bed model is available, in which case the swing over the bed in front of the faceplate is increased to 32 in. in a width of 11 in. The bed is exceptionally strong so as to resist deflection and the bedways are widely spaced. The headstock is designed to give 18 forward speeds and six reverse speeds, the forward range being from 15 r.p.m. to 1,000 r.p.m. All intermediate shafts in the headstock are mounted in ball or roller bearings and the main spindle is fitted at the front with Timken opposed taper-roller bearings, further support being provided by plain roller bearings. A hydraulically-operated clutch is incorporated in the transmission and the spindle is provided with a brake. The gearbox is totally enclosed and lubricated under pressure, the drive being transmitted thereto through an end train also positively lubricated. Thirty ratios are provided and a 4-to-1 step-up ratio is available to give additional coarse pitches. Without changing the end train, screws with pitches of from $2\frac{1}{2}$ threads per inch to 19 threads per inch can be cut, but with the standard change wheels the gearbox range can be halved or doubled, while additional change wheels enable metric, module and diametrical pitches to be cut. Thirty sliding and surfacing speeds also are available, and with the standard end train these extend from 0·005 in. to 0·038 in. for sliding and from 0·0025 in. to 0·019 in. for surfacing. The apron is of double-wall construction and the controls for sliding, surfacing and screwcutting are effectively interlocked to prevent incorrect engagement. At the front, a single lever controls the feed engagement, quick-power forward and quick-power reverse to the saddle, the speed of the carriage when operating under quick power being 12 ft. per minute.

High-Speed Gear-Grinding Machine.

The machinery shown by the Coventry Gauge and Tool Company, Limited, Coventry, included a thread grinder, a gear grinder, an optical jig borer, and a selection from their range of measuring instruments. The gear grinder is illustrated in Fig. 120, on Plate XLI. It is known as the Matrix No. 40 high-speed gear-grinding machine and operates on an entirely original principle, the method of grinding employing the fundamental principle of gear-tooth development from the basic rack, but in this case the rack is formed on the periphery of the grinding wheel as a continuous helix. This arrangement will be clear from an examination of Fig. 121, on Plate XLI, which shows a work-piece being offered up to a formed wheel. The work rotates continuously at a set rate in direct relationship to the grinding wheel in much the same way as in gear hobbing, but here the resemblance ends for, in addition to the hobbing principle, the work, by a rolling motion, explores the full width of the wheel. Thus the wheel generates the involute form entirely automatically and without adjustment to the machine apart from its initial setting. The machine possesses several advantages: quantities of gears of 16 diematrical pitch and finer, for example, can be ground simultaneously from the solid, and as it works on a generating principle the need for indexing is obviated. Furthermore, the helical rack form of the wheel enables any diameter of gear to be ground of similar diametrical, circular or module pitches without any further setting up apart from alterations to the change gears and repositioning of the wheel. Helical gears up to a helix angle of 45 deg. can be accommodated and both helical and spur gears of the same pitch can be ground with the same wheel without redressing.

The machine is entirely self-contained and embodies its own built-in coolant system and electrical gear. The helical rack formation is imparted to the wheel in two main operations, first by rough crushing and then by diamond dressing. Primary crushing is carried out by an annular grooved-rack form crusher, which is traversed across the wheel by means of a hydraulic system working in conjunction with a cam mechanism, the crusher being housed in a separate unit mounted above the grinding wheel. The same mechanism is then used to traverse two diamonds across the wheel, thus completing the formation of the rack. The complete wheel-head unit, which comprises the wheel, wheel spindle and electric motors, is shaped in the form of a drum which can be swivelled to 45 deg. each side of the horizontal position. This unit is mounted on V and flat slides to permit movement of the wheel into the work, the movement being controlled by means of a precision feed-screw and nut operated by a graduated handwheel on top of the work-head unit. The wheel spindle is fitted with ball bearings and, apart from lubrication, requires no further attention in service.

PRODUCTION MILLING MACHINE.

The exhibits shown by Modern Machine Tools, Limited, Maudslay-road, Coventry, included the M.V.A. production milling machine illustrated in Fig. 122, on Plate XLI. This machine is available in several forms and can be built up from standard components to have one, two or three spindles, that illustrated having the maximum. There is an infinitely-variable feed and a quick motion, the former being operated mechanically and the latter electrically. Normally, the quick motion operates at 3 metres per minute but machines can be supplied with motions operating at 4·5 metres per minute. The motor for the quick motion is provided with an armature brake and it is possible to use the quick motion in conjunction with the ordinary feed.

TOOL POST WITH INTERCHANGEABLE HOLDERS.

A multiple tool post for use on centre lathes and certain types of capstan lathe that enables a number of alternative tools to be interchanged in an exceptionally short time was being shown by F. Burnerd and Company, Limited, Kidbrooke Park-road, London, S.E.3. This unit, which is illustrated in Fig. 123, on Plate XLI, consists of a flat plate of Meehanite secured to the top slide of the lathe which has integral with it a central spindle. As will be seen from the illustration, the flat plate has two raised V portions at the front and to each side of the spindle. At the back there are tapered spigots also located one at each side of the spindle, and the tool holder is located in either the left-hand or right-hand side according to requirements, a V-groove at the front of the holder engaging with the raised V on the plate and a tapered hole at the back of the tool holder registering with the corresponding spigot. This combination of raised V and tapered spigot gives exceptionally accurate location. The tool holders are held firmly by a quick-acting clamp which swivels about the central spigot, a "slave" or dummy holder being inserted on that side of the tool post not occupied by the tool. A boring bar also is available for use with the tool post and, as will be seen from the illustration, this incorporates two holders; these are located one at each side of the central spigot when the tool is in use, and there is no need, therefore, for a dummy holder to be inserted.

(To be continued.)

LABOUR NOTES.

"MODEST, indeed" was the description given by Mr. J. B. Figgins, the general secretary of the National Union of Railwaymen, to the claim for a 10 per cent. all-round increase in railway wages, which he introduced before the Railway Staff National Tribunal on Monday. He informed the Tribunal that the claim could be regarded as a joint application by his union, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association. In addition to the all-round increase, the unions asked that payment for Saturday-afternoon work should be made at the rate applicable to the work performed, plus an addition equal to half the ordinary basic wage rate. The unions based their demands on the increases which had taken place in the cost of living since an advance of 8 per cent. in railway wages was conceded in September, 1951. The new demands were originally presented to the Railway Executive on May 23 and were rejected completely shortly afterwards. Some 450,000 railway employees would benefit from the increases.

Mr. Figgins referred to the undoubted hardship and injustice which were being experienced by members of his union as a result of the continual rises in the cost of living. According to the interim index of retail prices, living costs had risen from a level of 125 at the date of the union's previous application, to one of 135 in May, 1952, when the new demands were presented. It had to be noted, also, he informed the Tribunal, that the cost of living in May this year had risen by 35 points since June, 1947, whereas railwaymen's wages had risen by only 16·1 per cent. during the same period. The shortage of men in the operating grades, with all the disabilities which that entailed, was likely to continue indefinitely unless something was done quickly to raise railwaymen's rates of pay up to a level comparable with those obtaining in other industries where similar degrees of skill and responsibility were required.

As to the opinion frequently expressed that wage increases could only be considered justified in cases where there was an increase in productivity, Mr. Figgins suggested that, on that ground alone, the unions' demands were more than justified. The railway service were now handling more traffic than ever before and, in spite of handicaps, were handling it more efficiently. Mr. J. G. Baty, general secretary of the Associated Society of Locomotive Engineers and Firemen, stated that the wage-increase claim amounted to about 16*s*. a week and was based on rises in the cost-of-living index figure. It was wholly reasonable.

Describing the claims as unjustified, Mr. W. P. Allen, the labour relations member of the Railway Executive, informed the Tribunal on Tuesday that the Executive were, on this occasion, quite unable to make any offer to dispose of the claim. That was the first time in over 30 years that two major applications had been submitted within a period of nine months. It was also the third major application respecting wages and salaries which had been received on behalf of those sections of the railway staff within less than two years. The concessions which had been made since the formation of the Executive in January, 1948, had resulted in an addition of 40,200,000*l*. a year to their bill for wages and salaries. The cost of the demands then before the Tribunal, and applied only to those sections of the staff represented by the three unions concerned, would be about 22,500,000*l*. a year. If applied to all railway employees, the increases would result in an addition of 27,500,000*l*. to the annual labour costs. No major industry could face heavy increases in wages and salaries in rapid succession and still remain solvent. After further speeches on behalf of the three unions on Wednesday, the inquiry ended. The Tribunal's decision will be made known later.

Male clerks and persons employed in the higher clerical, administrative and commercial grades of the electricity-supply industry were granted increases in their salaries, varying from 10*l*. to 20*l*. a year, by an award of the Industrial Court, announced on Monday. The new scale of pay for boys and men in the general clerical grade will commence at 160*l*. and rise to 450*l*. per annum, against a previous salary range of from 150*l*. to 430*l*. per annum. Girls and women clerks will receive proportionate increases. The salaries of the higher clerical, administrative and commercial staffs, including women, have been advanced by 20*l*. and, in future, will range from 380*l*. to 1,090*l*. a year. In all, some 41,000 employees will benefit from the increases, which will be ante-dated to August 1. The claims originally submitted by the trade unions concerned were for an increase of at least 10 per cent.

Shipbuilding wages were discussed at a joint meeting between representatives of the Shipbuilding Employers' Federation and officials of the Confederation of Shipbuilding and Engineering Unions, which took place at the offices of the Ministry of Labour and National Service in London on Tuesday. The employers' representatives undertook to consult the central board of the Federation on the question of whether discussions could be opened afresh on the possibility of a wage increase for the industry. The board was due to meet yesterday. On Wednesday, a similar joint meeting took place at the Ministry's offices between officials of the Confederation and representatives of the Engineering and Allied Employers' National Federation. This was a continuation of last week's meeting, which was adjourned to enable the employers' delegates to consult the Federation's management board. They reported that authority would be sought to open fresh wage negotiations and the unions agreed to postpone indefinitely the restrictions on overtime and piecework, which were due to begin on October 20.

Coach-building employees at the Willesden works of Messrs. Park Royal Vehicles, Limited, returned to work on Tuesday after a strike lasting 14 weeks. At a mass meeting of the men concerned, on Monday, the decision to resume work was carried with only five dissentients, mainly, perhaps, owing to the apparent failure of the men's committee to spread the dispute to other factories in the group controlled by Associated Commercial Vehicles, Limited, to which Messrs. Park Royal belong. In all, some 1,100 men were involved in the stoppage, which commenced when 78 employees were suspended temporarily, owing to shortages of material caused by a previous strike of 22 operatives engaged on piecework. These men had had a difference with the management over rates of pay.

