3,000-H.P. GAS-TURBINE ELECTRIC LOCOMOTIVE; BRITISH RAILWAYS.

BRITISH Railways' second gas-turbine locomotive, No. 18100, has recently been delivered by the builders, the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. Like the first, built by Brown, Boveri and Company, Switzerland, it was ordered by the Great Western Railway before nationalisation of the main-line railways, but the experimental use of both locomotives has been taken up by the Railway Executive, under the direction of Mr. R. A. Riddles, C.B.E., M.I.Mech.E. As will be seen from Fig. 1, herewith, locomotive No. 18100 has two six-wheeled bogies; all the axles are driven. The continuous rating of the turbine is 3,000 h.p., though with transmission losses and auxiliary drives the power available at the rails is 2,450 h.p. The maximum tractive effort is 60,000 lb., the continuously-rated tractive effort is 30,000 lb. and the maximum service speed is 90 miles an hour. The power unit is designed to use gas oil as fuel.

The principal features of the locomotive were determined by the service requirements that were stipulated by the Great Western Railway. The locomotive was to be suitable for hauling the heaviest passenger trains on the western main lines, particularly that between London and Plymouth, at speeds up to 90 m.p.h. To work such trains satisfactorily over the steep gradients—up to 1 in 36—at the western end of the routes, it was necessary to provide a maximum starting effort of about 60,000 lb.; in view of the permitted axle loads, this led to the adoption of six axles, and as the weight of the locomotive in working order is 129·5 tons, the axle load is approximately 21·6 tons. Electric transmission was chosen as the only practicable and reliable means of satisfying these conditions. The power of the locomotive is actually more than sufficient for the traffic requirements of the Western Region, but the Metropolitan-Vickers Electrical Company—who have shared the financial and technical responsibility with the railway—were anxious for the new power unit to be suitable for overseas railways, where heavier duties might prevail and where less power might be available due to the ambient temperature and the altitude.

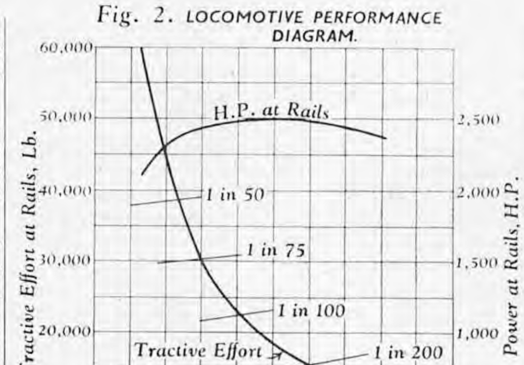
A nominal output of 3,500 h.p. at the turbine coupling was therefore selected and the design of the turbine, reduction gear and electric transmission equipment was based on that figure, though the blade profiles actually used in the power unit of No. 18100 limit the continuous output to between 3,100 and 3,200 h.p. That power is more than required for the present application and the continuous rating is therefore declared at 3,000 h.p. If the full nominal output is required in the future it can be made available by changing some of the existing blades for new blades of slightly different profile. Fig. 2, below, shows the power and tractive effort at the rails, against speed, assuming a turbine output of 3,000 h.p., a generator input of 2,850 h.p., an auxiliary load and gear loss of 150 h.p., and an electric transmission efficiency of about 86 per cent.; this gives 2,450 h.p. at the rails. The graph also shows, in conjunction with the tractive-effort curve, the "balancing" speeds on the level and on various gradients when the locomotive is hauling a train of 18 coaches, weighing 650 tons. Thus, for example, such a train could be hauled on the level at 85 m.p.h., on a 1-in-100 gradient at 41 m.p.h., and on a 1-in-50 gradient at 23 m.p.h. The gas turbine, which completed about 250 hours' running on the test-bed before being fitted in the locomotive, gave a full-load thermal efficiency of 19 per cent. The overall efficiency, allowing for gear and electrical losses, would thus be 16 per cent., and then, after deducting 75 h.p. for the auxiliaries, the tractive power at the wheels represents $15\frac{1}{2}$ per cent. of the calorific value of the fuel. This is equivalent to a fuel consumption of 0·88 lb. per horse-power per hour, and at half power the consumption would be about 1·3 lb. per horse-power per hour.

The body of the locomotive contains the power plant and a driving cab at each end; it is carried on two bogies of novel design, employing swing-links with resilient-rubber universal joints to permit a controlled swing-bolster action and bogie pivoting, without the use of actual bolsters, which would have required more space than was available between the bogie frames and within the fixed wheelbase. Each axle is driven through a single-reduction gear by a traction motor suspended on the axle and from a support on the bogie frame. The turbine, which is of the simple open-cycle type, without a heat exchanger, rotates at 7,000 r.p.m. when delivering full power, and drives three main traction generators at 1,600 r.p.m. through single-reduction gearing. The gas-turbine cycle is shown diagrammatically in Fig. 3, on page 162, and the power unit is illustrated by the photograph reproduced in Fig. 11, on Plate VII, and by the drawing, Fig. 12, on the same Plate.

The reduction-gear unit has two output shafts; one drives two of the main generators in tandem and the other drives the third main generator, the auxiliary generator and the exciter. The turbine, reduction gear and group of generators are mounted on a common bedplate, together with the main fuel and lubricant pumps, and constitute a self-contained unit which is on three support points on the locomotive frames. Each of the three main generators supplies two of the six traction motors. The motors of each pair are connected permanently

FIG. 1. C_0-C_0 GAS-TURBINE LOCOMOTIVE.

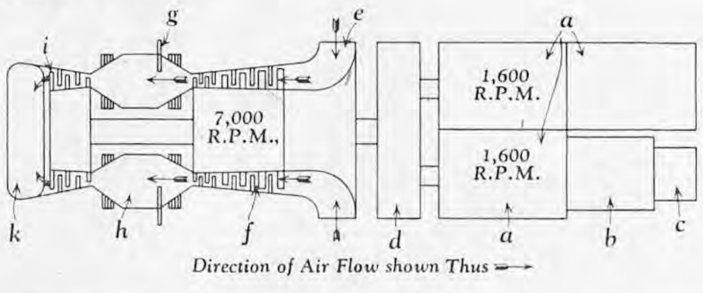
Fig. 2. LOCOMOTIVE PERFORMANCE DIAGRAM.



3,000-H.P. GAS-TURBINE ELECTRIC LOCOMOTIVE.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

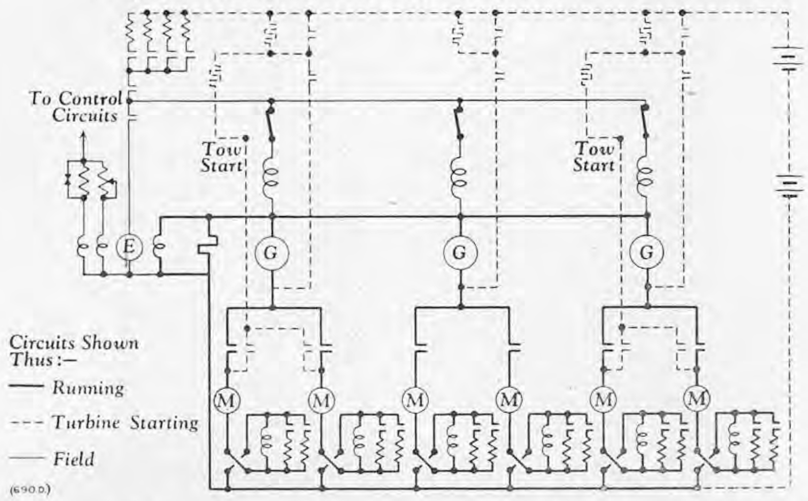
Fig. 3. POWER UNIT.



a Three Main Generators
b Auxiliary Generator
c Exiter for Main Generators
d Gearbox: Input Shaft 7,000 R.P.M. Two Output Shafts 1,600 R.P.M.
e Air Intake for Compressor
f Compressor
g Fuel Injection Nozzles
h Combustion Chamber, Comprising Six Flame Tubes Arranged Around Main Shaft
i Turbine
k Turbine Exhaust

(690 C)

Fig. 4. TRACTION ELECTRICAL CONNECTIONS.



(690 D)

in parallel. The principal auxiliaries are an auxiliary generator, exciter, main and auxiliary fuel and lubricant pumps, air-blast coolers for the turbine and reduction-gear lubricant, traction-motor ventilation centrifugal blowers, an air compressor and vacuum-brake exhausters, oil-fired steam boiler for train heating, and the turbine starting battery. The driver's control of the gas-turbine and electrical transmission has been made exceptionally simple, by an automatic system, so that highly-specialised training is not necessary, and the locomotive is equipped with automatic train control of the Western Region type for warning the driver of a distant signal at danger.

The case for using this type of locomotive in preference to steam traction rests mainly on economies from its higher efficiency and anticipated lower maintenance costs for equal work done. In relation to Diesel traction, its case rests largely on operating economies. In spite of the turbine's considerably higher fuel consumption, per horse-power per hour, than that of the Diesel engine, the cost for fuel and lubricant in relation to the ton-miles hauled is only a little higher for the turbine than for the Diesel locomotive. Moreover, experience so far has shown that in the higher powers gas-turbine locomotives can be built approximately half the weight and half the length of Diesel locomotives of the same power.

Turning to the design in detail, we deal first with the power plant. It is, as already stated, a simple open-cycle gas-turbine without heat exchanger, and the cycle of compression, heating and expansion of the air is carried out in a compressor, combustion chamber and turbine arranged in line and built into a single straight through unit, as shown in Figs. 3 and 12. The compressor is a 15-stage axial-flow machine with a pressure ratio of 5·25 : 1 at 7,000 r.p.m. and a mass flow of 50 lb. per second; it runs in two sleeve-type bearings. The turbine is a five-stage unit, also running in two sleeve-type bearings, and its rotor is direct-coupled to that of the compressor. The combustion chamber is made entirely of heat-resisting steel and consists of six flame tubes, with axes parallel to the machine axis, joined by flexible connection pieces at one end to the compressor outlet and at the other end to the turbine inlet. The compressor and turbine cylinders are joined by a tubular member surrounding the shaft coupling so that they constitute a single structural unit on which the combustion chamber is mounted. The power unit is supported from the bedplate on four pillar supports with sufficient flexibility to accommodate expansion. A sliding-key arrangement maintains the lateral location of the unit, and the inlet end of the compressor frame is secured longitudinally by securing it to the casing of the reduction gear, which is solidly bolted and dowelled to the bedplate. The total axial expansion at the turbine end is about $\frac{3}{8}$ in. The rotors of the compressor and turbine are located axially by a thrust bearing at the compressor inlet end.

The compressor cylinder, the two halves of which are shown in Fig. 7, on Plate VI, is of malleable iron and the rotor is a forged steel drum. The moving blades, machined from stainless-steel bar, and fixed blades rolled from similar material, are retained in dovetail slots machined axially on the rotor and circumferentially in the cylinder. The bearings are lined with white-metal and lubricated and cooled by a copious supply of lubricating oil under pressure. A supply of compressed air is taken from an intermediate stage to a balance piston at the inlet end for the purpose of balancing the end thrust of the combined rotors.

The turbine, parts of which are shown in Figs. 8, 9 and 10, on Plate VI, is of special heat-resisting materials, the cylinder being an austenitic-steel casting and the rotor an austenitic-steel forging, and the blading as follows :—

—	Fixed Blades.	Moving Blades.
1st stage ..	Nimonic	Nimonic.
2nd ,, ..	Steel (austenitic)	Nimonic.
3rd ,, ..	Steel ,,	Steel (austenitic).
4th ,, ..	Steel (molybdenum)	Steel (molybdenum).
5th ,,	Steel ,,	Steel ,,

The bearings are of similar design to those of the compressor, but additional cooling is provided by a flow of compressed air from an intermediate stage of the compressor.

Each of the six flame tubes of the combustion chamber (see Figs. 14, 15 and 16, on Plate VIII) is secured by quickly detachable unions to the compressor and turbine. The flame tube has an outer casing and inner primary chamber, both fabricated from austenitic heat-resisting sheet steel. By means of metering orifices, the correct proportion of the air flow is introduced into the primary to give complete combustion of the fuel, which is fed in at about 650 lb. per square inch from the fuel jets. The remaining air is mixed with the very high temperature products of combustion, downstream of the jets, so as to produce the designed temperature at the turbine inlet. The designed maximum temperature is 700 deg. C. Each flame tube has a double fuel injector with a small jet orifice for idling fuel and a large one fed from the main fuel valve. Two flame tubes are fitted with igniters, in the form of high-tension spark plugs combined with pilot-flame fuel jets. Ignition spreads to the other flame tubes through tubular connections between each pair of casings. The bedplate of the power unit carries the two electrically-driven main fuel and lubricant pump sets. Only one runs at a time, but any failure of fuel or lubricant pressure immediately causes the other set to operate.

To start the unit, the turbine is accelerated up to a self-sustaining speed by the main generators acting as motors fed from the starting battery, and once the driver has actuated the starting button the process is entirely automatic. The successive steps in the process are initiated by a timing or sequence controller driven at a controlled speed by an electric motor. The steps in the progression are as follows : auxiliary fuel pump starts, drawing fuel from the tank; main fuel and lubricant pump starts; igniters are switched on; then the automatic starting valve commences to move, the turbine starts to rotate, and by the time it reaches about 1,000 r.p.m. the starting valve commences fuel delivery through the idling jets of the combustion chamber. Thereafter the fuel combustion assists in the acceleration, and at about 2,500 r.p.m. the battery is automatically disconnected from the main generators and the turbine continues to accelerate under its own power to 4,000 r.p.m. The time from pressing the starting button until the turbine first rotates is 10 seconds; a further 25 seconds elapse until the battery is disconnected and a further 30 seconds until idling speed is reached. Full power may be taken from the turbine after about 10 minutes warming up at idling speed or at low power.

On shutting down after full-load running, it has been found beneficial to have a cooling period of about 10 minutes at idling speed or low power. After stopping the turbine an automatic barring sequence comes into operation which motors the turbine round for a few seconds at intervals of about three minutes to equalise the cooling stresses. An auxiliary lubricant pump circulates oil round the turbine bearings throughout the cooling period, and is automatically stopped by a bearing thermostat at the appropriate time. Throughout the operation of the locomotive, the turbine and generator are governed electrically to give the output selected by the driver on the master controller, and at the turbine speed for most efficient operation at that load. While this electrical governing deals with all normal working conditions, over-riding controls come into operation in the event of excessive turbine speed or gas temperature, excessive bearing temperature, or low fuel or lubricant pressures.