Improvements in the national man-power situation in Great Britain are recorded in statistics issued by the Ministry of Labour and National Service on Tuesday. The number of employees on short time in manufacturing establishments declined by no fewer than 122,000 during the three months ended August 30 last; a total of 304,000 on May 31 being reduced to one of 182,000 at the end of August. On the other hand, a total of 1,129,000 persons were working overtime in August, about the same number as in May. Further, persons registered as unemployed on September 15 numbered 389,600, compared with 403,600 on August 11, a decrease of 14,000 in five weeks. In the textile industry, the number of persons registered with the Ministry as out of work declined by 16,000 during the same period.

The number of persons in civil employment, which includes industry, commerce and services of all kinds, increased by 66,000 during the month of August, to an end-of-month total of 22,195,000. During the same period, employment rose by 14,000 in the basic industries, which include all mining, quarrying, fishing, agriculture, transport, communications, gas, electricity and water undertakings and services. This was mainly due to a seasonal rise in agricultural employment, but there was also an increase of 1,100 in the number of wage earners on colliery staffs. The mid-September unemployment total of 389,600, of whom 63,100 persons were only temporarily disengaged, represented about 1·9 per cent. of the country's working population.

SERVO MECHANISMS IN AIRCRAFT.*

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

The design of automatic pilots has been one of my main pre-occupations since the year 1925, but I do not think this is my sole reason for regarding the control of the aeroplane itself as the main application of the art of servo mechanisms in aircraft. It may, however, be accepted as justification for my not attempting to exhaust the field of other applications in this paper.

Although servo mechanisms have been used for a considerable time in the form of marine steering engines and, even earlier in the governor of Watt's steam engine—analysed mathematically by Clerk Maxwell in 1868—the name servo mechanism, according to the *Shorter Oxford Dictionary*, dates from 1889. This dictionary defines the term as "An auxiliary motor, e.g., one used for directing the rudders of a Whitehead torpedo, or the reversing gear of a large marine engine." However, it is only in the last two decades that the potentialities of the art have begun to be recognised. This revolution of thought is based primarily on the thermionic valve, but it did not occur until the need for improving weapons, to meet the ever increasing speed of modern war, forced designers to recognise that the thermionic valve could be used for controlling small electric motors as well as for amplifying signals in the communications industry.

As a result of this revolution of thought, the servo mechanism has passed from the field of sporadic mechanical invention to a part of the science of communications engineering. This change has speeded up the revolution by making available, in the field of servo mechanisms, the well developed theory of circuit design already produced by the earlier application of the thermionic valve in the communications field. Each branch of engineering develops its own language and habits of thought. It is therefore not surprising that the marriage of the two arts has led to a babel of confusion in the terminology. This is exemplified by the statement of I. A. Getting, of the Massachusetts Institute of Technology: "It is nearly as hard for practitioners in the servo art to agree on the definition of a servo as it is for a group of theologians to agree on sin." Various attempts are being made to define rigidly the terms required in the field of servo mechanisms but, since the art is advancing so rapidly, it is questionable whether this can be done at the present time without prejudicing progress. Any rigid definition of the term "servo mechanism" is in danger of excluding a potentially useful class and thus discouraging development of that class.

I think it can be agreed that a servo mechanism is a slave mechanism; that is, a mechanism doing some work in accordance with instructions received from a higher authority. Now the information incorporated in these instructions may include or not include the action of the slave. Thus we are presented with two broad classes which have been called closed-sequence and open-sequence systems. The present tendency is to restrict the term servo mechanism to the first of these classes in which the instructions are based upon a comparison between the desired and the actual performance—this difference being the error of the system. Although in a great many cases the derivation of this error is essential for the accuracy required, there are, in my opinion, strong grounds for preferring the open-sequence system in certain circumstances and it would be a supreme mistake to allow such systems to be declassed so that designers were discouraged from using them.

The same classification of control systems applies in the organisational affairs of man and in the control systems of the individual living organism. Thus a commander of an army could not function if every action throughout his command had to be continuously observed by him and his orders had to be conditioned by the actions of each individual soldier. Such an organisation would break down for two obvious reasons—intolerable information traffic congestion at G.H.Q. and intolerable delay in dealing with local situations. To meet these difficulties, we have had to introduce the principle which I think is aptly designated by the word devolution. We shall see that this principle of devolution is incorporated inevitably in most control systems except the very simplest and that it involves open-sequence control.

The present literature of servo systems is based mainly on simple systems and in my opinion tends to deny the open-sequence system its proper recognition. When it is admitted at all, it is generally in the form of some exceptional dodge to deal with exceptional circumstances instead of a sound general principle which should be employed in well understood circumstances. As an example of such dodges, I would mention a device often referred to as disturbance compensation. When an oven temperature is controlled by a simple closed-sequence system, there will be a rapid drop in temperature every time the oven door is opened. The classic treatment for reducing all deviations, whatever the cause, is to increase the stiffness of the control. In the technical language of the art we try to increase the loop gain, by which is meant the degree of variation of the supply of heat for a specified observed error in the temperature. But the classical treatment also tells us that we cannot go too far in this direction without running into instability; we reach a condition when the temperature instead of resting at the desired value oscillates about this value and, if the system is linear, these oscillations will continuously increase in amplitude. All practical systems are, of course, non-linear and, in fact, the oscillations cannot increase beyond the stage when the controller is employing the whole available range of control; in technical language the system is saturated. To minimise the drop in temperature when the oven door is opened, we can arrange to turn on extra heaters whenever the door is open. This is the device known as disturbance compensation. It will be recognised as a particular application of devolution or open-sequence control.

A more quantitative application of the principle of devolution, also in the field of thermostatic controls, is sometimes used in the control of the internal temperature of a building. Sudden changes in the outside air temperature will cause shock disturbances in the controlled internal temperature because of the delay before the magnitude of the disturbance is adequately sensed by the internal error detector. Again there is a limit to the extent to which this disturbance can be controlled by increasing the loop gain without introducing instability. But if a signal is passed to the controller from a thermometer exposed to the outside air, the necessary correction can be fed forward before any error in the internal temperature occurs. Here we have an example of the need for devolution to avoid the delay involved in the closed-sequence system. This example explains why the device of devolution in a control system is sometimes referred to as "feed forward" in contradistinction to the "feed back" characteristic of the closed-sequence system.

Human muscular control supplies a more striking example of the principle of devolution. All voluntary actions are directed by the higher brain centre with which consciousness is associated. But all communications through this centre are subject to a delay varying according to the complexity of the situation in which a judgment is exercised, but of the order of a quarter of a second in the simplest situations. This sets an upper limit to the frequency of disturbance which can be controlled by a communication system involving feed back. This can be demonstrated by requiring a subject to move a pointer so as to keep it aligned with a second pointer moved in a random fashion by extraneous means. The random movements can be represented as a composite pattern of a number of different frequencies. If none of these frequencies is higher than about a quarter cycle per second, accurate performance is comparatively easy, but when higher frequencies than one cycle per second are involved in the pattern the task becomes impossible. The dividing line is somewhere about half a cycle per second and varies a little according to the reaction time of the subject and such factors as fatigue. It is thus clear that, without involving some other principle, it would be impossible to account for the speed of touch typing or playing a piano. The principle involved is devolution to the lower nerve centres operating on local feed back through proprioceptors or kinæsthetic sense organs. A little reflection will show that almost every human muscular action—walking, talking, writing, playing games—is controlled on this devolution principle and that we should be very slow, awkward and stupid without it. Some animals appear to be born with their proprioceptor control systems highly developed, but in man they are developed slowly by training and the accumulation of callisthenic memory.

We can now examine how these principles of classical closed sequence and devolution or open-sequence control may be applied to a specific mechanical problem—the stabilisation of a platform in a moving vehicle. To maintain a platform locating a bombsight, a camera, or a radar scanning system, in a constant plane it is necessary to stabilise it about two independent axes by a gimbal system similar to the mounting of the ships' candle. To avoid unnecessary complexity in the presentation of the principles involved, I shall discuss the question on the assumption that the vehicle moves only about one axis.

In Fig. 1, page 482, is shown a conventional closed-sequence arrangement. The platform is pivoted about an axis parallel to that about which the vehicle moves and is located by a motor. A free gyroscope is carried on the platform and is coupled to an error detector which generates an error signal representative of the displacement of the platform relative to the gyroscope. This error signal is passed to an amplifier the output of which controls the motor. Thus, the motor is continuously driven to reduce any error detected. If we assume for the moment that the direction of the gyroscope axis remains constant, the platform is stabilised. Since the system is entirely error operated, errors are unavoidable.

Fig. 2 represents a crude open-sequence system for achieving broadly the same purpose. Though the application of the principle of devolution to this problem does not necessarily involve the substitution of a different type of gyroscope for sensing the disturbance, I have shown a form of gyroscope which measures the angular rate of disturbance of the vehicle. The signal from this rate gyroscope, after amplification, controls the speed of the motor which again locates the platform relative to the vehicle. For correct functioning, it is necessary to ensure a one-to-one relationship between the angular velocity measured by the gyroscope and the resulting angular velocity imparted to the platform.

The limitations of open-sequence operation are readily apparent from a consideration of the scheme of Fig. 2. Thus, if the platform is initially disorientated there is nothing, so far, in the system to restore the alignment. Moreover, extraneous disturbances, other than the angular movement of the vehicle, such as a load applied to the platform or a variation in the power supply, will modify the performance in such a way as to introduce disorientation. The advantages of the open-sequence operation are that errors are not required to initiate action and that much faster action can be achieved since the stability problem of the closed sequence, or closed loop as it is often called, is not involved. I shall have more to say later about closed-loop stability.

Fig. 3 shows a development of the open-sequence system on the lines of human muscular control. To ensure better correlation between the angular rate measured by the gyroscope and the angular rate imparted by the motor, a "kinæsthetic organ" in the form of a motor speed detector has been added. This device provides a signal proportional to the speed of the motor which is used to back-off the gyro rate signal. It should be noted that accurate setting of the amount of this local feed-back signal is necessary to ensure the required one-to-one relationship. This is analogous to the need for training in the acquisition of human skill. As a further refinement, the equivalent of the supervision of the human eye has been added in the form of a pendulum "monitor" carried on the platform. Any "steady state" misalignment of the platform is thus detected and a relatively weak

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

SERVO MECHANISMS IN AIRCRAFT.

Fig. 1. CLOSED-SEQUENCE SYSTEM, SINGLE AXIS.

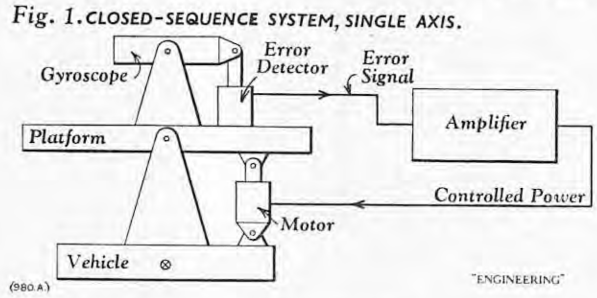


Fig. 2. OPEN-SEQUENCE SYSTEM, SINGLE AXIS.

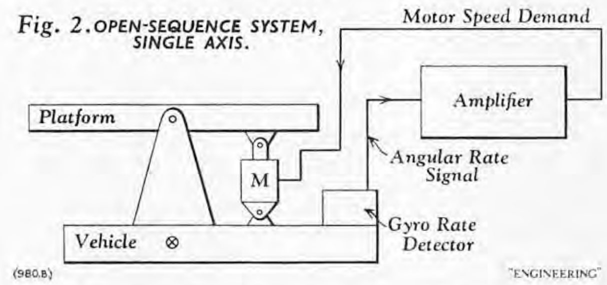


Fig. 3. MONITORED OPEN-SEQUENCE SYSTEM WITH LOCAL CLOSED LOOP.

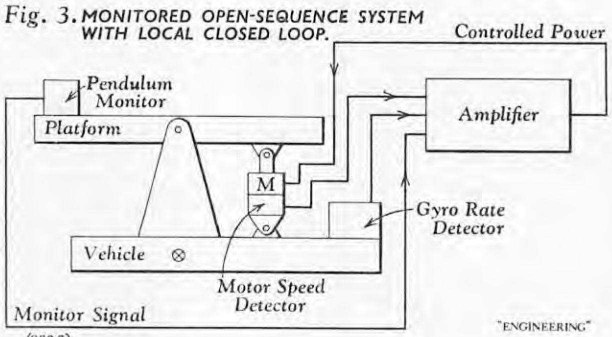


Fig. 5(a). ALTERNATIVE SCHEMATICS OF SYSTEM SHOWN IN FIG. 1.

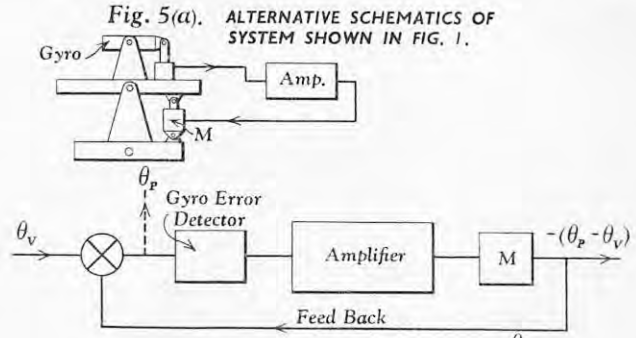


Fig. 5(b).

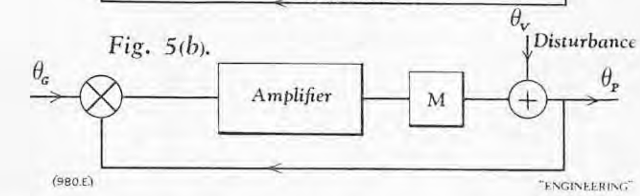
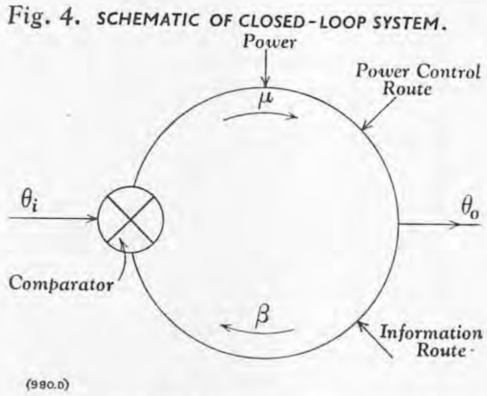


Fig. 4. SCHEMATIC OF CLOSED-LOOP SYSTEM.



signal, backed off by the resulting signal from the motor speed detector, keeps the platform moving slowly until the pendulum signal subsides to zero.

It will be observed that the short-term or dynamic control is still open sequence, as in Fig. 2, but that the long-term performance is now closed sequence through the pendulum monitor. Since a pendulum is disturbed by every acceleration of the vehicle, it is quite useless for providing short-term stabilisation. On the other hand, the gyroscope—either the displacement type of Fig. 1, or the rate type of Figs. 2 and 3—is useless for long-term stabilisation due to its inevitable slow wander and due to the rotation of the earth and the changing direction of the vertical as the vehicle moves over the surface of the earth. This last proviso may sound a little academic until one realises that the modern jet aeroplane could very nearly put a girdle round the earth in 24 hours.

The arrangement of Fig. 3 is thus a compromise between open- and closed-sequence control in which both the gyroscope and the pendulum are used within the limits of their capabilities and in which the dynamic performance is not dependent on platform error as in the closed-sequence arrangement of Fig. 1. It will now be appreciated that the closed-sequence system of Fig. 1 is an over simplification, in that it assumes a constant direction for the gyroscope rotor axis. In fact a gravity monitor is also required in this case to take care of the long-term performance. The gyroscope has to be provided with an auxiliary closed-loop system to cause it to precess in response to any error detected between its datum and that of a pendulum. Thus, the apparent simplicity of Fig. 1 is illusory and the compound system of Fig. 3, involving the principle of devolution, appears as a better system.

Closed-Loop System.—Because closed-sequence operation is generally required, at any rate for the long-term performance of a control system, the theory of the closed loop has been thoroughly developed and many authorities restrict the name servo mechanisms to systems operating on this principle. The uses to which closed-loop servo mechanisms are put are extremely various and include: (1) automatic regulation; (2) power amplification; (3) remote control; (4) stabilisation; (5) computing; (6) transducers in which a mechanical representation of a non-mechanical quantity is required; and (7) indicating instruments. The motor employed may be electric or fluid-operated. The modulation means may be electric, fluid, or mechanical, and, in the latter case, they may be employed in the output train of the motor as in the case of the infinitely-variable and reversible gear. Whatever variants are used, the closed-sequence system may be represented by the apparently simple schematic of Fig. 4.

In Fig. 4, a mechanical output quantity θ_o, position, speed or force, is controlled in conformity with an input quantity θ_i, by continuous derivation of an error signal in a comparator to which the output quantity is led by a route labelled "information route," the error signal being led by an independent active route, labelled "power control route," back to the output. It should be observed that the same system may be represented in more than one way by the same schematic, according to which quantities are regarded as the input and controlled quantities. Thus, in the system of Fig. 1, the angle of the vehicle θ_v may be regarded as input, the difference between the platform and the vehicle ($\theta_p - \theta_v$) being the output which is required to be equal and of opposite sign to the input in order to ensure that the platform angle θ_p shall be maintained at zero. In this case, the comparator is comprised by the structure, since the displacement of the platform—the error—is the difference between the movement of the vehicle and the counter movement provided by the motor. The sequence schematic then takes the form of Fig. 5 (*a*). It should be noted that, in this conception, although the loop output is the relative angle of the platform, the objective of the system is the suppression of the platform angle θ_p. Moreover, the information route, or feed back, is in this case utilised also for the transmission of mechanical power to the platform. It is perhaps more logical to regard the gyro datum angle θ_g as the input and the platform angle θ_p as the output, in which case, the same system is represented by the schematic of Fig. 5 (*b*). In this case, the movement of the vehicle must be regarded as an extraneous disturbance introduced into the loop. The comparator in this case is the signal pick-off of the gyro.

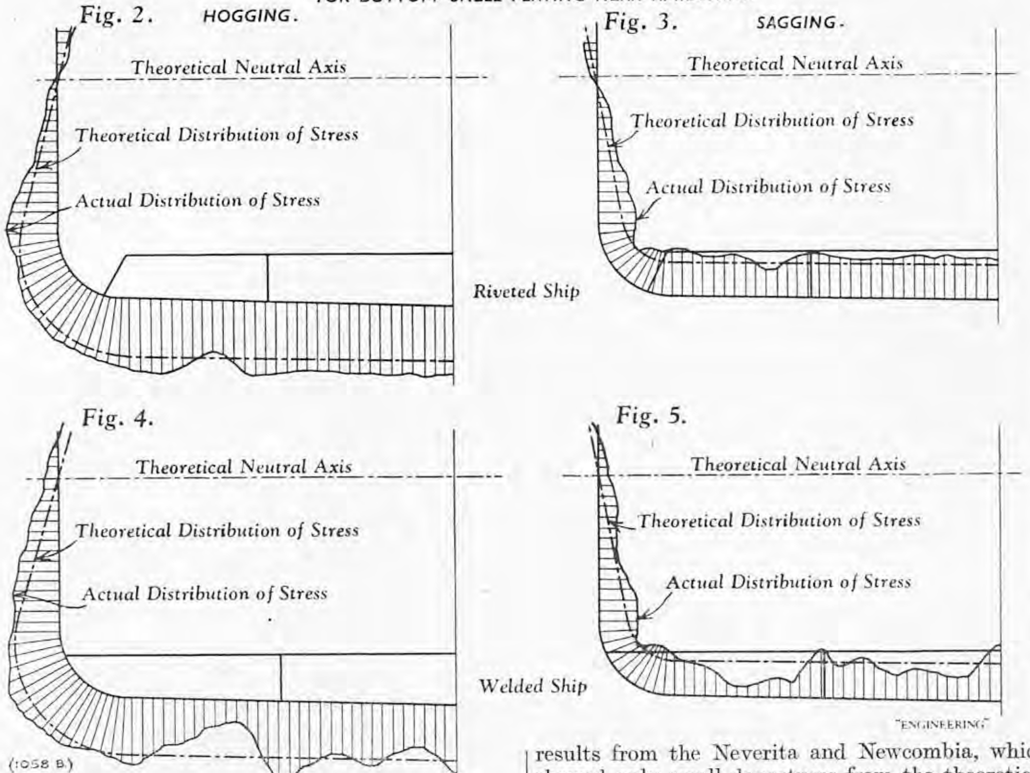
Reverting to the generalised schematic of Fig. 4, it will be observed that by routing the power and the information independently, each circuit can be designed to meet its specific requirements without being burdened with the responsibility of the double purpose requirement of the open-sequence system. Thus the requirement of fidelity is confined to the information route which need have no power loading. The power route must release the required power with sufficient sensitivity, but fidelity in regard to linearity and immunity from disturbance of output by ambient conditions or variations of supply or loading is not a requirement. The power control route, however, is required to possess datum stability (using the word stability in its non-technical sense), as regards its input. Thus any variation in its input required for zero output must be referred to the input comparator and thus included in the information route.

Certain broad principles can be established from a purely static consideration of the loop. Thus, if we designate the transfer ratio of the power route by μ and that of the information route by β, as indicated in Fig. 4, the output quantity is referred back to the input in the proportions β and $\frac{1}{\mu}$ by the two routes. Thus the ratio of falsely routed intelligence to correctly routed is $\frac{1}{\mu}$ to β, or 1 to $\mu\ \beta$. The error thus approaches zero as $\mu\ \beta$ approaches infinity. Now the quantity $\mu\ \beta$ represents the gain round the complete loop and is thus known as the "loop gain." Clearly we should use the highest practicable loop gain. Extremely high fidelity can be obtained by the use of a high loop gain provided the information route is itself of high fidelity. Often, however, it is necessary to change the form of the output quantity; for example, to change from position or speed to an electrical representation and this requires the interposition of some form of instrument the accuracy of which circumscribes the accuracy of the system. Such instruments are sometimes referred to generically as transducers. For the highest fidelity it is desirable to restrict such transducers to the power route, in which case the input and output quantities are of the same form, e.g., mechanical displacements. This principle of stricting all transducers to the power route is the basis of all null-reading measuring systems.