The three shafts of the reduction gear lie in a horizontal plane, the middle one carrying the pinion and each of the others a gearwheel. The pinion is made from case-hardening steel, the teeth profiles being ground after hardening. The gearwheel rims are of 65/72-ton chromium-molybdenum steel with the teeth finished by the shaving process. The teeth, of 5 diametral pitch, are single-helical. Each shaft is hollow and runs in two white-metal sleeve bearings. The drive shafts from the turbine and from the generators pass through the hollow shafts to couplings at the remote ends of these shafts, thus giving a certain flexibility in the drive without making the unit unduly long. Gear teeth and bearings are lubricated from the main turbine lubricant pump.

Two of the three main generators form a tandem unit, their yokes being bolted together and both armatures being mounted on a common shaft carried in two roller bearings in the yoke end-shields.

TURBINE AND COMPRESSOR COMPONENTS FOR LOCOMOTIVE GAS-TURBINE.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(*For Description, see Page* 161.)

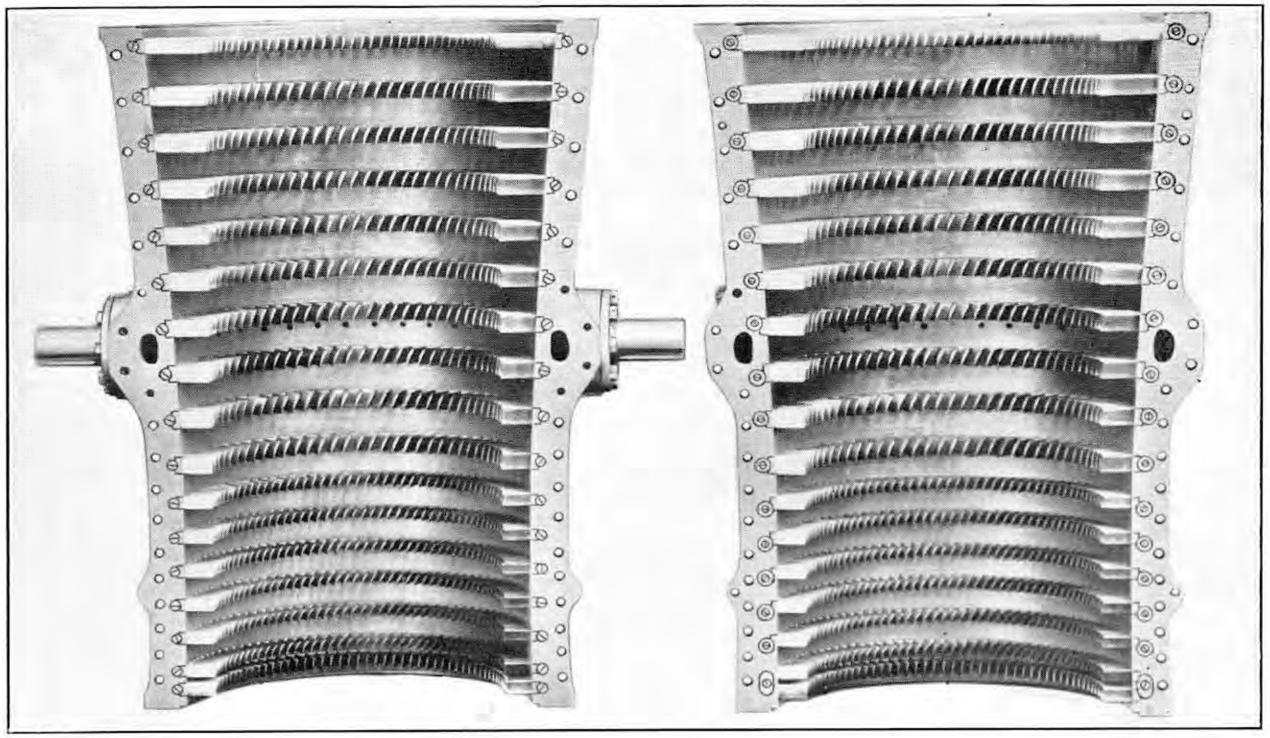


FIG. 7. TWO HALVES OF COMPRESSOR CYLINDER.

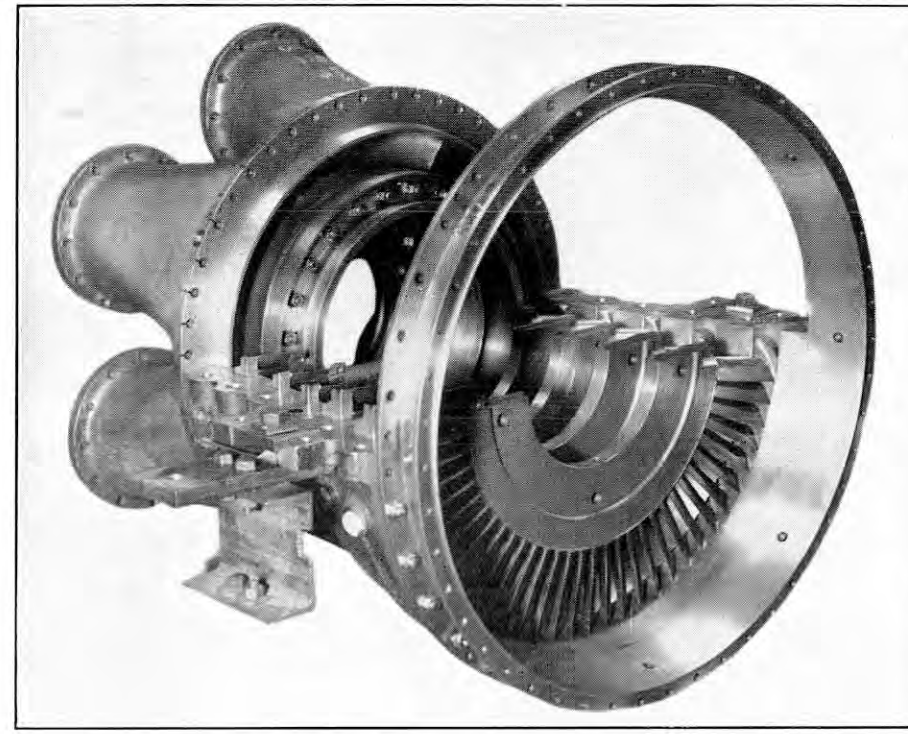


FIG. 8. HALF CYLINDER OF TURBINE.

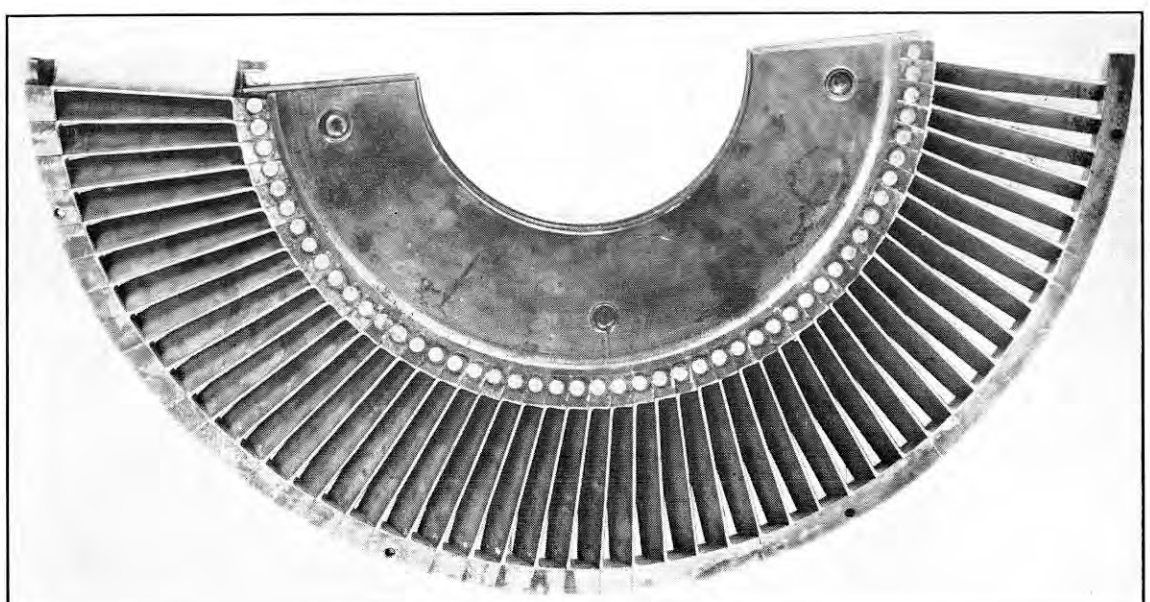


FIG. 9. HALF DIAPHRAGM OF TURBINE.

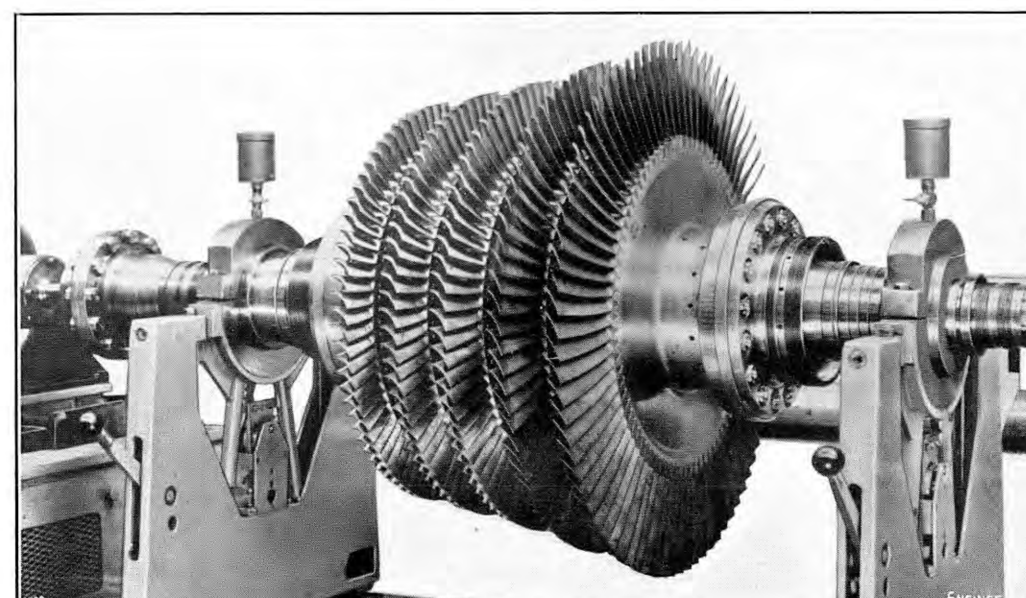


FIG. 10. TURBINE ROTOR.