(*To be continued.*)

THE LONGITUDINAL STRENGTH OF SHIPS.

DISTRIBUTION OF LONGITUDINAL STRESSES FOR BOTTOM SHELL PLATING NEAR AMIDSHIPS.



THE LONGITUDINAL STRENGTH OF SHIPS.*

By James Turnbull, O.B.E.

(Concluded from page 450.)

Behaviour of Hull Structures Under Longitudinal Bending.

Many ships have been subjected to longitudinal bending tests in still water, and it has been found that, in general, the resulting stresses agreed with those arrived at by the classical beam theory. In the Admiralty Ship Welding Committee's investigations, a further step was taken in comparing the behaviour of certain welded ships with the behaviour of sister ships of riveted construction. Figs. 2 and 4 show the distribution of stress across the bottom near amidships for a ship such as the riveted Clan Alpine in the hogging condition, compared with that for a welded sister ship under the same conditions. Figs. 3 and 5 show the comparison for the sagging condition.

It will be seen that these stresses, which are "heart-of-plate" stresses, have a distribution that follows the general trend of the distributions given by the simple beam theory, but that there are several notable departures. The most outstanding occurs near longitudinal stiffening members, where the observed stresses are higher than the theoretical values, while clear of such stiffening the observed values are smaller than the theoretical values. These departures are much more prominent in the welded than in the riveted ship.

The unfairness of the bottom plating between frames clear of longitudinal stiffening in the welded Ocean Vulcan was about double that of the riveted sister ship. This unfairness is the main explanation for the greatly reduced heart-of-plate stress in the bottom plating away from the longitudinal stiffening members. The corrugations of the bottom plating of the Ocean Vulcan were kept under observation at each dry docking following the bending tests. They were found to have increased on each occasion, and ultimately fairing and the fitting of additional longitudinal stiffening became necessary, to prevent a recurrence. In thin and abnormally unfair plating in a transversely framed welded ship, the surface stress may reach three times the heart-of-plate stress. These observations, combined with the results from the Neverita and Newcombia, which showed only small departures from the theoretical stress distribution, show conclusively that welded ships of appreciable size should preferably be stiffened longitudinally on the bottom and the strength deck over the midship portion at least.

Stress Concentration Factors and Stress Ranges.

As several war-time welded ships sustained fractures at hatchway corners, a special study was made by the Admiralty Ship Welding Committee of the stress at such discontinuities. Concentrations of stress of the order of two and a half times the nominal stress were found at certain discontinuities near amidships, and there was a tendency for the concentrations to be greater in the welded than in the riveted ships. These concentration factors must be regarded as being approximate. They indicate clearly, however, that a high intensity of stress may occur at hatchway corners and other discontinuities in the structure.

The subject of fatigue in ships' structures has not received much attention by naval architects, due, no doubt, to the absence of reliable information regarding the actual stresses and the number of times the various stress ranges are experienced in service. A statistical strain gauge was fitted to the Ocean Vulcan and it has been in satisfactory operation for over a year. Some interesting data have now been collated. Typical results taken over a period of one year are as follows:—

Range of Stress.	Number of Times Experienced.
1 ton per sq. in. (158 kg per sq. cm.)	266,884
2 tons per sq. in. (315 kg per sq. cm.)	7,105
3 tons per sq. in. (473 kg per sq. cm.)	1,329
4 tons per sq. in. (630 kg per sq. cm.)	102
5 tons per sq. in. (788 kg per sq. cm.)	5
6 tons per sq. in. (945 kg per sq. cm.)	2

It will be noted that the maximum range was only 6 tons per square inch (945 kg per square centimetre), and on only two occasions during one year of service. It is obvious that much more severe conditions could be experienced, and these may be recorded during this investigation, which is being continued. Although ships are subject to fatigue loading, it is by no means clear that fatigue is an important factor in the longitudinal strength of ships. It may, however, be important in regard to regions of stress concentrations when a ship has been consistently subjected to an injudicious longitudinal distribution of cargo.

Distribution of Cargo.

Unlike the conditions which ships meet at sea, the distribution of cargo can be controlled. It is perhaps true that many structural fractures experienced at sea are due mainly to injudicious loading. In tankers, unless loading distribution is properly controlled, there is a danger of excessive sagging stresses. Even when the cargo tanks are well spread out over the length of the ship, if the end tanks are left empty when high-density cargo is being carried, high sagging stresses may result. In these circumstances, it is advisable to reduce the cargo loads in the midship half length. Fore and aft distribution of ballast must also be carefully arranged if dangerously high stresses are to be avoided.

Twenty years ago, when large deep tanks were incorporated amidships in most dry-cargo ships, the ballast sagging condition was generally more severe than the loaded hogging condition. While the modern cargo ship has a better distribution of of ballast, she has finer lines, with large flare at the ends and cruiser stern, often with a forecastle and poop for cargo, with the result that the loaded hogging condition is now generally the more severe. This condition is worsened when, as sometimes happens, No. 3 hold is the only hold left empty.

Residual stresses, if they do in fact exist in an appreciable magnitude, need not concern the designer of hull structures provided good notch-tough steel is used in the construction.

There is no doubt that the research on ship's structures carried out under the direction of the Admiralty Ship Welding Committee constitutes one of the most important contributions to our knowledge of the strength of ships. While scantlings will continue to be based mainly on the service behaviour of earlier similar ships, it should now be possible to make a closer estimate of the actual stresses imposed by the forces of the sea. It is likely that the standard longitudinal bending-moment calculation will be superseded by a simplified still-water bending-moment calculation, to which will be added an estimate of the effects due to dynamic action.

Most research on actual ships' structures has been carried out on ships between 400 ft. (120 m.) and 500 ft. (150 m.) in length. It would add much to our knowledge and assist in arriving at reliable values for the dynamic factor if an investigation of the behaviour at sea of ships of other lengths, depths, forms, speed and draught-length ratios could be carried out. It is conceivable that such additional information may be obtainable without great expense in the near future. An example of this type of equipment is the statistical strain gauge fitted to the Ocean Vulcan. The chief officer takes the records, and the gauge, which does not interfere with the operating of the ship, is serviced only when the ship visits the United Kingdom.

Although knowledge of all the factors affecting the longitudinal strength of ships is still incomplete, the items requiring special attention are clearly shown by a study of structural failures and of the results of research. Perhaps the most outstanding deduction is the superiority in welded construction of longitudinal framing over transverse framing for the bottom and strength deck amidships. The high concentration factors show how important it is for the design of welded structural details at discontinuities to receive most careful consideration. These high factors and the probable existence of residual stresses show the desirability of using, in welded construction, good ductile notch-tough steel, especially for thick plating.

It is obvious that the danger of excessively high stresses being experienced at sea can be greatly reduced by arranging the fore and aft distribution of the cargo loading in such a way that the bending moment in still water is as near as practicable to the neutral condition; and, to minimise the effects of slamming, the draught forward in the ballast condition should be kept as great as possible consistent with other features, such as immersion of the propeller.

* Paper presented, in Genoa, at the Autumn Meeting of the Institution of Naval Architects, on September 26, 1952. Abridged.

Brush Research Scholarship, 1952.—The Brush annual research scholarship has been awarded this year to Mr. A. R. Wade to enable him to carry on an approved programme of research at a British university for a period of two years.

THE ADVANCING FRONT OF CHEMISTRY*.

By Professor W. Wardlaw, C.B.E.

In his *British History of the Nineteenth Century*, G. M. Trevelyan has stated that: "During the last 150 years the rate of progress in man's command over nature has been ten times as fast as in the period between Cæsar and Napoleon and one hundred times as fast as in the slow prehistoric ages. Tens of thousands of years divide man's first use of fire from his first application of it to iron . . . the art of writing preceded the printing press by tens of centuries. In those days each great invention was granted a lease of many ages in which to foster its own characteristic civilisation before it was submerged by the next. But in our day, inventions, each implying a revolution in the habits of man, follow each other as thick as the falling leaves."

The pace of scientific, social and economic changes in modern times is unprecedently rapid. It is easy to understand why the pace of our science of chemistry is growing ever faster and faster. In the last quarter of a century, the number of investigators in both pure and applied chemistry has enormously increased, while research itself is more adequately financed, and, to some extent, better organised, than ever before. It is tempting to try to imagine what will have been accomplished, say 50 years hence, if this acceleration continues. Many have indulged in speculations on the intellectual reactions which the great pace of the advancing front of science may involve. It has been suggested that life may not be long enough for the would-be investigator so to store his mind as to reach the growing frontier where his work should begin. Chemists may well consider that the pace of advance may be such that no human mind will be able to correlate into any significant whole the enormous accumulation of chemical facts. Yet I believe that man's curiosity about the universe and his own complex self will increase, and that the astonishing growth of our science of chemistry will continue.

Chemistry has been defined as the science of substances—their structure, their properties and the reactions that change them into other substances. For a long time, the story of chemistry was a record of the study of up to 92 chemical elements and their compounds. The 26 letters of the alphabet can be combined into hundreds of thousands of words, each with a different meaning. What, then, are the potentialities before the chemist, with some 92 elements at his command? Nevertheless, prophets have confidently predicted the demise of inorganic chemistry and even of organic chemistry. Chemistry, however, has confounded the prophets by its amazing vitality. The award of the Nobel Prize for chemistry for 1951 to E. M. McMillan and T. Seaborg directed the attention of the whole scientific world to the most spectacular advance made in chemistry for a long time: the extension of the Periodic System from element 92, uranium, to element 98, californium.

Elements heavier than uranium could not be found in Nature and speculations about their possible existence were freely made. In 1934, Enrico Fermi and his collaborators in Rome placed a small piece of radium and beryllium against some oxide of uranium. Some of the neutrons emitted from the radium-beryllium source were lodged in nuclei of uranium atoms and, as the new form of uranium had a β-ray emission, Fermi thought he had produced an element higher up in the Periodic Table. These researches were continued in Paris and Berlin and for several years it was believed that four or five successive transuranium elements could be synthesised by this simple method. In 1938 and 1939, the work of O. Hahn, F. Strassmann and Lise Meitner disclosed that scientists had not been creating new elements after all—instead, they had been splitting urnaium into two parts. The first real transuranium element, number 93, was discovered by E. M. McMillan and P. Abelson early in 1940, and from then on progress was rapid. With the help of powerful cyclotrons and the newly constructed uranium piles, a large team of workers concentrated on the task of producing new elements; Seaborg and his co-workers have identified elements 93, 94, 95, 96, 97 and 98, and much has been learned of the chemistry of these transuranium elements. It is natural to ask, will other transuranium elements be identified and the table extended beyond 98? Dr. Seaborg and Dr. McMillan think so. Further, they feel they can predict the chemical properties of these elements of the future.