3,000-H.P. GAS-TURBINE L

METROPOLITAN-VICKERS ELECTRI

(*For Descripti*

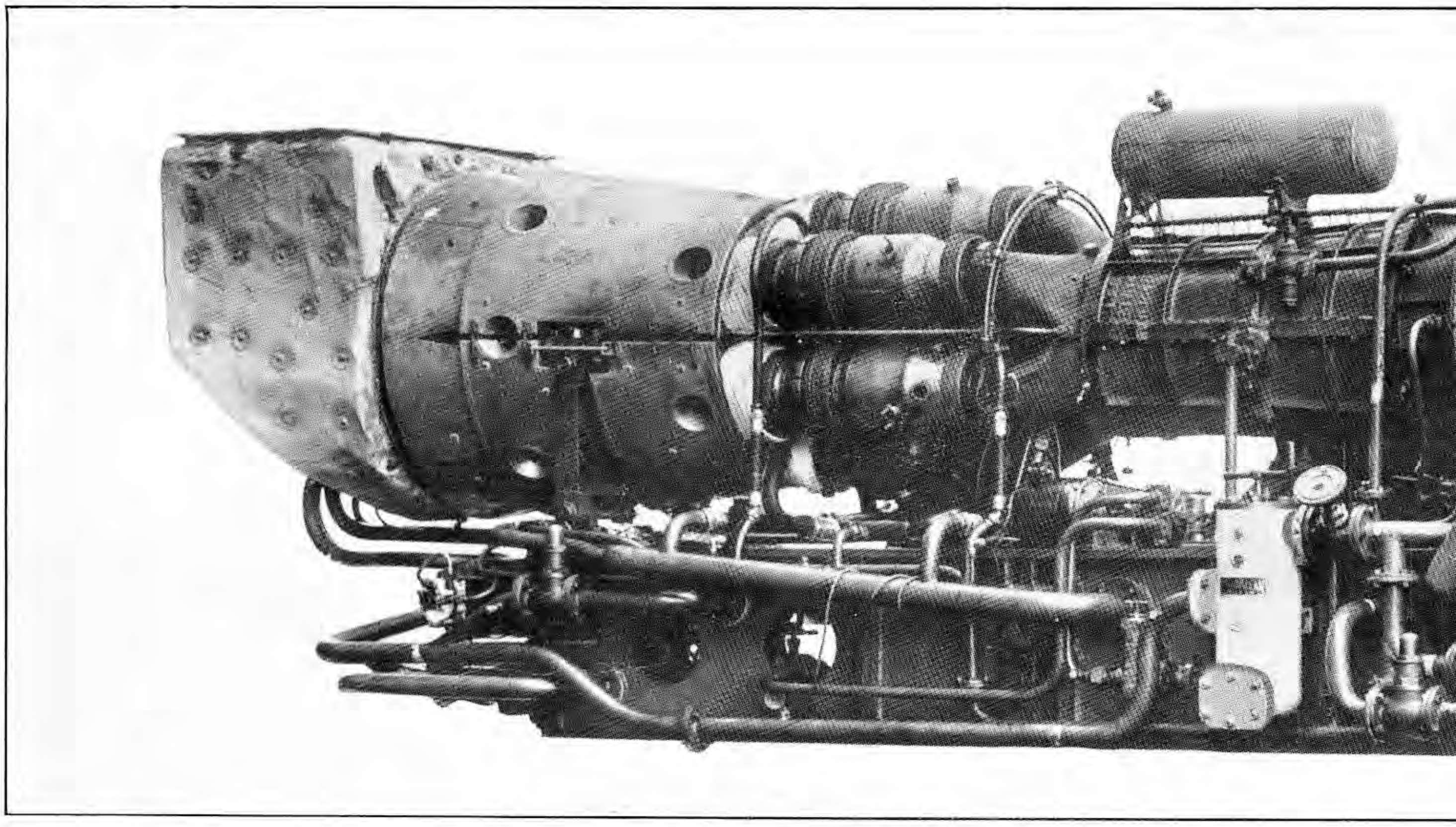
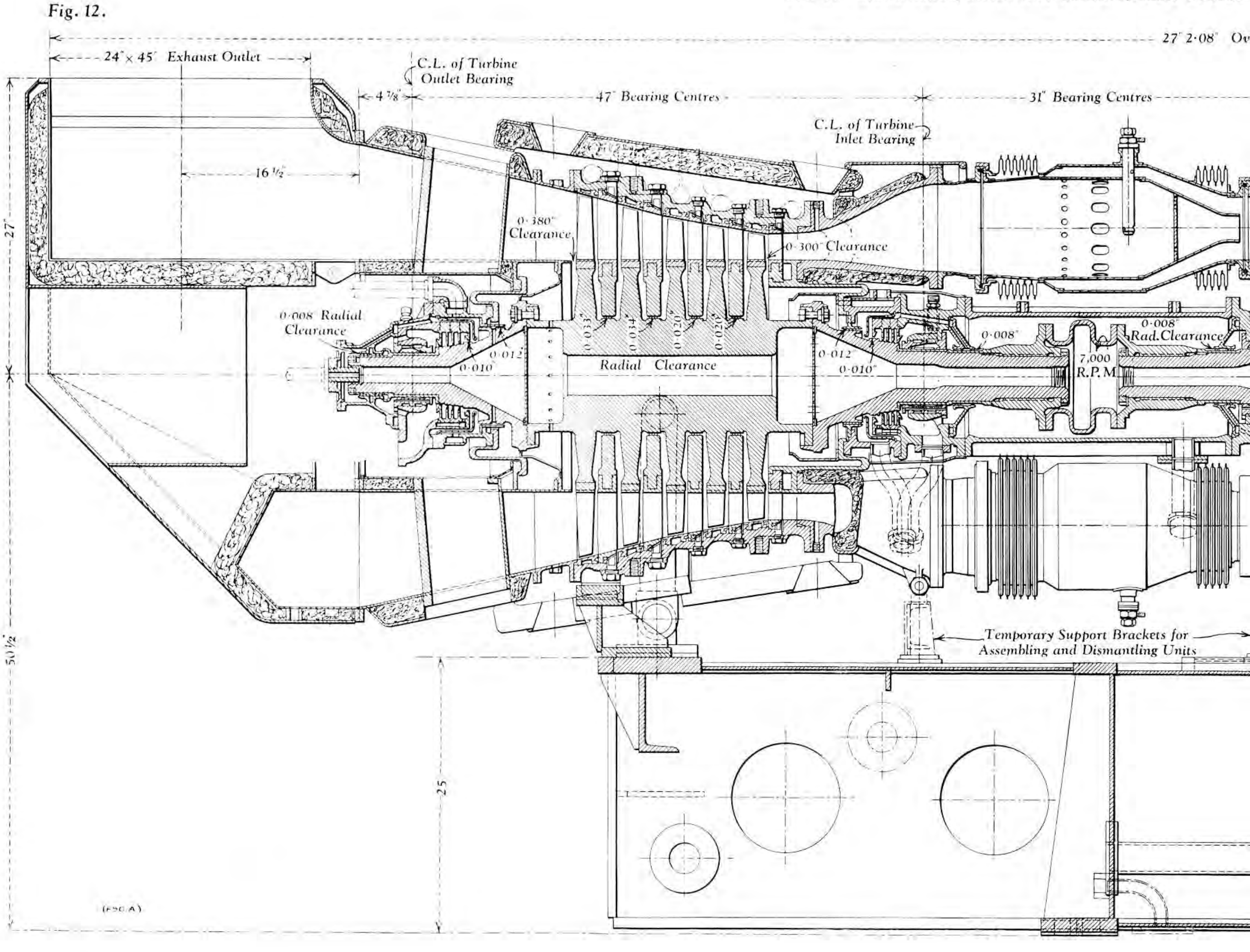


Fig. 11. Gas-Turbine, Reduction Gearbox, Main Generat

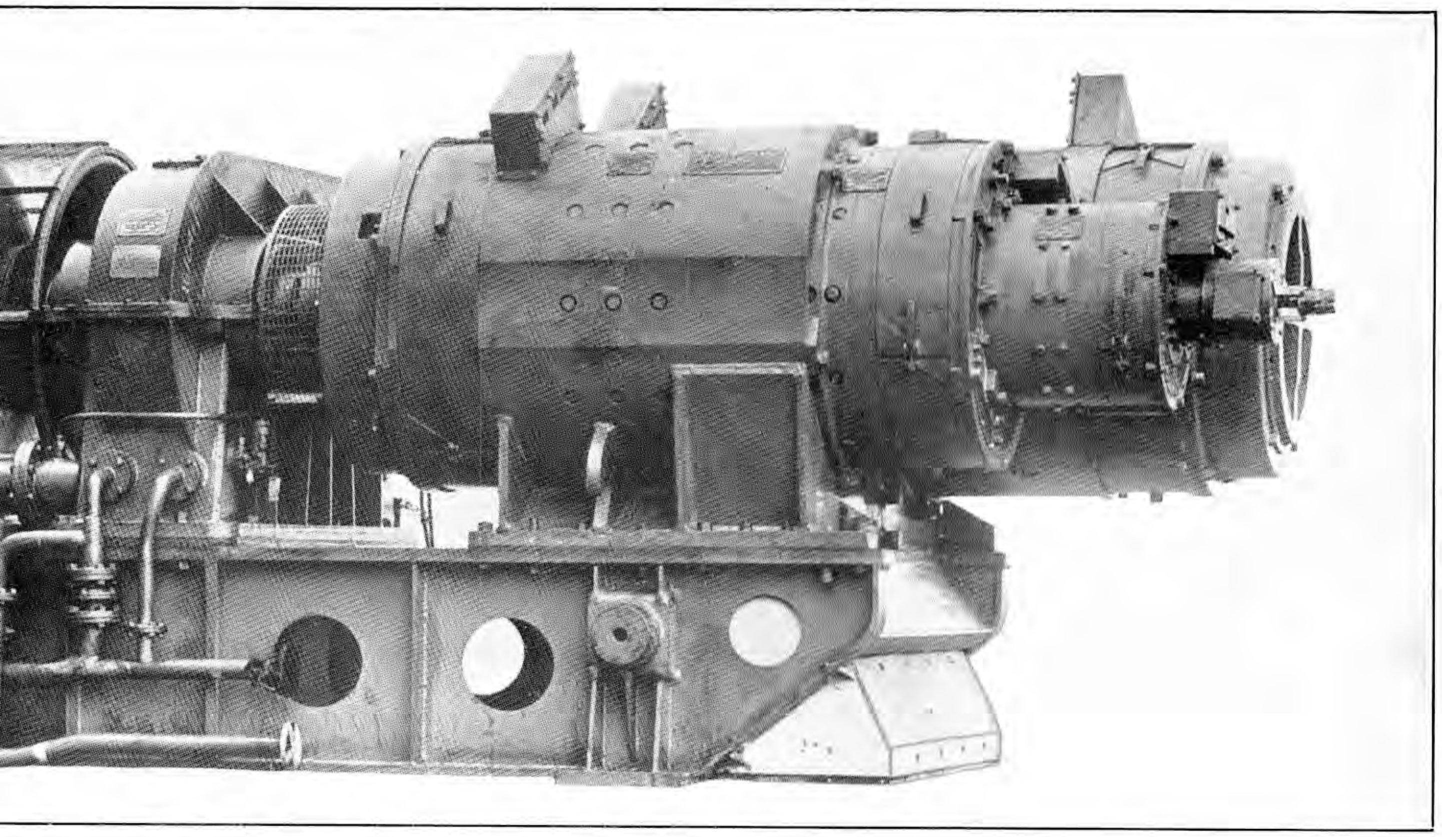
Fig. 12.



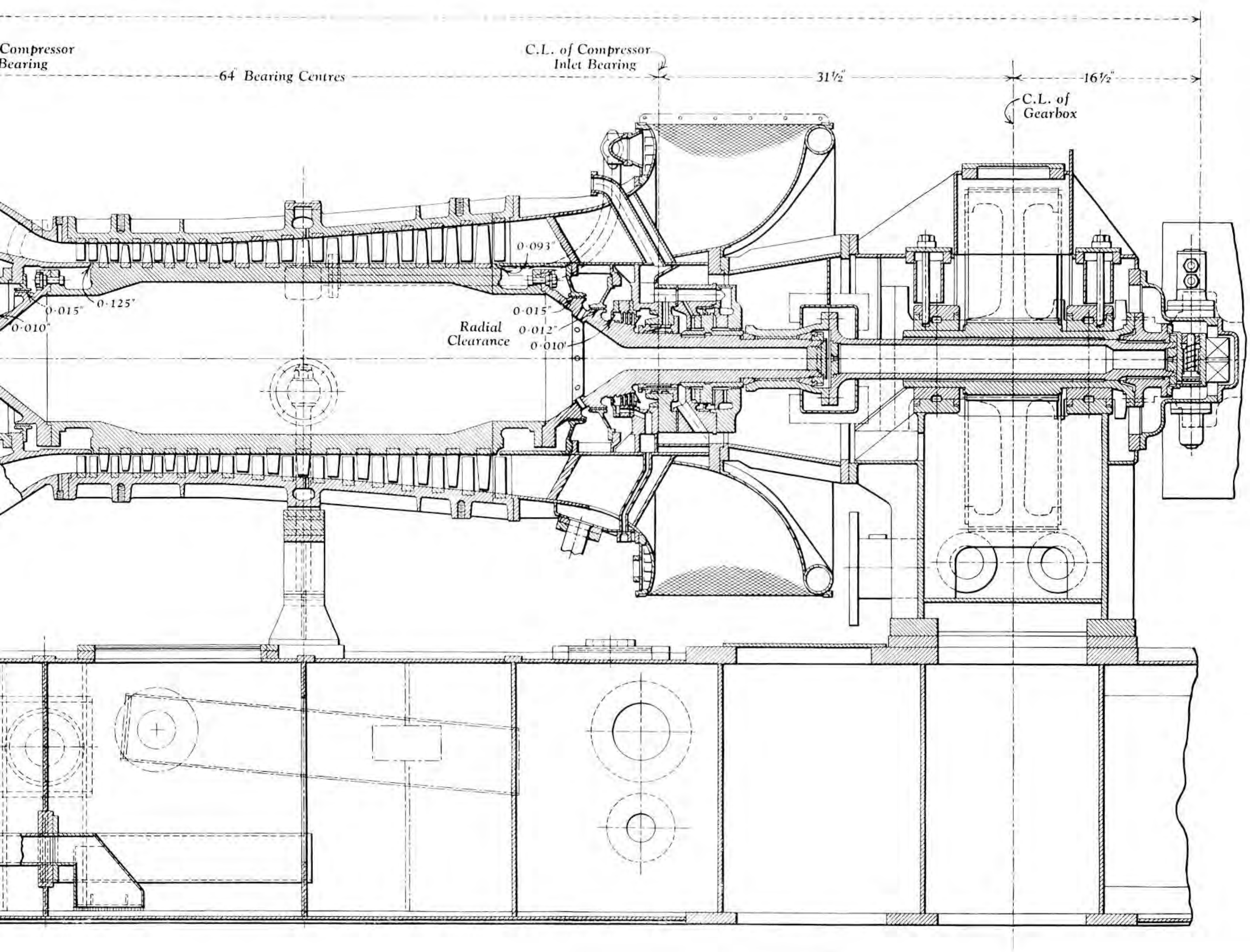
OMOTIVE POWER UNIT.

MPANY, LIMITED, MANCHESTER.

ge 161.)



ILIARY GENERATOR AND EXCITER MOUNTED ON BEDPLATE.



3,000-H.P. GAS-TURBINE LOCOMOTIVE POWER UNIT.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(*For Description, see Page* 161.)

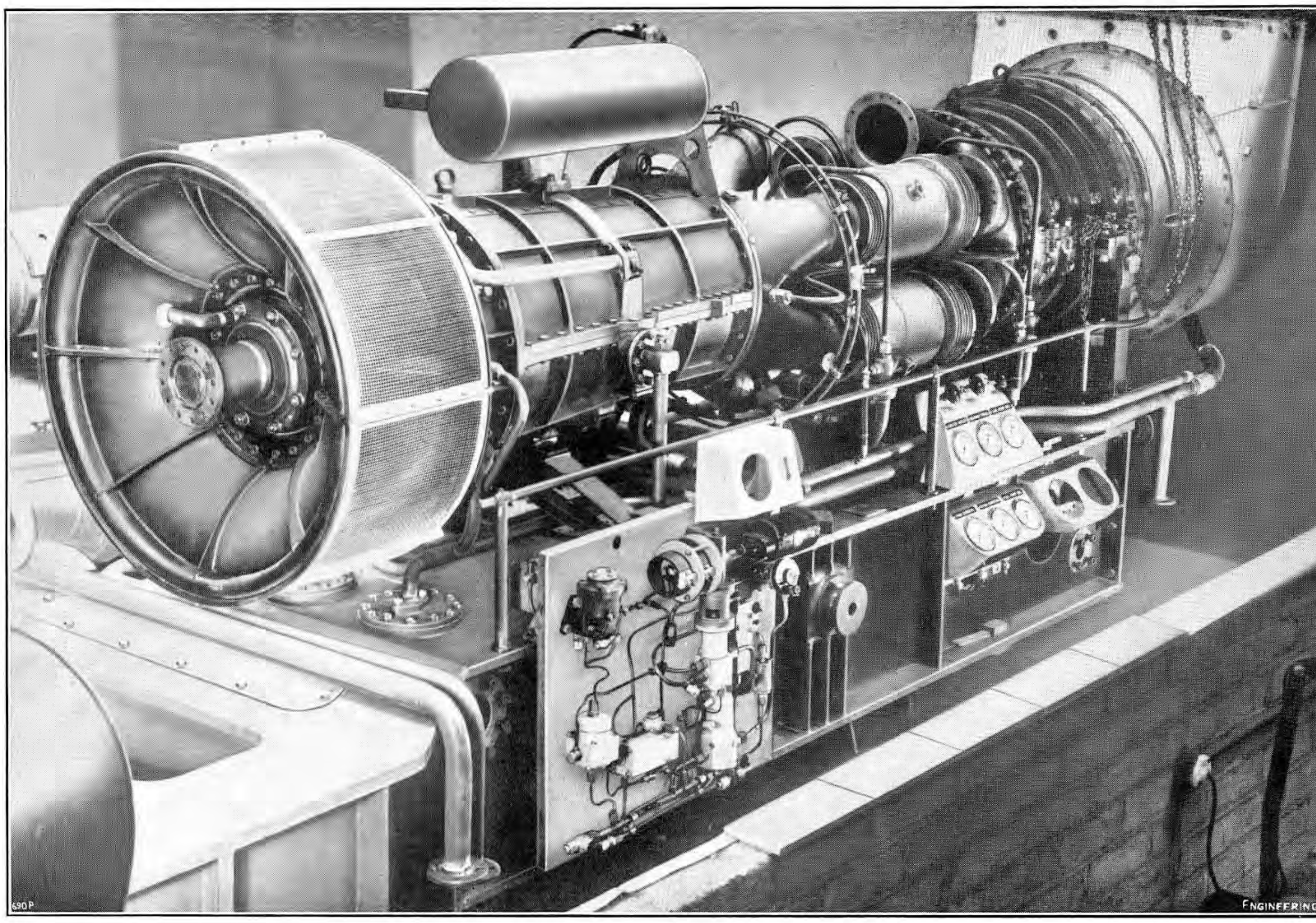


FIG. 13. GAS-TURBINE POWER UNIT PARTLY ASSEMBLED.