Particularly important in this work was the development of ultra-microchemical methods of analysis which enabled the chemistry of the transuranium elements, usually available in millionths of a gramme, to be investigated. The combined discoveries of the physicist McMillan and the chemist Seaborg and their associates have opened whole new fields for the investigator interested in the realm of inorganic chemistry. These results were made possible by a type of research organisation which nowhere has been brought to such perfection as in the big scientific laboratories of the United States. Ample means were placed at the disposal of the investigators in view of the great practical importance of the results to the atomic energy project.

Chemistry already has made an indispensable contribution to atomic energy research and development, and chemists will fill a major rôle in establishing nuclear power as a benefit to humanity. The next phase in the development of atomic power probably depends more on new materials than on any discovery in nuclear physics or improvement in atomic technology. This extension of technological interest in new metals, all over the world, is bound to emphasise the need for broadening our knowledge of both the familiar and unfamiliar elements and compounds. It is surprising how little we know about many of the chemical elements, even the metals. We know still less about certain elements which lie midway between the metals and the non-metals, the so-called metalloids. A host of new researches have been set in motion primarily by the needs of the atomic energy programme. However, the results may well be the starting-points of new developments in every phase of industry.

The contribution of chemistry to the development of atomic energy is not always fully appreciated. Because of the physical principles involved, it is sometimes said that atomic power is principally the concern of physicists. Obviously, anyone concerned with this field of work should be familiar with the basic facts of nuclear physics; however, it may be stated quite fairly that the economic future of atomic energy calls for the close association of scientists and engineers, and that the rôle of the chemist is a vital one. Among the problems which arise in inorganic and physical chemistry are those concerned with the behaviour of solid and liquid inorganic salts and metals at high temperatures. Of primary interest is the solution chemistry of many inorganic ions and complexes, while the effect of radiation on various kinds of liquids, solids and solutions poses problems of great complexity.

Basic studies of corrosion phenomena are of considerable importance, and the search for new materials for constructional purposes is imperative. Most of the elements have been surveyed for their neutron absorption and, as a result, special attention has been focused on the chemistry and metallurgy of beryllium, zirconium and other metals and alloys. It will be apparent that, in pressing ahead for practical results, it has been necessary to forgo much fundamental work. In due course, it will be desirable to fill in the scientific background.

A question of great general interest at the present time is, How far are we entitled to visualise the peaceful development of atomic energy in the Twentieth Century? Professor R. S. Sayers, Professor of Economics in the University of London, expresses the opinion that the possibilities of peaceful exploitation are not fantastically speculative if we confine our view to the next generation or so. For example, if coal prices rise relative to engineering costs, the date at which atomic furnaces are an economical proposition is brought nearer. Secondly, the cost of constructing plant of this new kind is highly relevant. It is apparent that an advantage lies with countries that, from war or post-war experience, have the "know how." This advantage is exceptionally weighty because of the complete novelty of the engineering problems. It is frequently stated that, on account of the difficulty of these problems, costs must be far too great for any commercial development to be envisaged, and reference is made to the astronomical sums spent on atomic-bomb development during the war. This ignores the fact, that, in the haste to get results in time to affect the issue of the last war, every practicable method was explored simultaneously and this raised the cost to a fantastic figure. In normal times, in developing a new idea for peaceful purposes, only the most promising of a variety of possible processes are followed up. Finally, there is the "wear and tear" or depreciation charge and the rate of interest. The depreciation charge will depend on the success with which the constructional problems are solved; particularly, whether the new constructional materials stand up to the radioactive substances involved. The interest charge should be governed by the scarcity of capital in the community. To sum up, Professor Sayers contends that development within the next generation is going to depend on three factors: the success of the search for new materials of construction, the relative price of coal and other fuels, and the rate of interest. In fact, "a capital hungry world will not be able to afford atomic energy. But a world in which thrift abounds and coal miners are rare, will jump at it."

(To be continued.)

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

WATER PIPES FOR AGRICULTURAL USES.

The comparative merits of different types of small-diameter water pipes used in connection with rural water supplies, particularly on farms, are discussed in the *Report of the Working Party on Small Diameter Water Pipes*, which is published by H.M. Stationery Office, Kingsway, London, W.C.2 [price 6*d*.]. The report is restricted to information about the nature, cost and properties of pipes of 2 in. diameter or less, for outdoor use only, in rural areas. No attempt is made in the report to relate the findings to the supply position, but emphasis is laid on the need to select pipes which will resist corrosion caused either by the nature of the soil in which they are laid or by the water which they may carry. Among the conclusions reached on the subject of corrosion, the following points may be noted. For general use, galvanised steel pipes can be used without risk for non-corrosive waters and soils, but they should not be laid where the rapid corrosion of ferrous metals is to be expected; where corrosion is known to be slight and where the pipe trenches are likely to remain reasonably dry, such pipes may be used, although with the risk that some future replacement may be necessary. Steel pipes coated both internally and externally are likely to withstand corrosive conditions satisfactorily provided the coating remains continuous throughout. Copper tubing was found to be satisfactory under all conditions except for carrying very acid waters. Except for highly sulphated grounds, asbestos-cement pipes of more than $1\frac{1}{2}$ in. diameter were found to be suitable, provided the metal joints were adequately protected and the pipes were evenly bedded. Polythene pipes—a B.S. specification is in course of preparation—were proved to be satisfactory for cold water supplies in all soils and for all waters. On the point of cost, there was found to be little to choose between the galvanised-steel and the asbestos-cement pipes, but the plastic pipes and the copper were found to be two times and three times, respectively, more expensive than the galvanised steel. The report also stresses the importance of avoiding wastage of water and of minimising maintenance costs by using sound materials and workmanship.

Lighting Demonstration Room.—The lighting demonstration room of Holophane, Limited, Elverton street, Vincent-square, London, S.W.1, has been re-opened and is available to engineers and architects who wish to demonstrate the basic principles of illumination to their clients.

DEVELOPMENT OF THE FLYING-BOAT AIRLINER.

Fig. 4. AIRCRAFT SIZE FOR VARYING RANGE FOR 12 PER CENT. PAY LOAD.

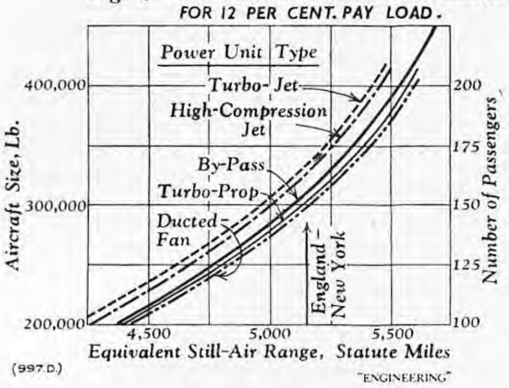
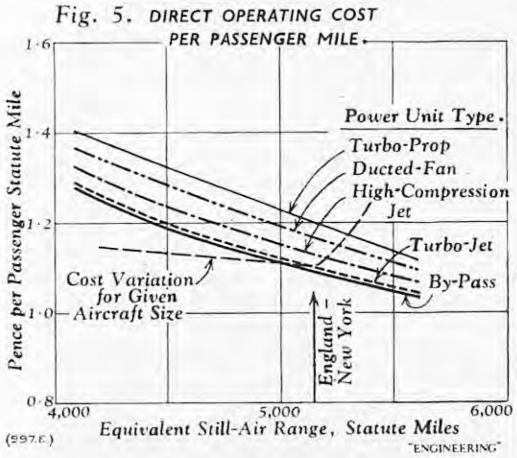


Fig. 5. DIRECT OPERATING COST PER PASSENGER MILE.



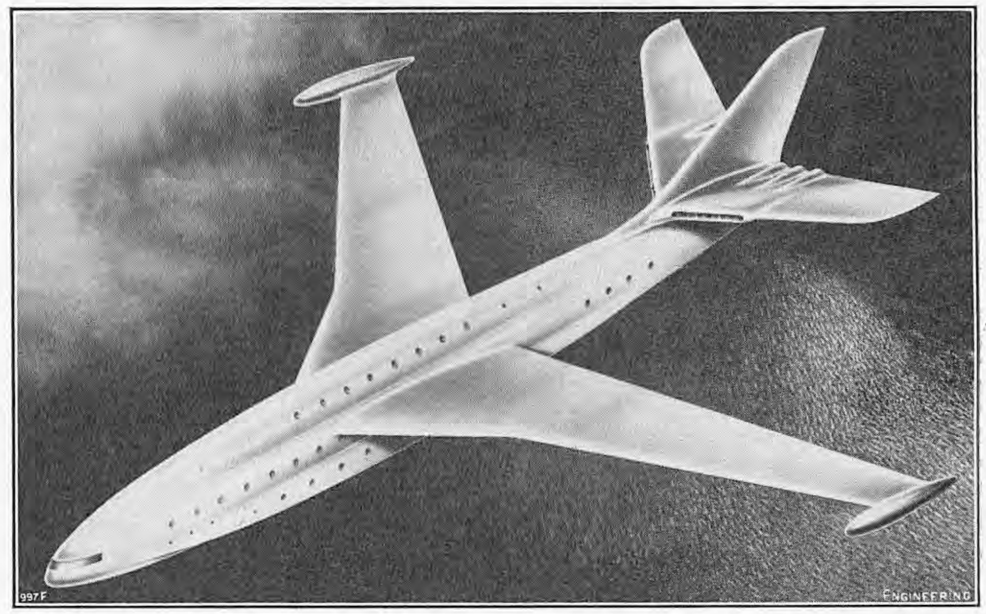


FIG. 6. FUTURE DESIGN OF FLYING-BOAT AIRLINER.

THE FUTURE DEVELOPMENT OF THE FLYING-BOAT AIRLINER.*

By HENRY KNOWLER, A.M.I.C.E., F.R.Ae.S.

(*Concluded from page* 453.)

CONSIDERING now the types of power plant which are available, these are: piston engine, turbo-propeller, ducted fan, and turbo-jet. The speed requirement appears to eliminate the use of piston engines although their fuel economy, when they are in the compounded form, makes their use attractive from other aspects; in particular the high propulsive efficiency which is obtained with large-diameter propellers. The Froude analysis of propulsive systems shows that to improve the efficiency the amount of energy wasted, in the form of kinetic energy of the propeller slipstream, should be reduced while the rate of momentum change through the disc area is maintained. Hence, the mass flow must increase and the slipstream velocity reduce, a condition which is best met by the use of a propeller; it is found with reducing effect in the ducted fan and the by-pass engine.

Though the piston engine is not considered suitable the turbo-propeller can be used in the conditions desired. This engine, in common with the turbo-jet, is capable of high thermal efficiency in the low density conditions at altitude which are favourable to high-speed flight. At the speed of 0·83 Mach-number, the propeller tips will be supersonic and there will be a large loss of efficiency due to this. However, it is possible to design especially for tip speeds in excess of sound and still retain a fairly high efficiency, about 75 per cent. being a reasonable estimate for the conditions envisaged. In spite of this possibility it is impossible to avoid the serious disadvantage of excessive noise, and for this reason the turbo-propeller, in combination with the supersonic propeller, may be quite unsuitable for passenger aircraft. To offset the good propulsive efficiency of the turbo-propeller at the speed considered, are higher installed weight, a greater profile and interference drag, and the additional drag of parts in the slipstream.