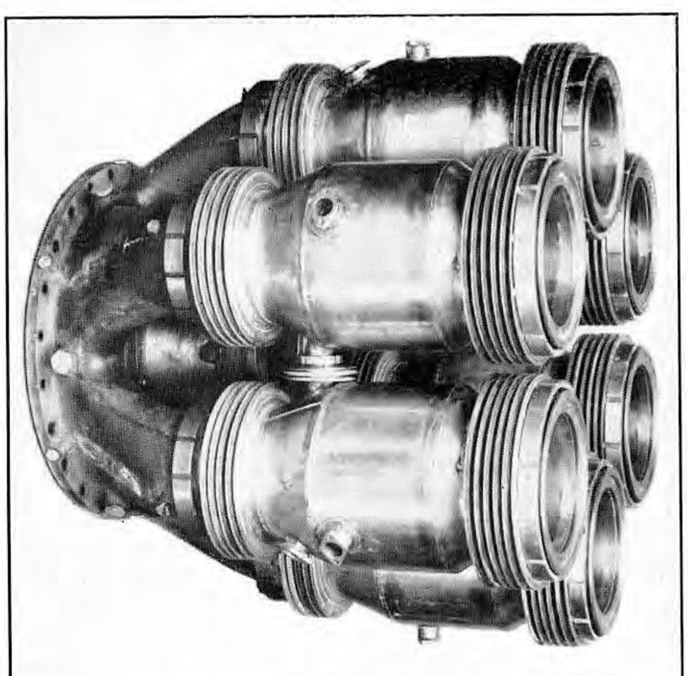


FIG. 14. COMBUSTION-CHAMBER ASSEMBLY.

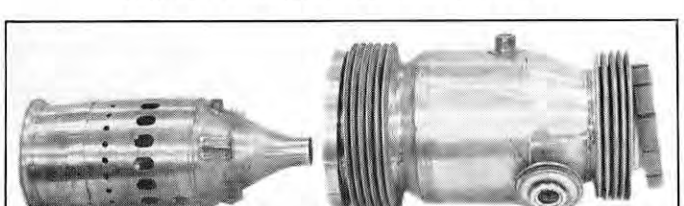


FIG. 15. FLAME TUBE WITH PRIMARY CHAMBER REMOVED.

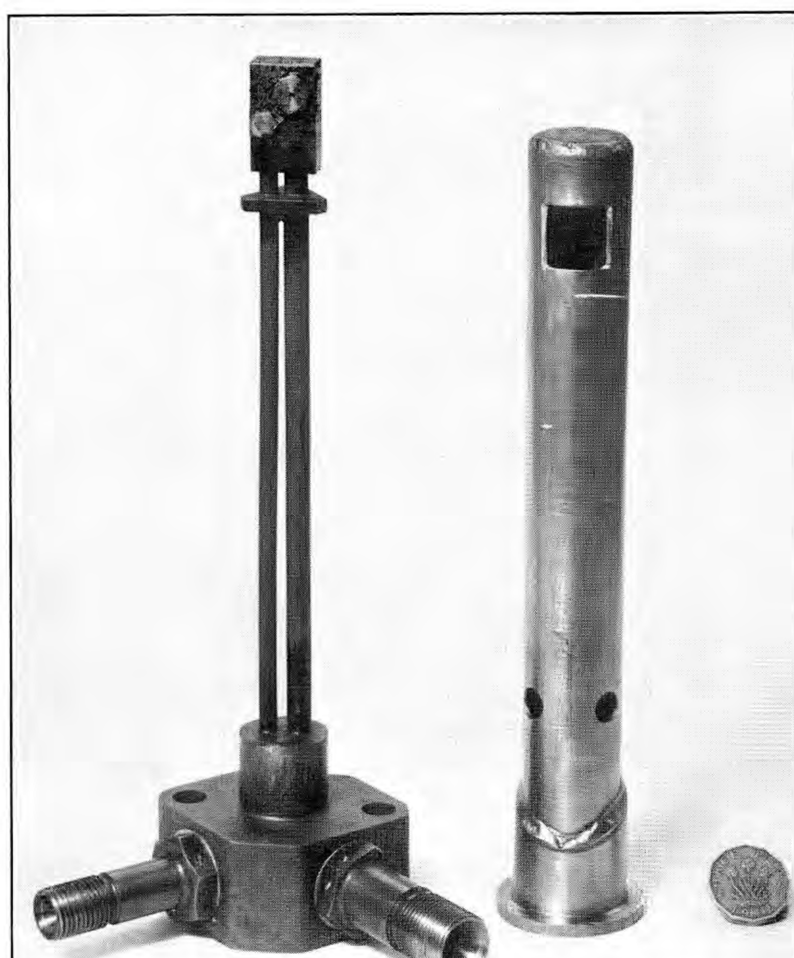


FIG. 16. MAIN AND IDLING FUEL JETS.

3,000-H.P. GAS-TURBINE ELECTRIC LOCOMOTIVE.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

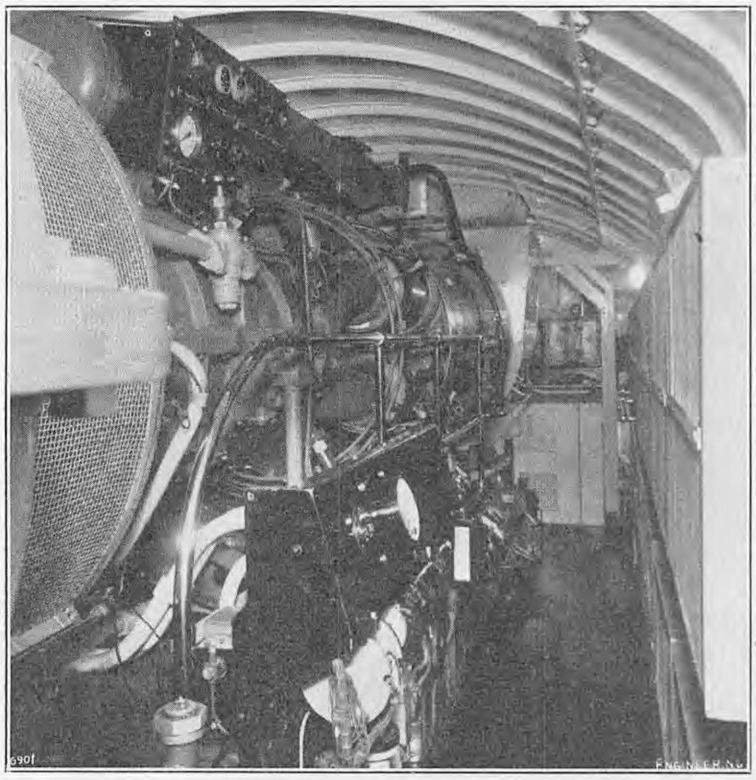


FIG. 5.

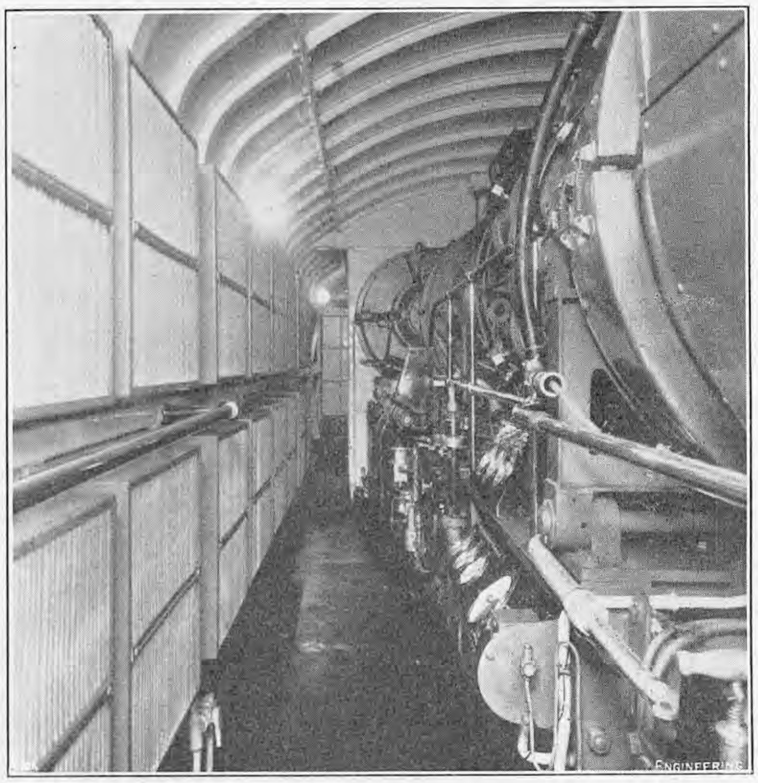


FIG. 6.

FIGS. 5 AND 6. SIDE AISLES IN TURBINE COMPARTMENT, SHOWING AIR FILTERS.

The third main generator and the auxiliary generator form a similar tandem pair, and the yokes of both tandem sets are bolted side by side to make up the generator group. An exciter is overhung from the auxiliary generator. Each main generator is a self-ventilated direct-current 6-pole compensated interpole machine, the field being fed from the exciter, as shown in Fig. 4, opposite. The ratings to B.S. 173-1941 for Class B insulation are as follows: continuous, 1,100 amperes, 666 volts, 1,600 r.p.m.; one hour, 1,250 amperes, 580 volts, 1,600 r.p.m.; maximum voltage, 825; maximum current, 2,200 amperes. The auxiliary generator and exciter are also self-ventilated direct-current machines. The former has six main poles and interpoles and is shunt-excited under the control of a voltage regulator to give 110 volts irrespective of its load and the turbine speed. Its B.S. continuous rating (Class B insulation) is 65 kW, 110 volts, 1,280 r.p.m. The exciter has six main poles and interpoles and is excited by three windings—a separate excitation fed from the 110-volt auxiliary mains, a separate excitation regulated by the automatic output-control gear, and a reverse compound excitation directly proportional to the main generator total-load current. Its B.S. continuous rating (Class B insulation) is 10·5 kW, 55 volts, over a speed range of 1,280 to 1,600 r.p.m.

The six traction motors are separately-ventilated four-pole series and interpole machines. Each is carried on its axle by plain suspension bearings and has roller bearings on its armature. The nose side of the motor yoke is suspended from the adjacent bogie transom by a link with a resilient rubber bush at each end. This form of suspension gives the freedom of movement which is necessary without the wear associated with the more conventional nose-suspension arrangements. The transverse location of the motor in the bogie is by another resilient rubber-bushed link between the motor end and the bogie frame. The chief object of this arrangement is to eliminate the uncontrolled lateral movement of the heavy mass of the motor along the axle, which is inimical to good riding at high speeds. A secondary but important advantage is the elimination of thrust wear on the bearing, which is generally the critical factor in suspension-bearing maintenance. The ratings of the motor, to B.S. 173-1941, for Class B insulation and a ventilation air flow of 2,500 cub. ft. per minute, are: continuous, 550 amperes, 666 volts, 706 r.p.m. (33·5 m.p.h.); one hour, 650 amperes, 565 volts, 580 r.p.m. (27·5 m.p.h.); maximum current, 1,100 amperes; and maximum voltage, 825.

The drive to the axle is by single-reduction spur gearing of 21 : 58 gear ratio and 2·066 diametral pitch. The gearwheel is torsionally resilient, the rim being separate from the centre but mounted on it through a series of resilient rubber bushes which permit a small relative torsional movement. Such an arrangement cushions the transmission of shocks from the rail to the motor armature, particularly at rail joints or other irregularities, and reduces the corresponding stresses in rails, gear teeth, armature shaft and other armature parts, and contributes to better riding of the vehicle as a whole and to reduced maintenance. The gearwheel centre, rim and pinion are steel forgings. The teeth are cut after the blanks have been hardened by oil quenching.

(To be continued.)

LITERATURE.

Hydraulik und Wasserbau auf Neuen Grundlagen.

By A. SCHÄFER. Franckh'sche Verlagshandlung, Stuttgart, Germany. [Price 35 DM.]

THE title of this book suggests a new approach to basic hydraulics and hydraulic engineering, and, in fact, it does take the form of an engineer's notebook rather than a treatise on the subject. It comprises 45 main sections with appropriate subdivisions which attempt to classify with a fair measure of success the practical problems encountered in the design of hydraulic structures. A brief introduction to the fundamentals of flow in pipes includes useful data on the effects of branch pipes, valves, parallel pipes, syphons, diffusers, Venturi meters, and flow between reservoirs at different levels. Considerable attention is devoted to the determination of critical depth and of hydraulic jump in open channels which contain contractions and submerged weirs. There are also some interesting notes and diagrams relating to the location of power stations, and of weirs in open channels. This study is extended to cover the effect of discharge into waterways through sluice gates, and of the ejector action for increasing discharge or lowering the level at the outlet of a turbine draft tube.

The treatment of backwater curves examines silting and erosion problems, and the estimation of standing waves introduces friction, damping, and the effect of lakes or changes in the width and depth of the channel. The influence of standing waves on the speed and manœuvrability of vessels in the channel is referred to. Hydraulic turbines and pumps are briefly dealt with on conventional lines, with a passing reference to underwater generating plants. The short sections dealing with surge chambers and the hydraulic ram are rather elementary. The interesting data and exercises concerning the equipment and the emptying and filling of navigation locks is extended subsequently to cover the effects of these operations on the vessels in lockage. Ground-water problems, with particular reference to earth and rock-filled dams, are concisely reviewed; and the useful introduction to devices for the destruction of energy accompanying discharge of water over and under various forms of gate is simple, but unusual. The final section of the book is devoted mainly to various forms of gates and mentions vibration, its causes and prevention. The important question of sealing is excellently treated and this also applies to the calculation of the static and dynamic forces on drum, segment and bear-trap types of gates of somewhat unusual form, as well as the application of circular arched beams to free roller-type gates.

Higher mathematics are avoided throughout and, where intractable equations are involved, useful approximate or empirical formulæ, based on practical experience or model tests, are often provided as the basis for more accurate solutions. The liberal use of diagrams and numerical examples of a practical character makes this book one that can be followed by those unaccustomed to the German language and its technical terms. It is a valuable introduction to more specialised treatises on particular problems, and should also form a useful text for those students of hydraulics who aim to include the German language in their technical equipment, since the sections are sufficiently short to constitute interesting exercises in translation, while, at the same time, treating important technical problems.

MANCHESTER-SHEFFIELD-WATH RAILWAY ELECTRIFICATION.

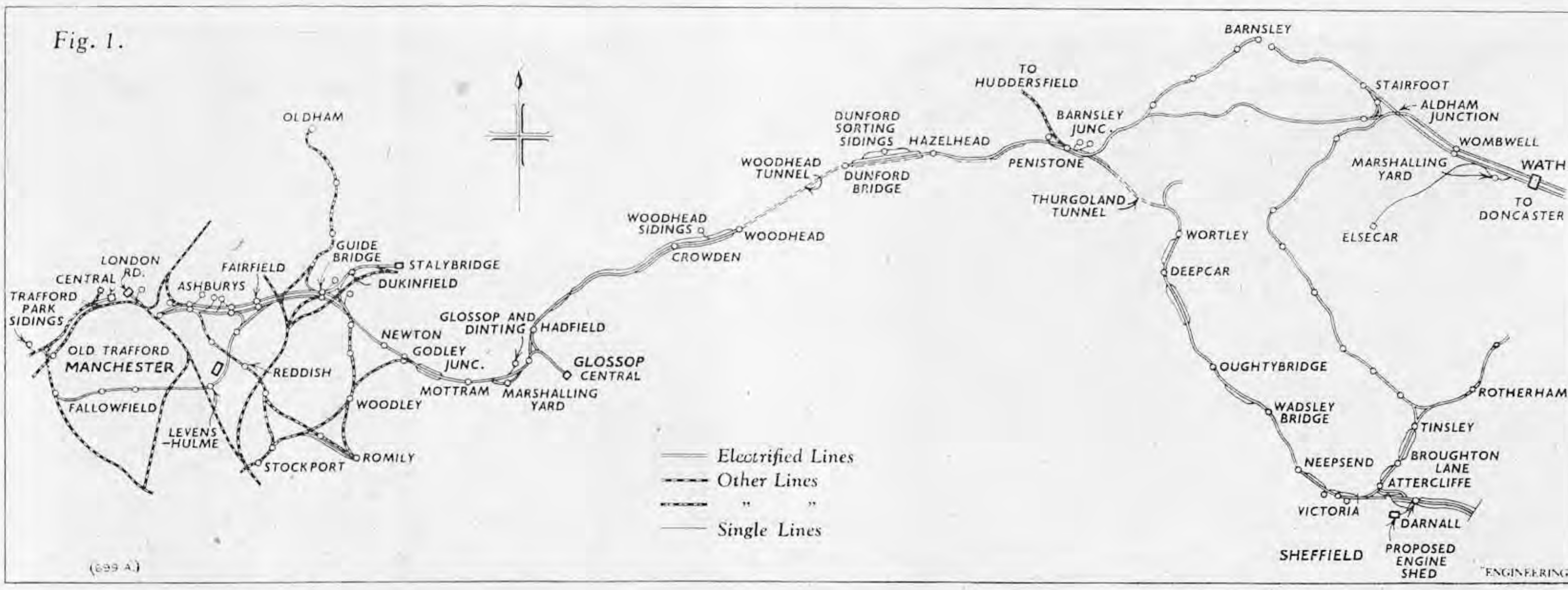


Fig. 1.

ELECTRIFICATION OF THE MANCHESTER-SHEFFIELD-WATH RAILWAY.

THE first stage of the Manchester-Sheffield-Wath-on-Dearne electrification scheme of British Railways was opened for traffic on Monday, February 4, though for some weeks a limited number of trains have been worked electrically. This stage, as shown on the map reproduced in Fig. 1, comprises the section from Wath to Dunford Bridge, a distance of 17 miles. Of this, the portion from Wath to Barnsley Junction is used entirely for freight traffic, while that from Barnsley Junction to Dunford Bridge forms part of the main line from Sheffield to Manchester, which is also undergoing electrification.

Power for the first stage of the scheme is being supplied from the British Electricity Authority's network through a substation at Aldham, and is transmitted thence at 33 kV through cables laid alongside the track to substations at Aldham Junction, Strafford Crossing, Barnsley Junction and Dunford. These cables, which were manufactured by Messrs. W. T. Henley's Telegraph Works Company, Limited, 51, Hatton Garden, London, E.C.1, are of the three-core screened single lead-covered and single wire-armoured and served type, and are normally carried on cast-iron hangers mounted on concrete posts. The supervisory control, telephone and protection circuits are carried in seven and four-star quad pilot cables, which are mounted on the same posts, creosoted wooden battens being fitted to hangers to give additional support. Where obstructions are encountered, the cables are housed in pre-cast concrete troughing, which is laid so that the lids are at surface level; and where the tracks are crossed, asbestos-cement ducts are placed in concrete some 6 ft. below the rail level.

As subsidence is likely on the section between West Silkstone Junction and Wath, owing to the presence of underground mine workings, specially long reinforced-concrete posts have been installed as supports, as shown in Fig. 2, the cables being carried on these in asbestos-covered steel troughing. Concrete cable bridges have been inserted in this troughing mid-way between the posts and slack cable has been provided at the track crossings. These arrangements were adopted as the result of observations made over a period of two years on an experimental route. The longest continuous run of 33-kV cable is 583 yards; it was installed in the Oxspring tunnel, where the restricted clearance did not permit a straight-through joint to be made. Barrier joints are installed on the section between Barnsley Junction and Strafford Crossing, which includes the Wath Bank with a gradient of 1 in 40 for about two miles. Near Aldham Junction both the 33-kV and the pilot cables are being carried temporarily on double and single catenaries, and

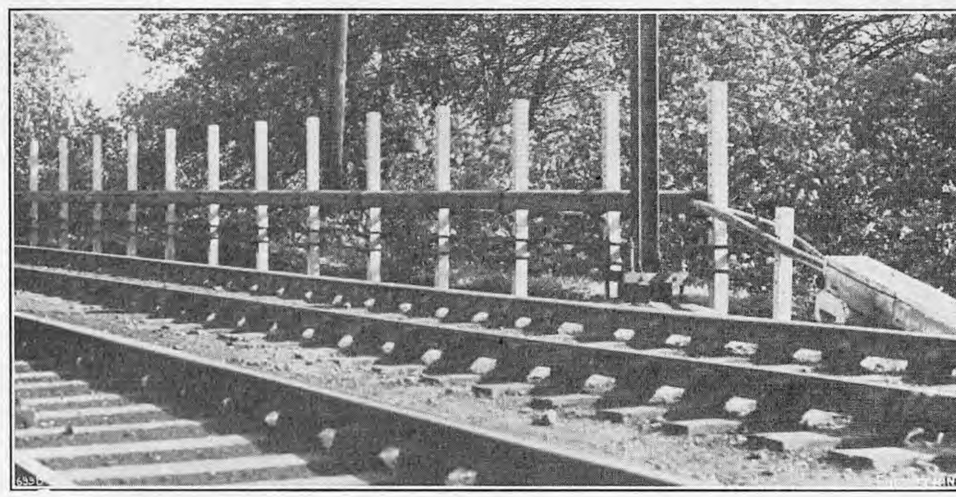


FIG. 2. 33-KV CABLE INSTALLATION.

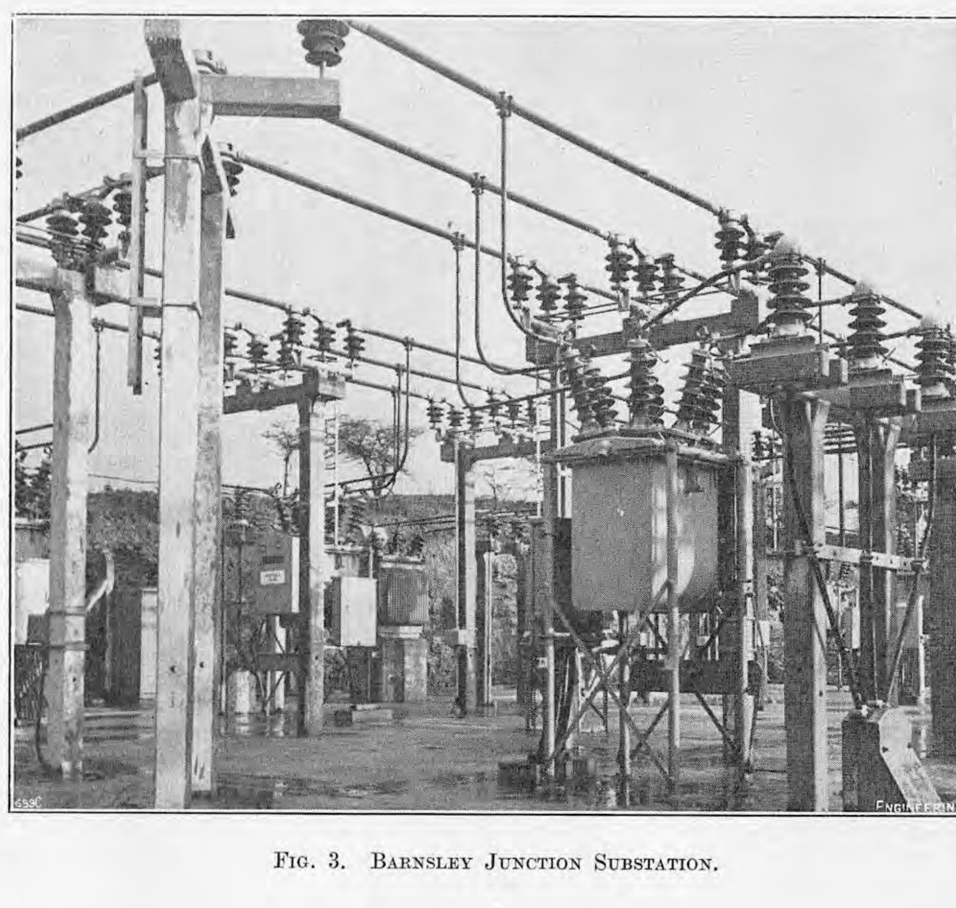


FIG. 3. BARNSLEY JUNCTION SUBSTATION.

MANCHESTER-SHEFFIELD-WATH RAILWAY ELECTRIFICATION.

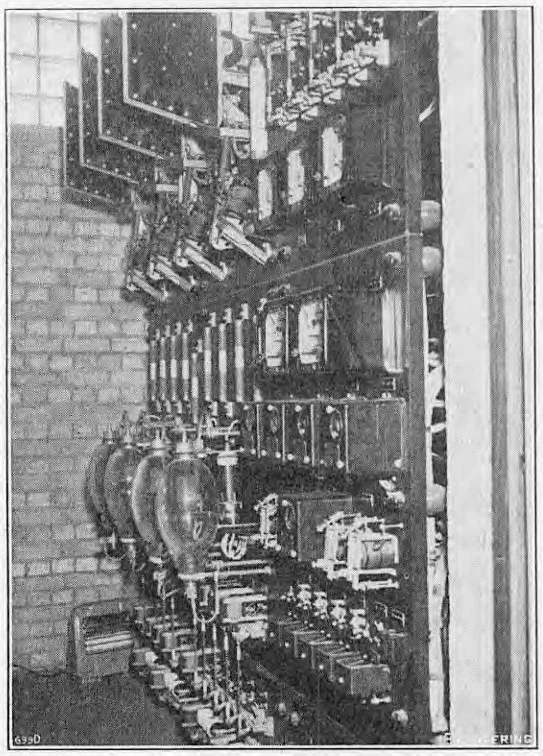


FIG. 4. REGENERATING EQUIPMENT AT BARNSLEY JUNCTION.

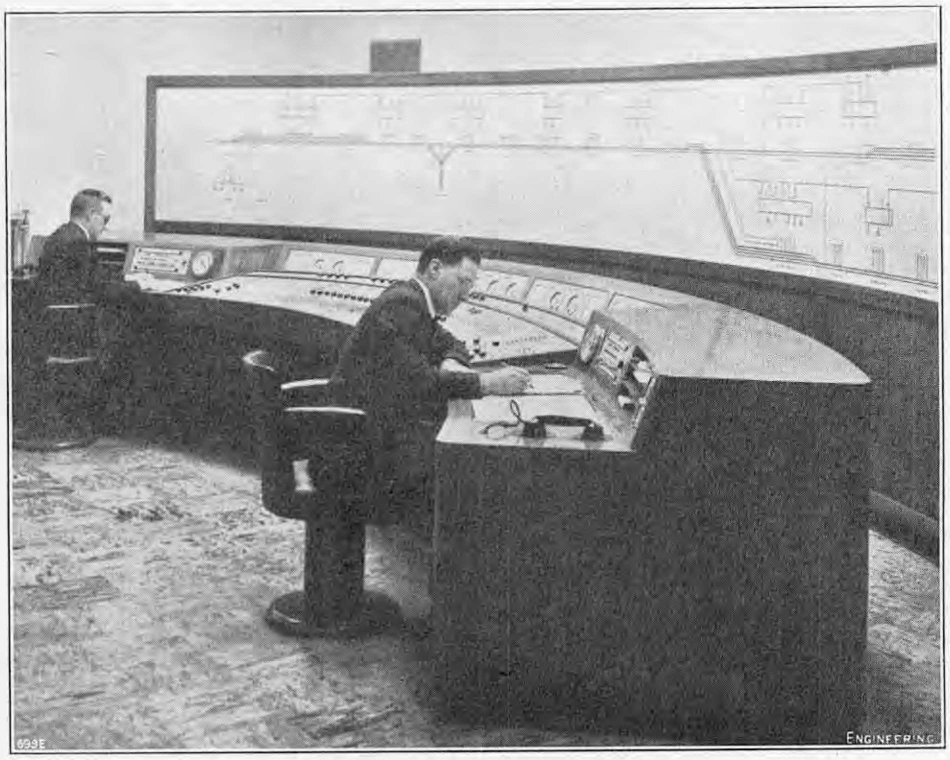


FIG. 5. PENISTONE CONTROL ROOM.

the existing bridge over the Dearne and Dove canal is being replaced.