This is the day of the turbo-jet, which has everything in its favour aerodynamically, except the high propulsive efficiency which is necessary for long range, having low installed weight and adding little to the aircraft drag. These two attributes make it a serious competitor to the turbo-propeller, even where long range is required. The turbo-jet also gains considerably at high speed due to the augmentation of compression ratio by ram effect.

Although the ducted fan has had, as yet, little development, its high propulsive efficiency at the specified speed makes it attractive, the efficiency falling between that of the straight turbo-jet and the turbo-propeller. Due to direct coupling of the fan to the turbine the weight of gearing is eliminated, but it is necessarily heavier than the turbo-jet due to the complexity of the fan drive. From the aircraft design aspect it introduces installational problems which are difficult to solve. Probably the most effective method is to mount in "pods" and accept the additional drag and weight entailed.

The ducted fan in low ratios of mass flow becomes what is termed a by-pass engine. In this form it has the advantage that, by mixing the jet streams, heat exchange takes place, with some advantage to efficiency. The by-pass engine is little heavier than the turbo-jet and when installed is as clean aerodynamically.

In order that comparisons can be made between various power plant installations, estimates have been made based on the most recent trends in specific weight and overall thermal efficiency for the types of propulsion available. The characteristics used are considered to be representative of the present state of the art, and normal component efficiencies, combustion temperatures and compression ratios have been assumed.

In the estimates of range performance, which are presented in Fig. 4, the thrust to maintain a cruising speed of 550 miles per hour on a family of aircraft of differing weights, has been found and the basic engine power and weight derived. The take-off problem on aircraft with turbo-jet power fixes a minimum limit to the $\frac{T}{W}$ loading compared with that needed for high-speed cruising. Assistance at take-off can be used to lower this limit and a ready means of doing this is the use of water injection into the jet units during the take-off run. An augmentation of thrust of 15 per cent. is a reasonable assumption and this method has been adopted. The five types of engine represented are shown on curves of equivalent still-air range for aircraft of increasing take-off weight. Fig. 4 can be used to predict the size of aircraft necessary for operating various long-stage flights. For instance, the equivalent still-air range required for the England to New York non-stop journey is 5,150 miles, due allowances and reserves of fuel having been made, and including 85 per cent. winter frequency of head-winds. It will be seen that aircraft weights of 335,000 lb. down to 300,000 lb. are necessary for aircraft fitted with engines from turbo-jets to turbo-propellers respectively.

We are now in a better position to judge the suitability of each of these types of power for long-range high-speed operation. It has already been stated that the supersonic propeller may not be found suitable for passenger transport because of excessive noise which is well-nigh impossible to reduce within the limitations of aircraft design. Nevertheless, it will be seen that, provided a propeller efficiency of 75 per cent. can be obtained, the turbo-propeller gives the best overall performance. The ducted fan appears to have much to recommend it but, owing to its high-velocity slipstream, it must be mounted clear of wing and structure and it has a high noise level. The overall efficiency falls close to that of the turbo-propeller. The by-pass engine, it will be remembered, is a ducted fan with a low ratio of mass flow, and it would appear that an engine of this type might be the solution to the present problem. The overall efficiency is little short of that of the two already mentioned. Such an engine can be installed far aft in the aircraft, the jet outflow being beyond the habitable part of the body.

It will be seen, therefore, that if the choice of power is the by-pass engine the aircraft for the direct Atlantic journey is about 310,000 lb. in weight. It will have a landing speed of 130 miles per hour and, in landplane form, the take-off from an aerodrome would require a runway length of about 3,300 yards. A payload of 12 per cent. on this aircraft represents a passenger complement of 150 with provision for luggage, mail and freight. The "block-to-block" time of the west-going journey under average headwind conditions and with reasonable stand-off time allowance will be about eight hours, thus making a daily return trip possible. On a local-time basis the aircraft leaving England, say, at mid-day would, after eight hours' flight, arrive at 3 p.m. in New York. The same aircraft, after three hours' turn-round time, can leave New York at 6 p.m. arriving back in England about 6 a.m. the following morning, the east-going journey having taken one hour less. This leaves six hours in hand for servicing before leaving again at mid-day.

The attractiveness to paying passenger and operator alike of an aircraft such as this needs no further argument. This inquiry has been made with the use of flying boats in view and we see that even larger craft will be possible, especially when new aerodynamic and propulsive improvements become available.

* Paper read before Section G of the British Association at Belfast, on Monday, September 8, 1952.

The subject of aircraft of very large size leads to discussion of runway problems. When London Airport is completed, with duplicate 3,000-yard primary and 2,000-yard secondary runways, taxi-ways and hard standing, an area of concrete paving well over five square miles will have been laid. The maintenance of airports is a heavy charge on the State—e.g., 2,800,000*l*. in 1951 over and above what is recovered from airline operators. Already, there is an outcry against the danger and noise associated with airports adjacent to built-up areas. The requisitioning of vast areas, the loss of valuable agricultural land, and the prohibitive cost of new construction, has resulted in authoritative statements, in which the belief has been expressed that the flying boat is the logical solution to these and a number of other difficulties associated with future long-range passenger transport.

It should be realised that the attainment of high range and aerodynamic efficiency on an aircraft is not the whole story, since the high cost of operation may eliminate its practical application. An approach has, therefore, been made to this problem by the use of the standard method recently drawn up by the Society of British Aircraft Constructors, for the estimation of direct operating costs, which is applicable to all types of aircraft. Operating costs are divided into annual costs, such as obsolescence, insurance, etc.; fixed hourly costs, such as maintenance and overhaul; and hourly running costs, such as fuel, crew, etc. All items of cost, therefore, are related to time. On the other hand, revenue is dependent on payload, distance and rate of delivery —hence, high-speed transport, although involving increased operating cost, may well show a better economy than smaller, slower and apparently cheaper aircraft. It should also be remembered that journeys interrupted by refuelling stops are, in effect, a series of short journeys which include landing fees, ground costs and added flying time to carry out the "let-down to re-climb" routine. It is also clear that the daily return journey made possible by the high-speed airliner makes a high utilisation possible. For instance, the aircraft cited above could well have a utilisation of 4,000 hours although credited with 3,000 hours only in the cost estimates which have been made.

Fig. 5 shows the cost per passenger mile of the family of flying boats designed for varying stage distances, the number of passengers being shown in Fig. 4. As can be anticipated, the cost of carrying passengers on a given size of aircraft rises with the stage distance, but, due to the improvement in tare weight and aerodynamic efficiency with increasing size, the direct operating cost per passenger mile actually reduces as the range for which the aircraft is designed rises, and compares favourably with any existing aircraft. These results will be surprising to many who have previously thought in terms of large machines being economically inefficient. The estimates which have led to these curves show this to be to the contrary, and support the views of those who believe the future of aircraft will lie with the big machine.

First-class traffic is likely to go to the biggest, most comfortable and fastest airliner and, because of this, high load factors are probable. It may not be realised but it is a fact that the load factor—i.e., the percentage of the seats sold—is more important than any other single factor in the operating economy of a commercial aircraft. From Figs. 4 and 5, the size of flying boat and direct operating cost have been found for the North Atlantic direct flight, but there are numbers of other journeys on which intermediate stages can be omitted and advantage taken of swift communication. Among these are: a two-stage route to South Africa, two stages to South America, one to India, and three stages to Australia. For these journeys the longest stage distance is equivalent to about 5,700 miles, and it can be seen from Fig. 4 that this distance is possible with a flying boat of the type discussed, of about 450,000-lb. in size.

Before closing this paper, it is proposed to consider a few of the improvements which can be foreshadowed for the future, improvements which will increase the range of a given size of aircraft or permit a smaller one to attain the same performance. On the question of turbine-engine developments I am indebted to Mr. F. M. Owner for the assistance given by his paper, "The Application of Power to Aircraft,"* where the effect of increased combustion temperature and compression ratio on the specific thrust and fuel consumption of turbine engine is discussed. Under the flight conditions with which we are dealing, the general effect of increasing the combustion temperature is to improve the specific thrust of a turbo-jet, but, quite possibly, to increase the specific consumption, whereas an increase in compression ratio has the effect, within limits, of reducing the specific consumption. However, the gain is not large and may be no more than 10 per cent. for a quite large increase in complication. The effect of changing operating conditions on a turbo-propeller are more beneficial. A rise in combustion temperature has the effect of improving the specific power output without making any difference to the specific fuel consumption, but increase in compression ratio improves the latter while having little effect on the specific power. By-pass engines and ducted fans show improvements due to rise in combustion temperature and compression ratio which lie between the turbo-propeller and the turbo-jet. The by-pass engine could also benefit from a limited increase in mass-flow ratio up to about 1:1. It is probable, therefore, that during the next few years improvements will be made in this type of engine, making it still more suitable for the high-speed flying boat.

Much attention has been directed recently to methods of drag reduction by controlling the boundary-layer behaviour by suction or other means. No attempt is made here, however, to estimate the possibilities in this direction, but clearly big increases in transport economy—possibly 20 to 30 per cent.—can result if an application can be made which is also a sound engineering proposition. Whatever the solution, it is almost certain that it will be applied in conjunction with turbo-jet propulsive systems. The curves in Fig. 4, it will be noticed, have a limiting range, under the conditions assumed, of below 6,000 miles. The improvements in power and drag reduction mentioned will extend this range considerably, but there will still be a limitation unless new power principles come into use. The generation of power from nuclear fission is shortly to have application in both the supply of electrical power and as a motive force for a submarine. It is reported also that studies are now being made in America for an atomic-powered aircraft. There is no clue, so far, as to the method of converting the energy into thrust, but it can be inferred that vapour-driven turbine engines with propellers or ducted fans will form the power units, at least in early installations. The weight of reactor unit, controls and screening will be high; this part of the installation takes the place of the fuel load in conventional aircraft. Therefore, provided the reactor-unit weight is known, an approximate approach to the aircraft weight can be made. In the largest of the family of aircraft discussed the weight of fuel available is about 45 per cent. after allowing for the weight of turbine and propeller. It will be seen, therefore, that if the reactor weighs, say, 100 tons, an aircraft of about 500,000 lb. weight will be necessary.

The range available is, of course, almost unlimited, but 12,000 miles is the maximum necessary to reach the most distant point on the globe. The atomic-powered aircraft will cruise at constant weight and power throughout the flight and it can be assumed that, for economic reasons, the cruising power will approach the maximum of which the plant is capable. As a consequence, for take-off and initial climb, assistance from some other form of energy, such as liquid rockets, will be necessary. In order to reduce power assistance as much as possible, it will be wise to make the take-off from water, where runway length is unrestricted. Since the weight of fuel consumed is insignificant, the design optimum aerodynamic conditions should prevail throughout the flight, and the unusual condition is met in which the take-off and landing weights are the same. The possibility of landing flying boats at their take-off weight has always been recognised as an acceptable manœuvre. The unobstructed approach run, unrestricted landing area, and short run after touch-down reduce the landing hazard, and the shock-absorbing properties of a V-bottom ensure low landing accelerations even at overload weights. It is thought, for an aircraft capable of the maximum stage distances, a mean speed in the subsonic range will permit very swift journeys while avoiding unnecessary expenditure of weight on the power supply.

To conclude this paper, a return is made to the original theme, and by way of summary an artist's impression of the type of flying boat airliner which has been under discussion is shown in Fig. 6. The intention was to predict the design which would attract the traveller by its speed and by what can be called the flying boat's traditional comfort, and still be a commercial proposition. I wish to thank the members of the technical staff of Saunders-Roe for their help in the preparation of this paper, particularly Mr. J. C. Stevenson, Mr. H. Lloyd and Mr. P. Hoskin.

* *Proceedings of the Joint Engineering Conference*, 1951.

COMBINED CONCRETE STREET-LIGHTING COLUMN AND LANTERN.

THE street-lighting column and lantern shown in the accompanying illustration is an answer to a plea, which was made some years ago by the Association of Public Lighting Engineers, that equipment of this kind should form an architectural whole. The combination is intended for side road lighting with either 100- to 200-watt tungsten or 80- to 125-watt mercury lamps, and incorporates a prismatic glass bowl, which is attached to a concrete head that has been developed from a bracket arm of the same material. The only exposed metal work is a narrow ring between the glass and the concrete.

This ring is cast from an aluminium alloy and is highly resistant to corrosion. As it requires no painting, maintenance is only a question of lamp replacement and cleaning the glass bowl. The head is integral with a 15-ft. concrete column.

Another pattern of column and lantern has been designed for main-road lighting with either 85- or 140-watt sodium lamps. In this, light control is effected by Perspex prismatic plates, which are sealed to the inside of a self-cleaning open bowl of the same material. This bowl is also attached to a concrete head, which is developed from the concrete bracket arm. There is, therefore, no exposed metal work within the bowl, except the lamp holder and lamp supports. These supports are also made of corrosion-resistant material. A hinged Perspex dish for attachment to the open bowl can, however, be supplied to protect the lamp completely. Both columns are made by Messrs. Crompton Parkinson, Limited, Aldwych, London, W.C.2.

SOME BRITISH CONTRIBUTIONS TO EXPERIMENTAL PHYSICS*.

By Professor A. M. Tyndall, C.B.E., F.R.S.

In the citation of a recent award of the Nobel prize to an English physicist, these words occur: "His special claim to consideration is, in my view, the fact that he has shown that discoveries of fundamental importance can still be made with the simplest apparatus." The speaker was referring to Professor C. F. Powell and his use of a photographic emulsion to record the tracks of charged particles of high energy. My reason for quoting from the occasion is that, in my view, the words emphasise an approach to the field of experiment which is characteristic of much of the best of British physics and in accordance with the great scientific tradition of the British race.

Examples of simple experiments which have opened up large fields for discovery are common in our literature. Each of us, indeed, might make his own selection. Immediately I think of Rayleigh, in 1890, adding weighed amounts of olive oil to the water in a bath in order to find the least thickness of a surface layer which would impede the movement of camphor under surface tension forces. This simple experiment not only gave an estimate of molecular dimensions, but led the way to the conception of a monomolecular film with all its applications to liquid and solid surface phenomena. Or I recall Vernon Boys revolutionising a corner of instrument design by shooting an arrow across the floor of the laboratory, so that along it trailed a thin fibre drawn from a molten lump of quartz. Or A. P. Chattock, describing at the B.A. meeting of 1898 the first determinations to be made of the mobility of both positive and negative gaseous ions, by measurements of the pressure of the electric wind; devising for it a sensitive pressure gauge which was taken by Stanton to the newly-opened National Physical Laboratory in 1901, and used there in the first accurate and reliable determinations of the pressure of wind on structures, and in all the early pioneering wind-tunnel investigations in aeronautics.

The history of electrical discharge in gases, the subject of one of our discussions, is a long one. Robert Boyle was detecting the chemical action of electrical discharge when he noticed the smell that accompanied the rubbing of amber; but the subject will always be particularly associated with the work of J. J. Thomson, Townsend and Rutherford in Cambridge, over 50 years ago, when, by simple means, they explored the phenomena of gaseous conduction in ionisation chambers. The subsequent ramifications of these experiments have been legion, yet that period has been termed the age of sealing-wax and string; when, with the eyes of the whole scientific world focused on the Cavendish Laboratory, its equipment in apparatus was probably inferior to that of a number of its Continental competitors.

To-day we are still concerned with the phenomena of ionic mobility, recombination and diffusion, then being investigated for the first time. Modern work on the electrical breakdown of gases by disruptive discharge is an outcome of the early experiments by Townsend in which he carried the voltage-current characteristic of an ionisation chamber into the region where ionisation by collision between electrons and molecules sets in. Nuclear physics sees another application of this early work in the proportional counter used, for example, with good effect recently in Glasgow by Curran and his collaborators in the study of soft radiations and slow electrons.

The same period saw the interpretation of ionic diffusion in terms of classical kinetic theory, modified a few years later by Langevin to allow for the effect of the charge on the ion in creating induced electric dipoles on the surrounding molecules, treated as elastic spheres in thermal agitation. Though the limitations of this early treatment are now apparent, there are some collision phenomena for which it still gives a good working model. For instance, we showed at Bristol that ions of the alkali elements move through pure gases at speeds agreeing in the main with this theory. Moreover, when the attractive field is great enough, it binds a cluster of molecules to the ion, despite the shocks of thermal agitation.

Thus a small ion like Li^+ will collect a cluster of highly polarisable atoms of xenon even at room temperature; but, in neon, it is necessary to reduce the thermal velocity by working at 90 deg. K before this effect is observed. In helium the effects are not appreciable until temperatures of the order of 20 deg. K are reached. In the presence of traces of a highly polar impurity such as water vapour, the formation of clustered ions may be followed experimentally at ordinary temperatures. Indeed, without special precautions to avoid the presence of polar molecules, ions in the lower atmosphere normally exist in the clustered state. But this simple classical picture is not adequate when we consider collisions between electrons and molecules, or between charged and uncharged molecules of the same gas. So here we have a link between the classical and the modern picture of events.

The subject of the physics of the high atmosphere affords a striking example of my theme. I have in mind the first experiment of Sir Edward Appleton by which, with Barnett, he directly established the existence of the Kennelly-Heaviside layer of ionised air. Yet it was merely the radio analogue of an experiment familiar to every student of physics, namely, the production of Lloyd's fringes by interference between two trains of light waves from a line source, one of which in transit had suffered reflection at a mirror surface. In the optical experiment, the pattern is observed as a variation in intensity with position. In the radio experiment, it was more convenient to fix the receiver and vary the wave-length of the radiation. The waves were received in Oxford from a transmitter in Bournemouth and recorded on a fairly quick-recording galvanometer.

This simple start by Appleton on the study of the ionosphere had an even greater significance. For one thing, it concentrated attention on echoes and so led to radar and the science of radiometeorology. In turn, that led to the detection of intense radio sources in outer space and so to a new science of radio-astronomy. Radio-astronomy would have afforded me with good examples of pioneering work still in progress in Cambridge by Ryle and others, and at Jodrell Bank, near Manchester, by Lovell and his collaborators, but I will only briefly mention two items. Firstly, another radio analogue, in this case of Michelson's stellar interferometer, has been developed by Ryle to map the areas of far distant radio sources; secondly, the latest news from Manchester is of the proposed start on the erection at Jodrell Bank of a new great radio telescope, which should do for radio-astronomy what the large visual telescopes in the United States have done for classical astronomy.

The next subject to which I wish to refer is the physical properties of materials in the solid state, a subject which is being actively pursued on both sides of the Atlantic at the present time. It was Sorby, in England, who first subjected the surface of a solid opaque material to microscopic examination, but anyone who reads some later papers in 1900, by Ewing and Rosenhain, on the microscopic study of the crystalline structure of metals will realise how much arose from them. Not of least importance among their observations was the discovery of the phenomenon of slip at gliding planes when plasticity starts.

The study of the solid state also owes much to the methods of X-ray analysis. Although the Braggs, father and son, were not the first in the field in the discovery of X-ray diffraction, their measurement of an atomic spacing by X-ray reflection had the kind of simple directness to which I have specially referred. Through it they founded the science of X-ray spectroscopy with its countless applications in both pure and applied science.

As one illustration of the present activity in Britain in the field of the solid state, we may take some recent work on the growth of crystals. For a long time, physicists have been puzzled why crystals grow as fast as they do from supersaturated surroundings. Since its binding energy to a surface will depend upon the number of close neighbours, an atom is less likely to condense upon an ideally flat surface than at other places. Calculations suggest, indeed, that, if growth depended upon this process, it is most improbable that the known rates could be reached.

On the other hand, X-ray diffraction studies have shown that most real crystals are imperfect. One common defect is a lattice misfit known as a dislocation, a conception with which the name of G. I. Taylor is closely associated, and which is now being extensively applied to explain some of the mechanical behaviour of crystalline solids. Now a principal crystal face which contains the end of a screw dislocation will have a step, one end of which terminates at the end of the dislocation. Such a step forms a much more favourable place for the retention of arriving atoms. But in this case it is easy to show that new layers never start, because condensation at the step does not eliminate the step. As the step advances it acquires a spiral form, giving in the case of one dislocation a single layer in the form of a helicoid, instead of a series of parallel layers on top of one another.

When this theory was first put forward by F. C. Frank in 1949 at a conference in Bristol, it received dramatic confirmation by the production from the pocket of a member of the audience (L. J. Griffin) of a micro-photograph of this phenomenon on the surface of natural beryl; a striking example of the interplay of theory and experiment. Since then, many spiral patterns on crystals of compounds and of metals have been found, and the process of growth has been watched under the microscope.

Dr. H. D. Keith, later this morning, will be describing work that Dr. J. W. Mitchell and he have been conducting on the crystal forms of silver, produced in the reduction of silver bromide by standard chemical developers. What they have done is to produce a single crystal of pure silver bromide in the form of a laminar sheet, about 0·2 mm. in thickness and of given orientation. They then study under the microscope the growth of silver crystals in its surface. They have shown in this way that, even in the long-investigated subject of photographic action, an experiment framed on a simple basic principle can lead to a new theory of development.

(To be continued.)

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

"Comet" Service to Singapore.—British Overseas Airways Corporation have announced that a jet-propelled service between London and Singapore is to be inaugurated on October 14, with de Havilland Comet air liners. The total journey time on the eastward journey will thus be reduced from about $2\frac{1}{2}$ days (as at present, with Argonaut aircraft) to $27\frac{1}{4}$ hours, of which $20\frac{1}{4}$ hours are spent in the air. The total distance, by way of Rome, Cairo, Bahrein, Karachi, Calcutta, Rangoon, and Bangkok, is 7,761 miles. The westward journey, from Singapore to London, will take 34 hours 20 minutes, and an additional call will be made at Delhi. This service will operate once a week in each direction. A second weekly Comet service will be introduced on October 31, calling at Beirut instead of Cairo, and at Delhi on the outward journey, but not at Rangoon.