The 33-kV cables are looped into the four substations mentioned above through ironclad switchgear, which was made by Messrs. A. Reyrolle and Company, Limited, Hebburn, Co. Durham. One of the substations is shown in Fig. 3, opposite. Three of these substations each contain two 12-anode steel cylinder rectifiers, which were supplied by Messrs. Bruce Peebles and Company, Limited, Edinburgh, while that at Barnsley Junction is equipped with three similar units. All these rectifiers are rated at 2,500 kW, but are capable of carrying loads up to 10,000 kW for short periods. The total installed capacity on this section of the line is therefore 22,500 kW. All the substations are equipped with protective relays as well as with local control and remote supervisory gear. Direct-current smoothing equipment and auxiliaries are also provided. The cathode of each rectifier is connected to the direct-current positive 'bus-bar through a high-speed circuit-breaker with a continuous rating of 2,000 amperes, which is arranged to trip on reverse currents exceeding 2,500 amperes. Connections are made thence to the overhead traction system through 1,600-ampere high-speed circuit-breakers, which are calibrated in 500-ampere steps from 3,000 amperes to 5,000 amperes, so that they trip on excessive forward current. Similar circuit-breakers are installed in the track sectioning cabins, which are located between most of the substations to limit the voltage drop and to enable faults to be cleared with certainty.

All these circuit-breakers, which were manufactured by the British Thomson-Houston Company, Limited, Rugby, are magnetically held and tripped by a series-turn diverting flux from the holding armature. They are capable of interrupting a short-circuit in less than 0·022 second. They are shelf-mounted between brick dividing partitions and sheet-steel front doors are fitted to the cubicles thus formed to facilitate maintenance. The positive 'bus-bars and the isolators associated with each breaker are mounted under the shelves. The supply for operating the closing and holding circuits is taken from the 1,500-volt 'bus-bars, the equipment for this purpose also being enclosed in cubicles. All the rectifier circuit-breakers are arranged to close automatically as part of the starting operations and their positions are indicated in the central control station at Penistone.

The substations at Strafford Crossing and Barnsley Junction are equipped with multi-stage resistance units for dissipating the power returned to line when regenerative braking is being used in the locomotives and there is no other load on the system. These units, which were also supplied by the British Thomson-Houston Company, are made up of four sections, each of which is capable of absorbing 150 amperes at 1,500 volts. They are automatically controlled by thyratrons which close contactors across the direct-current 'bus-bars at the substations within a few milliseconds of regeneration causing the voltage to rise and before it has increased to a value likely to cause damage. As the regenerated current falls, the four sections of the resistance are successively disconnected. A device is fitted which prevents the main loading contactors from being operated too frequently. This apparatus, in Barnsley Junction substation, is shown in Fig. 4.

Normally, both the substations and the track-sectioning cabins will be unattended and will be remote supervisory controlled from the control station at Penistone through the pilot cables mentioned above. The control equipment in this station, of which a view is given in Fig. 5, includes an indicating master control panel, which may be connected as required to any substation or track-sectioning cabin for operational purposes and the position of the equipment therein indicated. The extra high-tension and direct-current voltages and the rectifier output can also be ascertained. The control desk is illuminated by twenty 4-ft. 40-watt warm-white fluorescent lamps, which were supplied by the General Electric Company, Limited, Kingsway, London, W.C.2, and are installed in sets of four above the five panels of a laylight, which is glazed with Morocco diffusing glass. Segments of white-flashed opal glass are inserted in these panels to coincide with the ends of the lamps. The illumination on the desk is about 34 lumens per square foot. Lighting in the vertical plane is also provided on the mimic diagram to give an illumination of 15 lumens per square foot. General lighting of the same intensity is obtained indirectly from thirty-four 4-ft. 40-watt lamps, which are arranged in a continuous cornice, 122 ft. long, round the four sides of the room.

The 1,500-volt overhead equipment, from which the current for traction is collected by the locomotives, has been installed by British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, and is generally similar in design to that used on the Liverpool-street-Shenfield line.* It consists of a main catenary of hard-drawn stranded copper, from which an auxiliary catenary is suspended by solid copper dropper wires. A solid grooved cadmium-copper contact wire, with which the pantograph collector makes contact, is in turn hung from the auxiliary catenary. The equivalent copper section of the system being 0·75 sq. in. Over the sidings the collecting equipment consists simply of a main catenary collecting wire. These collecting systems are supported on steel gantries, which are spaced about 210 ft. apart on straight runs, as shown in Fig. 6, Plate IX, while on curves cantilever structures of the type illustrated in Fig. 7, on the same Plate, are used. Where the number of tracks does not exceed four, broad flange beams are used as supports, but where there is a larger number lattice structures have generally been employed. At complicated crossings, and where there are large groups of sidings, compound structures with three or more masts are being employed, as will be clear from Figs. 8 and 9, Plate IX, while Fig. 10, Plate X, illustrates the arrangement of the switch gantry and feeders outside a substation. Where space is not available between the tracks for the masts, the overhead equipment is supported on head spans which cross all the tracks and are attached to tall masts erected in the cess.

As already mentioned, the major part of the route runs through areas where subsidence due to colliery workings is likely to occur. The track must therefore be packed up periodically to maintain the correct grading and provision has also had to be made in the design of the structures to maintain the height of the conductor wire relative to the tracks. All masts, bridges and cross-spans in these areas have therefore been made adjustable and the foundations and structures have been designed to withstand the additional stresses which will occur when the equipments are raised. The problems involved in carrying out this part of the work are discussed in a separate article which appears on page 180 of this issue.

The conversion of the Wath-Dunford Bridge section to electric traction has necessitated the alteration of the existing direct-current track circuits to

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

those of the alternating-current condenser-fed type with either double-rail or single-rail impedance bonds. All the semaphore distant signals on the main lines have also been converted to the colour-light type and moved to give increased braking distance. Where a distant signal was carried below a stop signal the two have been combined in one colour-light signal. In some cases it has been necessary to suspend the new signals in cages from the overhead line equipment and examples of this type of construction are illustrated in Fig. 12, Plate VIII. Colour-light signals containing 25-watt and 12-volt lamps have also been substituted for semaphore signals in certain cases, especially in the Penistone area, where the gantries and brackets interfered with the catenary equipment.

At Wath, Elsecar Junction and Wombwell Main Junction, where interchange between electric and steam locomotives takes place, colour-light signalling has also been installed, and points situated beyond the distances possible for mechanical working have been equipped with electrical machines operated by direct current at 110 volts. At Elsecar Junction and Wombwell Main Junction, the electrically-operated points and their associated colour-light signals are controlled from small panels fixed over the mechanical lever frames in the signal boxes and are electrically interlocked with them. One of these frames is illustrated in Fig. 13, Plate X. A new 90-lever mechanical frame has been installed at Barnsley Junction in connection with the additional locomotive facilities which have been provided at that place. The existing overhead open-wire communication circuits throughout the route have been replaced by paper-insulated lead-covered cables, which are generally carried on stakes. The new signalling and track circuits are supplied at 415 volts three-phase from the traction substations. This current is converted to 660-volt single-phase for transmission and is then stepped down to 110 volts at the various signals. Stand-by equipment, consisting of a 40-h.p. Diesel engine coupled to a 25-kVA 415-volt alternator, is installed at Aldham.

The contractors for this portion of the installation were the Siemens and General Electric Railway Signal Company, Limited, East-lane, Wembley, Middlesex, although some of it was carried out by the staff of British Railways.

(To be continued.)

THE ENGINEERING OUTLOOK.

VI.—THE MOTOR-VEHICLE INDUSTRY.

THE output of all motor vehicles from United Kingdom factories in 1951 was 6 per cent. lower, and output of cars 9 per cent. lower, than in 1950. This is disappointing, since the output of 758,000 vehicles in 1950 was a record and it seemed that the industry was well on the way to its goal of a million vehicles a year. Hopes of this were quickly dispelled when imports of sheet steel from the United States ceased abruptly at the beginning of 1951 and the industry had to accept a cut of 20 per cent. in its allocation. By strict economy in the use of steel and by concentrating to a greater extent on the production of chassis and knocked-down cars it was possible to minimise the effects of the cut, but a fall in output could not be avoided. Sheet is not the only scarce material—some alloy steels, drop forgings and zinc die-castings have also caused anxiety, though so far they have not curtailed output. Marketing problems added to the difficulties of the situation: for the first time since the end of the war the upward trend of exports was reversed. As is shown in Table I, herewith, and Table II, opposite, abridged from the *Monthly Digest of Statistics*, the exports of cars and chassis in 1951 numbered only 368,700, compared with 398,100 in 1950; and of commercial vehicles, 144,400 compared with 147,000. This was due partly to shipping difficulties in the early part of the year, but there was a serious deterioration in demand in some of the main markets, notably Australia and Canada. The prospect improved in the last few months of 1951, however, and the number of vehicles exported in November—52,140, valued at 20·5*l*. millions—was a record. The announcement that the United States is to make available 1,000,000 tons of steel, some of it in the form of sheet, gives some promise for a higher output in 1952, but the prospects are affected by many other factors, some of which are discussed below.

The burden of re-armament is particularly evident in the motor-vehicle industry, since, with diminished supplies of raw materials, it must attempt to reconcile the conflicting needs of defence, exports and the home market. The production for defence is not large in relation to the total output of the industry, though for some companies it constitutes an important part of their total orders. Ministry of Supply orders received by Leyland Motors, Limited, are valued at 7*l*. millions. Among the "Big Six" motor firms, the Rootes Group are stated to have orders for "several thousand" 3-ton Army general service lorries, as well as a one-ton "combat" vehicle. The Austin Motor Company took over an aircraft factory at Cofton Hackett, adjoining their Longbridge Works, and are producing large numbers of a four-wheel drive "jeep"-type Army vehicles. This is the biggest armament contract placed so far, enjoying a very high degree of priority; several companies are involved, including the Rover Company and the Standard Motor Company. Mr. L. P. Lord, vice-chairman of the new Nuffield-Austin merger, speaking at the annual general meeting of the Austin Motor Company in December, expressed the hope that the company's "immense programme of production for re-armament" would be additional to the normal output of cars and commercial vehicles. The Standard Motor Company have also had to increase capacity, and have purchased a new factory of 500,000 sq. ft. at Liverpool, to which they are transferring all their spares and service facilities in order to make room at Coventry for the production of the Rolls-Royce Avon turbo-jet engine. Among the smaller manufacturers, Alvis Limited have received an important contract for the manufacture of an armoured fighting vehicle which has been developed to operate on terrain hitherto regarded as impracticable for anything but a track-laying vehicle. Jaguar Cars, Limited, have a contract to build Meteor engines for tanks and are expected to require an extra 2,000 hands at their new Browns-lane factory. It is understood that a quarter of the factory area of 1 million sq. ft. is to be devoted to the production of the Meteor engine.

Even if the total of defence orders does not impose a great strain on the capacity of the industry, it makes heavy claims on the supply of raw materials. Military vehicles, because of their four-wheel drive and the need for greater toughness, require more of the scarce materials, particularly alloy steels, than an equivalent number of civilian vehicles; and, in the competition for priorities, the home market is inevitably the loser. In 1951, the home market quota for cars was fixed at 80,000, but, as a stimulus to production, manufacturers were given permission to place on the home market any production in excess of 460,000. For 1952, this concession has been withdrawn, and Mr. R. A. Butler, the Chancellor of the Exchequer, has announced that the quota of private cars must be reduced to 60,000. The increased imports of steel from the United States may, of course, change this, though there are many claimants for the additional supplies.

TABLE I.—UNITED KINGDOM: PRODUCTION OF PASSENGER CARS AND CHASSIS.*

—	Monthly Averages or Totals for Four-week or Five-week Periods.								Value of Deliveries.† (1,000*l*.). Monthly Averages or Calendar Months.	
	Total Production (Number).				Production for Export (Number).					
	Total.	1,600 c.c. and Under.	Over 1,600 and not over 2,200 c.c.	Over 2,200 c.c.	Total	1,600 c.c. and Under.	Over 1,600 and not over 2,200 c.c.	Over 2,200 c.c.	Total.	For Export.
1948	27,376	19,832	5,522	2,022	19,350	15,567	2,623	1,160	9,385	5,272
1949	34,358	23,343	6,160	4,855	22,683	15,853	3,805	3,025	12,059	6,441
1950	43,543	29,411	7,463	6,669	34,126	24,587	5,448	4,091	15,746	10,374
1949—Oct. ..	37,678	25,265	6,879	5,534	24,463	17,620	3,357	3,486	13,539	7,277
Nov. ..	37,178	25,696	5,390	6,092	27,865	19,708	4,115	4,042	14,381	8,783
Dec.‡ ..	41,280	28,406	6,233	6,641	28,584	20,934	3,319	4,331	13,740	7,875
1950—Jan. ..	39,657	27,389	6,462	5,806	31,860	23,200	4,820	3,840	12,879	8,561
Feb. ..	40,694	27,655	7,067	5,972	32,620	23,431	5,178	4,011	14,949	10,352
March‡ ..	51,020	34,001	9,163	7,856	41,192	28,749	6,818	5,625	17,744	12,164
April ..	38,314	26,268	6,622	5,424	29,776	21,524	4,867	3,385	13,790	9,053
May ..	42,794	28,948	7,628	6,218	34,911	25,205	6,072	3,634	16,062	11,156
June‡ ..	50,028	34,173	8,777	7,078	40,480	29,763	6,332	4,385	16,556	11,387
July ..	43,456	29,575	8,118	5,763	34,435	25,700	5,424	3,311	16,436	10,832
Aug. ..	30,747	20,956	5,356	4,435	24,282	17,641	3,970	2,671	12,592	8,550
Sept.‡ ..	49,538	33,291	8,365	7,882	37,976	27,083	6,361	4,532	16,440	10,744
Oct. ..	45,391	30,215	7,506	7,670	34,701	24,456	5,455	4,790	16,880	10,564
Nov. ..	46,514	30,460	7,558	8,496	34,742	24,651	5,219	4,872	19,045	11,883
Dec.‡ ..	44,362	30,005	6,929	7,428	32,535	23,643	4,855	4,037	15,574	9,237
1951—Jan. ..	41,202	26,884	6,541	7,777	30,570	21,868	3,999	4,703	15,572	9,169
Feb. ..	40,380	27,643	5,734	7,003	29,773	22,069	3,834	3,870	15,068	8,194
March‡ ..	41,592	29,510	5,655	6,427	31,067	23,170	4,127	3,770	18,545	12,266
April ..	38,418	27,225	5,722	5,471	31,930	23,841	4,406	3,683	15,092	10,413
May ..	38,177	26,396	5,511	6,270	31,297	23,174	4,167	3,956	16,142	11,195
June‡ ..	44,740	30,731	6,440	7,569	34,731	25,753	4,478	4,500	16,110	10,455
July ..	38,495	26,406	5,644	6,445	27,160	18,757	4,331	4,072	16,732	10,223
Aug. ..	25,971	16,658	4,217	5,096	20,658	13,672	3,708	3,278	13,269	9,063
Sept.‡ ..	44,478	31,529	7,024	5,925	36,420	26,694	5,951	3,775	15,761	11,257
Oct. ..	41,933	29,350	6,536	6,047	32,144	24,267	3,893	3,984		
Nov. ..	41,157	29,231	5,599	6,327	33,554	26,014	3,695	3,845		
Dec. ..										