Formation of Metal Fixing Association.—A new organisation, to be known as the Metal Fixing Association, has been formed by the owners of various systems for fixing insulating linings in buildings with metal components. The objects of the Association include the general promotion of the industry; the collation and dissemination of statistical and other information; legislation affecting the industry; and negotiations with recognised bodies in the architectural, building, engineering and allied professions, and with Government departments and local authorities; but it will not be concerned with the maintenance of prices. Another of the new body's aims is the definition of minimum standards of materials and workmanship, in which connection it hopes to publish a code of practice in the near future. Membership will be open to all firms maintaining a full-time metal-fixing department, including the direct employment of personnel. Mr. H. F. Payne has been appointed secretary of the Association, the offices of which are at 32, Queen Anne-street, Cavendish-square, London, W.1 (Telephone: LANgham 7616). The founder members are: Anderson Construction Co., Ltd., Bowaters Building Boards, Ltd., Celotex, Ltd., W. H. Heywood & Co., Ltd., Sundeala Board Co., Ltd., Tentest Fibre Board Co., Ltd., and the Merchant Trading Co., Ltd.

NOTES ON NEW BOOKS.

Safe Working Loads of Lifting Tackle.

By L. Linder, A.M.I.Mech.E. Second edition. Issued by the Testing Department of Messrs. Coubro and Scrutton, Limited, 11, West India Dock-road, London, E.14. [Price 42*s*.]

In the course of building up, over many years, a deservedly great reputation for lifting tackle of high quality and reliability, the engineering staff of Messrs. Coubro and Scrutton have accumulated a comprehensive knowledge of their special subject, which is here conveniently presented to meet the needs of other lifting gear designers. The author's general plan has been to examine and solve the stress problems presented, first by individual components, and, secondly, by a variety of assemblies of lifting tackle, and thence to evaluate permissible loads relative to dimensions and arrangements of gear, always on the basis of materials complying with the requirements of the relevant British Standards. Most of the design data and formulæ are derived from the widely-known work on lifting gear carried out at the National Physical Laboratory some 20 years ago, but many other practical investigations, including those in the firm's own laboratories, have been used with critical discretion; so that, in addition to chains and connecting components of wrought iron or steel, ropes of wire and fibre, ships' derricks, and booms of steel, as well as of Oregon pine, now come within the scope of the book. Since the first edition appeared in 1945, several important sections have been entirely rewritten, while the addition of other fresh material and the extended range of tabulated safe loading values have brought the contents of the new volume completely up to date. The result is a scrupulously careful compilation which, while concerned especially with the loading and discharging installations of cargo ships, also covers adequately the main requirements of lifting tackle for use ashore, including a deal of compactly displayed information on such matters as statutory regulations, testing, maintenance and inspection. From the announcement that Messrs. Coubro and Scrutton have recently added a 100-ton chain testing machine to their already extensive range of equipment, it may be inferred that technical data for incorporation in a future, third, edition of Mr. Linder's book are already being collected. Meanwhile, his present work is assured of a cordial reception over a wide field of mechanical and marine engineering.

The Elements of Thermodynamics.

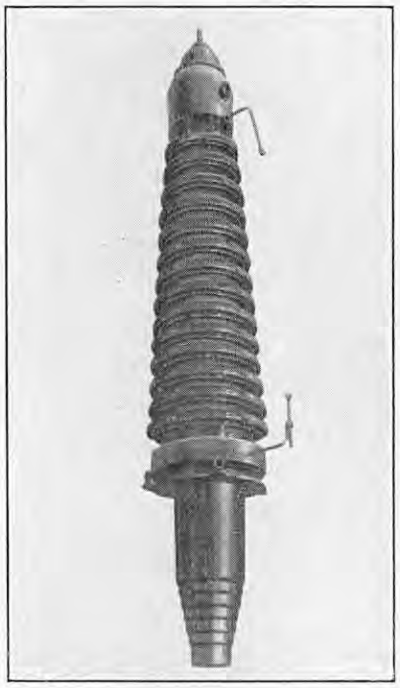
By Professor Charles Fabry. Translated from the French by G. F. Herrenden Harker, M.A. The Quality Press, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 15*s*.]

Like all good teachers, the late Professor Fabry knew that text-books for beginners in science should be small enough not to appear too formidable, and should start from the ordinary conceptions of things, leaving the precise examination of their nature until the student arrives at a stage when he feels the need for it. The present work, of which six editions have appeared in France since 1928, fulfils both these conditions. It will slip easily into a jacket pocket, and the consideration of such matters as thermometry and calorimetry are postponed until nearly the end, after the two Laws of Thermodynamics and the main deductions from them have been discussed. The object of the author has been to present thermodynamic principles in a form suitable for students of physics generally, rather than to elaborate those aspects of the subject of special interest to those concerned with chemical or engineering transformations. The treatment follows classical lines in the sense that the ideas of statistical mechanics are not introduced, nor is there any attempt to propound a so-called Third Law of Thermodynamics. A particularly interesting chapter deals with the conditions of equilibrium as expressed in terms of equalities between the "intensive" properties, as distinguished from those properties which specify stages of configuration alone. The author has assumed a familiarity with differential equations that might be flattering to many elementary students in this country, but the reasoning is always clear and the text lucid. The translation, moreover, is excellent, though the use of the word "source" to denote a reservoir of heat, regardless of whether it is giving heat out or taking it in, is neither good French nor good English. The usual term "sink" is certainly preferable in the latter case. This, however, is too slight a matter to interfere with the appreciation of a very attractive little book.

275/300-KV RE-ENTRANT TRANSFORMER BUSHING.

One of the difficulties of using conventional terminal bushings on transformers at very high voltages is that considerable clearance must be provided round them to prevent spark-over to the walls of the tank. Consequently, the dimensions of the tank or of the bushing mounting turrets, which form part of it, may be large and transport may be correspondingly more difficult.

With a view to overcoming these obstacles, the Bushing Company, Limited, Hebburn-on-Tyne, have designed a range of re-entrant bushings, an example of which is shown in the accompanying illustration. They consist of a synthetic-resin



bonded paper condenser insulator, the air end of which is protected externally by a porcelain rain shed. The space between the insulator and this rain shed is filled with oil and is sealed in the factory to prevent moisture gaining access. The lower end of the bushing is so constructed that the end of the high-voltage electrode terminates within the body of the insulator at some distance from its lower end. The external boundaries of the high-voltage termination are completely surrounded by solid insulation.

The lowest extremity of the bushing takes up a voltage intermediate between the mains voltage at the end of the high-voltage electrode and that of earth at the end of the earthed electrode, the exact value depending upon the design and disposition of the equipotential layers inside the body. The lead-in cable from the electrode to the winding is fully insulated to eliminate spark-over from it to the lower extremity of the bushing. As a result, the diameter of the transformer tank turret can be made smaller and its height reduced so that the saving in volume is often considerable.

The bushings are fitted with standard "Texolex" top caps and oil reservoirs, the former being removable to allow easy access to the cable socket. The connection to the transformer lead can therefore be made without exposing the filling oil or the condenser insulator to the atmosphere. Any reduction of the insulating properties of the bushing is therefore avoided, even if the top connection is made on site in unfavourable weather.

BOOKS RECEIVED.

Tiefziehen von Aluminium. By Mostafa Abdel Aziz. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 10 Swiss francs.]

Selected Government Research Reports. Vol. I. *Plastics.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 35*s*. net.]

Structural Steelwork for Buildings. By H. P. Smith. Third revised edition. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 7*s*. 6*d*.]

Overseas Economic Surveys. Paraguay. By I. L. Henderson. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s*. net.]

National Building Studies. Research Paper No. 14. *Reactions between Aggregates and Cements.* By Dr. F. E. Jones. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. 3*d*. net.]

The Technique of Design. By P. J. Wallace. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 12*s*. net.]

The Composition and Assaying of Minerals. By John Stewart-Remington and Dr. Wilfrid Francis. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 17*s*. 6*d*. net].

Atmospheric Pollution. Its Origins and Prevention. By Dr. A. R. Meetham. Pergamon Press, Limited, 2, 3 and 5, Studio-place, Kinnerton-street, London, S.W.1. [Price 35*s*.]

Wind-Tunnel Technique. By Dr. R. C. Pankhurst and D. W. Holder. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 57*s*. 6*d*. net.]

Vacuum Technique. By Professor Arnold L. Reimann. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 50*s*. net.]

The Institution of Mechanical Engineers. Automobile Division. Proceedings 1950-51. Offices of the Institution, Storey's Gate, St. James's Park, London, S.W.1.

BRITISH STANDARD SPECIFICATIONS.

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

Malleable-Iron and Copper-Alloy Pipe Fittings.—Revised editions of two specifications, B.S. No. 143, covering malleable cast-iron and cast copper-alloy pipe fittings, and B.S. No. 1256, relating also to malleable cast-iron (whiteheart process) and cast copper-alloy pipe fittings, have now been issued. In each case the pipe fittings are for steam, air, water, gas and oil. B.S. No. 143 is concerned with screwed B.S.P. (British Standard Pipe) taper thread or A.P.I. (American Petroleum Institute) line pipe thread, and B.S. No. 1256 with screwed B.S.P. taper male and parallel female thread. The two specifications have been revised with a view to simplifying the range of sizes and fittings and to provide only for those sizes of fittings in common use. They specify the dimensions of plain or reinforced fittings suitable for working pressures of up to 200 lb. per square inch in the case of water, and of up to 150 lb. per square inch in that of steam, air, gas and oil. The fittings are for use with nominal pipe sizes within a range of $\frac{1}{8}$ in. to 6 in. Tests for porosity and ductility are specified. [Price of each specification, 7*s*. 6*d*., postage included.]

Definitions for Single-Point Cutting Tools.—A detailed set of definitions of the numerous terms employed in connection with single-point cutting tools for lathes, boring mills, and planing, shaping and similar machines, has now been issued. The publication, B.S. No. 1886, has been prepared with the assistance of representatives of the British Hard Metal Association, the Welded and Brazed High-Speed Steel Tool Trade Association and other authorities. Particular attention has been given to definitions of rakes, working angles, clearance angles, tool elements and similar matters. As a result of this, it is stipulated that the Maximum Rake System shall be the British Standard method of defining rake, as distinct from the German and American systems. A number of line drawings and diagrams serve to assist and clarify the definitions in the text. An appendix is devoted to extracts from Dr. D. F. Galloway's book, *Standardisation and Practical Application of Cutting-Tool Nomenclature,* published by the Institution of Production Engineers. The extracts, on a method for the conversion of rake angles, have been slightly amended where necessary to bring them into line with the Maximum Rake System of nomenclature. The rake-conversion chart of Mr. Galloway is reproduced in the specification. [Price 6*s*., postage included.]