* Including taxi-cabs. † Including spares. ‡ Five-week period.

In a statement issued in August, the Society of Motor Manufacturers and Traders protested that, "discounting any other considerations, the day is long past when the car was regarded as an instrument of luxury-class pleasure; it is needed in numbers at home to perform economically the countless industrial and commercial uses in which it is a vital link." Sir Reginald Rootes, deputy-chairman of the Rootes Group, attacked the purchase tax, stressing the need for plentiful and cheap transport: "Dearer transport for man and goods," he said, "can only inflate costs. We must all of us keep up a continuous representation until a saner appreciation of economics achieves the necessary result." That the reduction of purchase tax is as essential as removal of the arbitrary quota if the home market is to get all the cars it needs was brought out by Mr. G. E. Beharrell, President of the Society of Motor Manufacturers and Traders, at the annual Motor Show dinner in October. He said that, in 1938, the minimum net income required to run a car was considered to be £450 a year, whereas to-day a minimum income of £1,250 was needed. A low-priced car in 1938 cost the equivalent of 24 weeks' earnings of the average wage-earner in the motor industry, but to-day, though earnings are twice as high, 45 weeks' earnings would be required. While few would dispute the desira-

MANCHESTER-SHEFFIELD-WATH RAILWAY ELECTRIFICATION.

(*For Description, see Page* 164.)

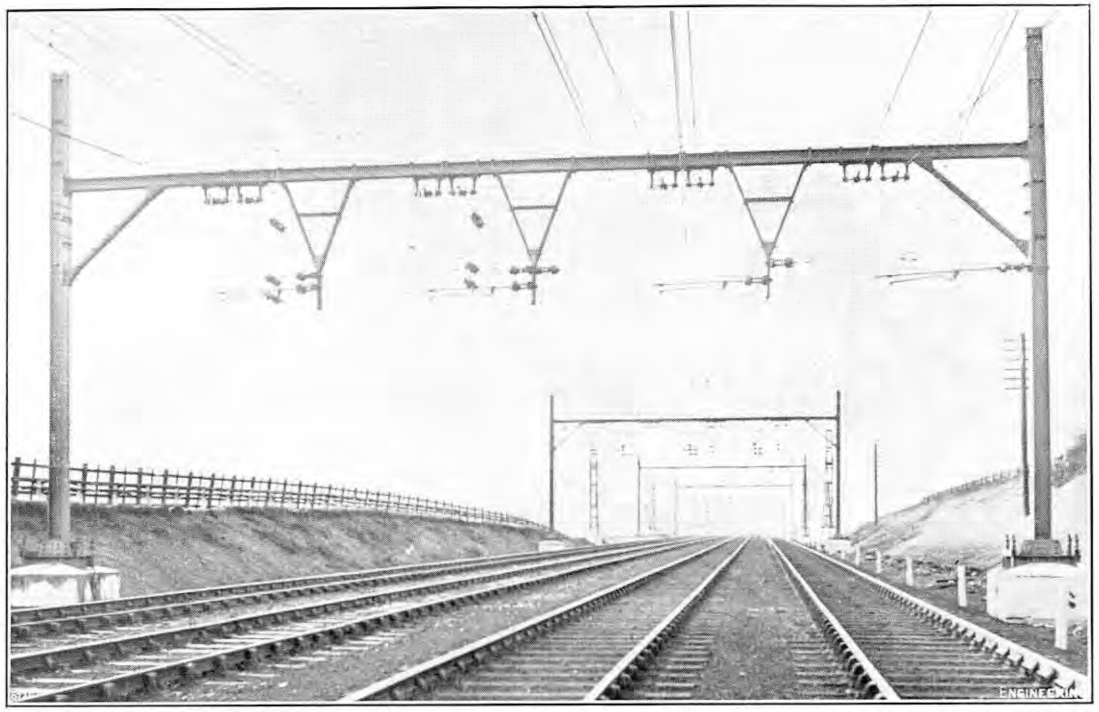


FIG. 6. FOUR-TRACK OVERLAP SPAN.

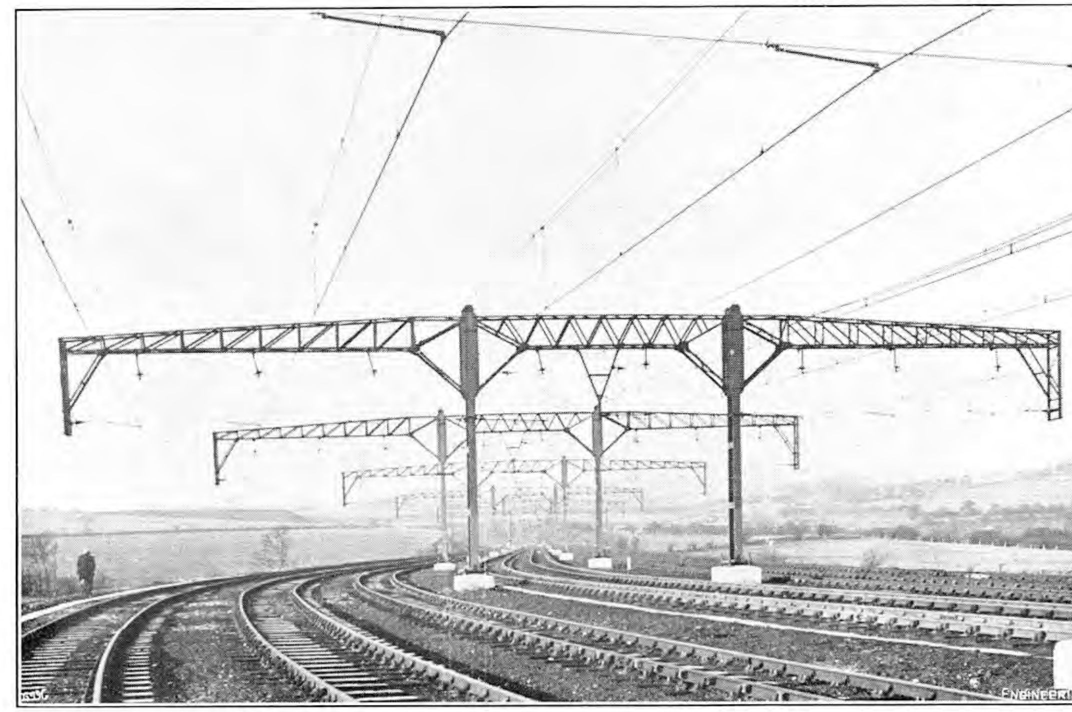


FIG. 7. CANTILEVER STRUCTURES AT WOMBWELL.

FIG. 8. OVERHEAD EQUIPMENT IN WATH YARD.

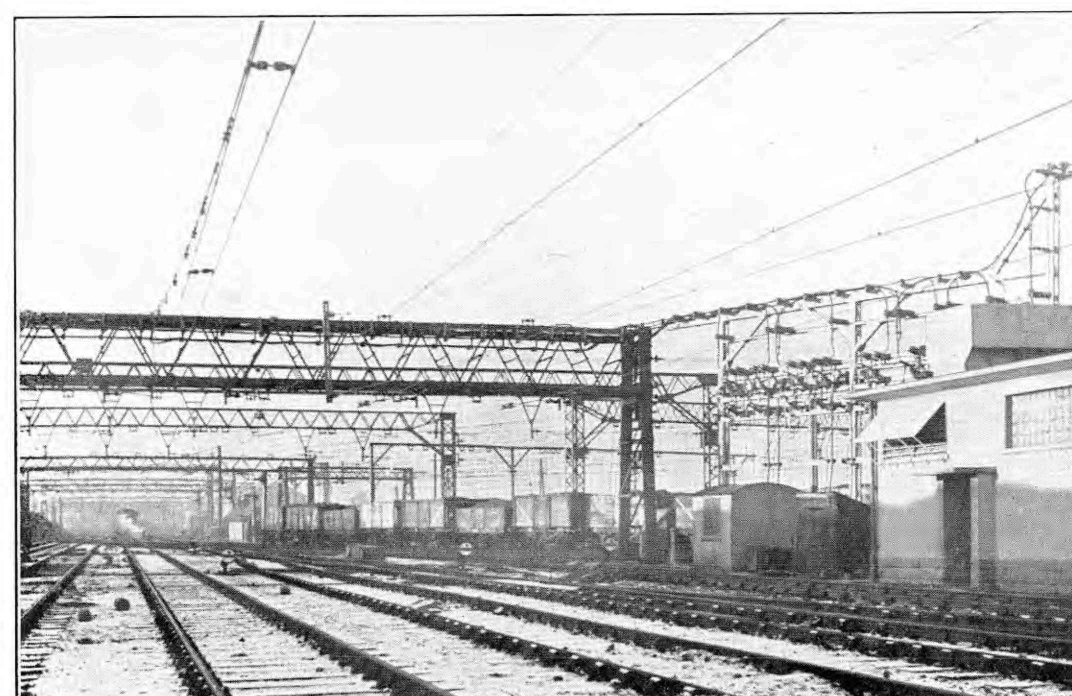


FIG. 9. EQUIPMENT AT BARNSLEY JUNCTION.

MANCHESTER-SHEFFIELD-WATH RAILWAY ELECTRIFICATION.

(*For Description, see Page* 164.)

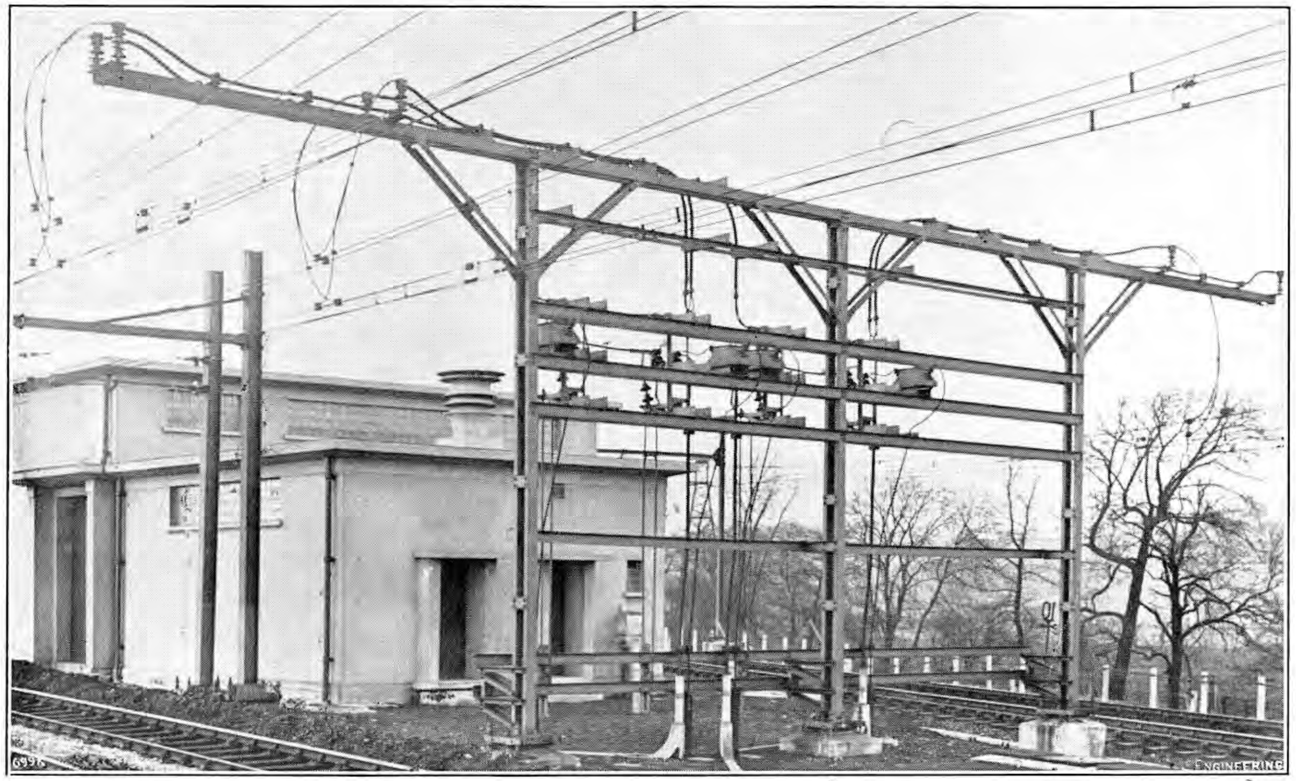


Fig. 10. Substation Switch Gantry and Feeders at Aldham Junction

Fig. 11. Up Goods Signal at Wath.

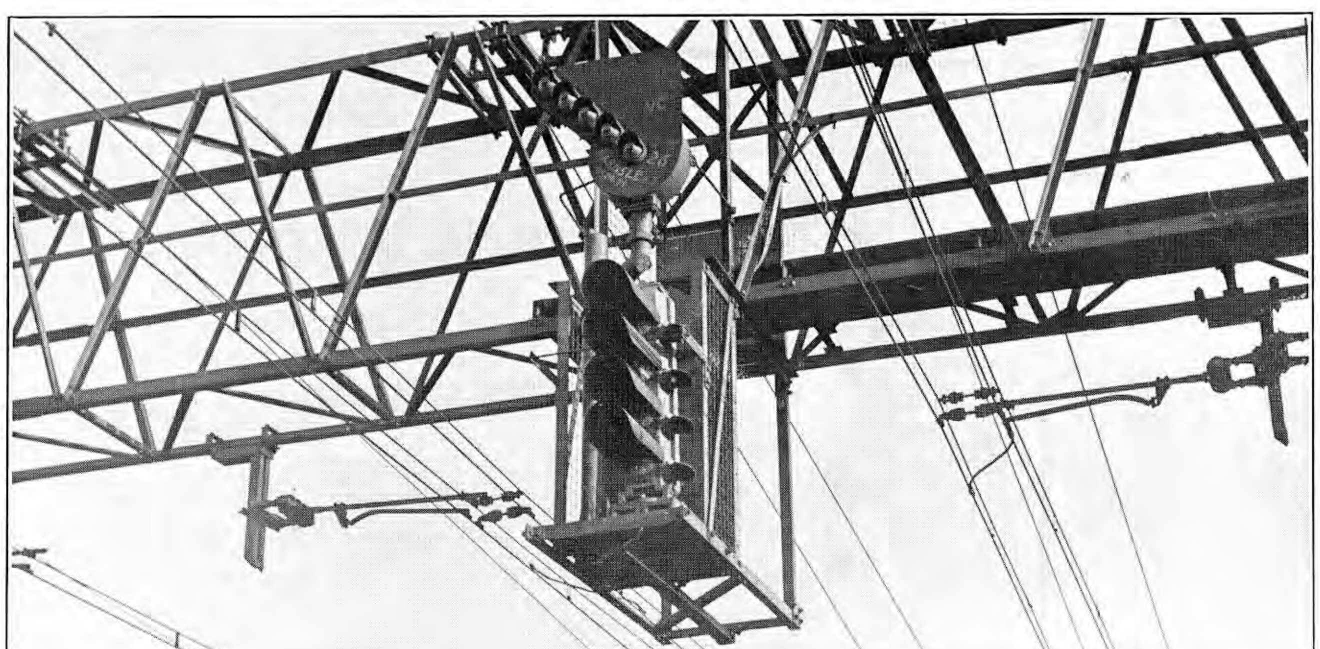


Fig. 12. Colour-Light Signals and Indicator at Barnsley Junction.

Fig. 13. Key-Switch Panel at Wombwell Junction Signalbox.

bility of a larger home market for cars, particularly when it is remembered that 1·5 million of the 2·4 million cars now on the road are between 12 and 20 years old, it is doubtful whether, in the long run, it will absorb as many cars in a year as is generally supposed.

Like many other export industries, the motor-vehicle industry considers that a healthy home market is of great importance in maintaining exports. The statement of the S.M.M.T., quoted above, goes on to stress that an increase in the allocation of cars to the home market would give more scope for the absorption of rising costs of production and that this would assist in keeping overseas prices competitive in times when foreign cars are making quick headway in the export markets, particularly on the Continent. This comes very near to advocating dumping, a practice which has been condemned by the industry when done by others. Quite apart from this, the motor industry should be prepared to see the high degree of protection that it now enjoys on the home market substantially reduced if the American pressure to secure freer European trade succeeds.

TABLE II.—UNITED KINGDOM: PRODUCTION OF COMMERCIAL VEHICLES AND CHASSIS.*

—	Monthly Averages or Totals for Four-week or Five-week Periods.										Value of Deliveries† (£1,000): Monthly Averages or Calendar Months.	
	Total Production (Number).					Production for Export (Number).						
	Carrying Capacity.					Carrying Capacity.						
	Total.	Under 15 cwt.	15 cwt. to 6 tons.	Over 6 tons.	Public Service Vehicles. ‡	Total.	Under 15 cwt.	15 cwt. to 6 tons.	Over 6 tons.	Public Service Vehicles. ‡	Total.	For Export.
1948	14,169	5,146	7,458	496	1,069	6,983	2,804	3,562	193	424	9,125	3,460
1949	18,031	8,054	8,175	591	1,211	8,898	4,339	4,068	206	284	10,613	3,795
1950	21,763	10,014	10,249	555	945	13,736	6,709	6,509	202	316	12,163	5,764
1949—Oct. ..	19,760	9,553	8,463	567	1,177	10,071	5,390	4,280	115	286	10,838	4,028
Nov. ..	19,879	9,418	8,725	498	1,238	11,164	5,792	4,871	160	341	12,046	4,777
Dec.§ ..	21,725	9,887	9,603	700	1,535	11,852	6,473	4,759	207	413	11,900	4,630
1950—Jan. ..	19,341	9,418	8,328	469	1 126	12,055	6,485	5,154	130	286	10,650	4,647
Feb. ..	20,630	9,870	9,069	549	1,142	13,190	6,884	5,817	175	314	12,667	5,506
March§ ..	26,346	12,049	12,359	665	1,273	17,049	8,263	8,207	234	345	13,126	6,185
April ..	20,203	9,545	9,153	662	843	13,022	6,623	5,954	164	281	11,987	5,207
May ..	22,189	10,529	10,193	514	953	14,820	7,444	6,856	245	275	12,401	6,458
June§ ..	25,318	11,424	11,950	808	1,136	15,638	7,434	7,632	184	388	14,120	6,334
July ..	20,339	9,714	9,659	303	663	12,987	6,352	6,256	123	256	11,139	5,575
Aug. ..	16,164	7,163	7,759	390	852	10,138	4,787	4,845	172	334	9,488	4,720
Sept.§ ..	24,354	11,158	11,892	464	840	15,504	7,743	7,211	212	338	12,969	6,360
Oct. ..	21,753	9,329	10,979	545	900	13,560	6,227	6,735	227	371	12,757	6,210
Nov. ..	21,817	9,593	10,839	682	703	13,435	5,976	6,898	301	260	13,281	6,518
Dec.§ ..	22,703	10,370	10,805	612	916	13,431	6,290	6,538	251	352	11,371	5,452
1951—Jan. ..	21,867	9,896	10,441	739	791	14,806	7,364	6,881	248	313	12,409	6,400
Feb. ..	22,634	10,565	10,446	663	960	14,720	7,119	6,990	240	371	12,554	6,104
March§ ..	23,795	11,562	10,280	912	1,041	14,234	7,069	6,274	415	476	14,025	6,797
April ..	21,471	9,871	9,688	956	956	13,500	6,309	6,361	360	470	13,623	6,859
May ..	20,764	9,289	9,536	969	970	13,463	6,395	6,242	307	519	13,692	6,857
June§ ..	23,448	11,235	9,892	1,146	1,175	14,523	7,221	6,161	491	650	13,708	6,669
July ..	19,918	9,801	8,234	1,028	855	10,858	6,063	3,819	539	437	14,371	6,256
Aug. ..	14,943	6,141	7,213	874	715	9,420	3,870	4,752	399	399	12,314	6,435
Sept.§ ..	23,936	11,405	10,439	1,193	899	15,051	7,570	6,500	557	424	15,416	7,767
Oct. ..	21,810	9,709	10,037	1,183	881	13,747	6,390	6,353	603	401		
Nov. ..	21,842	9,893	9,834	1,289	826	14,317	6,688	6,680	554	395		

* Battery-driven electric road vehicles are excluded. † Including spares. ‡Including trolley-buses, but not tramcars; figures refer to production of chassis. § Five-week period.

TABLE III.—UNITED KINGDOM: EXPORTS OF NEW CARS AND CHASSIS.

—	Number.			Value (£1,000).		
	1949.	1950.	1951.	1949.	1950.	1951.
Complete Cars.						
Ireland	7,183	8,144	11,558	1,853	2,034	2,908
South Africa	15,538	19,313	22,601	5,037	4,494	6,031
India	5,577	10,378	11,746	1,662	2,673	3,262
British Malaya	5,273	5,910	13,610	1,531	1,871	4,967
Ceylon	2,760	2,516	4,639	764	729	1,546
Australia	51,616	76,246	58,402	18,407	28,233	23,040
New Zealand	9,054	16,380	29,662	2,257	4,539	10,519
Canada	31,205	76,229	27,391	7,814	21,504	8,422
Sweden	3,376	23,647	16,302	1,003	7,378	5,519
Belgium	11,621	12,955	11,163	3,273	3,810	3,631
Switzerland	5,285	5,154	3,311	1,738	1,924	1,384
Portugal	3,761	2,623	2,186	1,060	791	728
United States	6,686	19,977	19,807	1,847	6,062	7,408
Brazil	7,882	7,176	9,209	2,580	2,363	3,609
Other Countries	51,800	56,661	67,532	15,985	19,066	25,234
Total	218,617	343,309	309,119	66,811	107,471	108,208
Chassis.						
Australia	33,130	45,916	48,940	4,874	7,270	8,416
Other British countries ..	2,939	4,060	6,157	519	818	1,412
Foreign countries	3,257	4,838	4,521	608	1,006	1,127
Total	39,326	54,814	59,618	6,001	9,094	10,955
Total, complete cars and chassis	257,943	398,123	368,737	72,812	116,564	119,163

There can be no question in the present economic crisis about the desirability of maintaining exports of motor vehicles. They were valued at 253*l*. millions in 1951, representing nearly 11 per cent. of all British exports. As will be seen from Tables III, IV, V, and VI, taken from the *Trade and Navigation Accounts of the United Kingdom*, the number of cars and chassis exported was 7·5 per cent. lower than in 1950, and the number of commercial vehicles 2 per cent. lower. The most serious drop occurred in the Canadian market, to which only 27,400 cars were exported in 1951, compared with 76,200 in 1950. In both the United States and Canada, re-armament has brought a restriction in consumer credit. When, in Canada, during the autumn, it became necessary for a buyer to put down 50 per cent. of the price of a new car as an initial instalment and to clear the balance within 12 months, the market slumped, sales of British cars falling more than sales of American cars. So serious was the position that it was thought advisable to return to Britain 3,500 of the unsaleable cars. The losses to be borne by the British manufacturers are even more serious than this would indicate, for very heavy outlays have been incurred in setting up the selling organisations which built up sales from almost nothing in 1947 until Canada became the second biggest market for British cars in 1950. An extension of the period of payment to 18 months means a slight easing of credit restrictions in Canada, but it will probably not influence the sales of British cars greatly. There is, however, at least some hope that there will be a further relaxation of restrictions as conditions improve.

TABLE IV.—*United Kingdom: Exports of Cars, by Types.*

—	Number.		Value (£1,000).	
	1950.	1951.	1950.	1951.
Complete Cars.				
Assembled—				
Not exceeding 1,000 c.c.	29,024	31,199	7,265	8,498
Exceeding 1,000 c.c. but not 1,600 c.c. ..	166,332	136,745	47,955	45,970
Exceeding 1,600 c.c. but not 2,200 c.c. ..	47,782	37,226	19,149	17,010
Exceeding 2,200 c.c. but not 2,800 c.c. ..	19,172	20,364	8,252	9,903
Exceeding 2,800 c.c. but not 3,500 c.c. ..	4,421	5,091	3,281	4,027
Exceeding 3,500 c.c. ..	7,982	3,674	5,318	3,609
Unassembled—				
Not exceeding 1,000 c.c.	10,032	9,849	2,004	2,037
Exceeding 1,000 c.c. but not 1,600 c.c. ..	45,173	50,335	10,331	12,726
Exceeding 1,600 c.c. but not 2,200 c.c. ..	5,135	5,140	1,693	1,781
Exceeding 2,200 c.c. but not 2,800 c.c. ..	7,379	9,284	1,818	2,546
Exceeding 2,800 c.c. but not 3,500 c.c. ..	44	20	29	14
Exceeding 3,500 c.c. ..	833	192	376	87
Total, complete cars	343,309	309,119	107,471	108,208
Chassis.				
Not exceeding 1,000 c.c.	3,550	1,504	439	230
Exceeding 1,000 c.c. but not 1,600 c.c. ..	33,915	43,236	5,207	7,540
Exceeding 1,600 c.c. but not 2,200 c.c. ..	11,851	9,723	2,467	2,174
Exceeding 2,200 c.c. but not 2,800 c.c. ..	5,426	4,922	929	880
Exceeding 2,800 c.c. ..	72	233	52	131
Total chassis ..	54,814	59,618	9,094	10,955
Grand Total ..	398,123	368,737	116,565	119,163

Conditions were somewhat easier in the United States market, where sales of British cars during the summer stood up well against a declining trend in sales of American-made cars. Later in the year, however, there was some considerable deterioration; in November and December, only 2,000 British-made cars were exported to the United States, compared with 5,000 in November and December, 1950. There is little hope of improvement in 1952. The output of cars in the United States is expected to continue at about four millions a year in 1952. This is considered by the Defence Transportation Administration to be the minimum necessary to maintain the 26 millions out of the 40 million cars on the road which "fill an essential need"

British exports of cars and chassis to the largest market, Australia, were lower in 1951 than in 1950, but this was partly due to shortage of shipping in the early months of the year The demand for ocean-going tonnage, particularly on the Australian shipping routes, has increased greatly as a result of rising world consumption of raw materials and the local wars in the Far East; motor-vehicle manufacturers are now trying to circumvent the difficulty by chartering their own ships. It was largely due to the use of such specially chartered tonnage that record exports to Australia were achieved in November. In December, there was again a falling off, only 4,300 cars being despatched, compared with 6,000 in December, 1950. This again is evidence of irregularity of sailings rather than of falling demand.

The prospects for maintaining sales in Australia, however, are not very bright. Mounting inflation in Australia has necessitated stringent financial controls. Income tax was increased in October and sales taxes were imposed on a wide variety of consumer goods; in the case of cars, this now amounts to 20 per cent. As a result, some orders for new cars have been cancelled and the heavy arrears of orders correspondingly reduced. General Motors Holden's, Limited, an Australian subsidiary of the General Motors Corporation of the United States, who are producing the Holden car at the rate of 20,000 per annum, state that they are not perturbed by the sales prospect. With the addition of sales tax, this American-type car was selling in October at 1,071*l*., compared with 968*l*. for the Austin A.40. Before the imposition of sales tax, the ordinary private user had to wait five years for delivery of a Holden car and the arrears are still considerable. Local manufacture and assembly of motor vehicles is to be further extended in Australia. The Ford Motor Company of Australia, a subsidiary of the Ford Motor Company of Canada, are undertaking an expansion scheme estimated to cost about 4*l*. millions at their plants at Sydney, Brisbane, Adelaide and Perth. It is planned to make motor-vehicle engines, including the V.8, in Australia for the first time. Leyland Motors, Limited, and John I. Thornycroft and Company, Limited, are to open factories near Sydney, and Joseph Lucas, Limited, are to make electrical equipment. These developments must, in the long run, bring about a fall in the value of British exports to Australia, and are particularly serious to those makers, such as the Austin and Morris companies, who ship their cars more or less complete and who, at present, are disposing of probably a tenth of their total output in Australia. The situation is apparently viewed with considerable concern, for both Lord Nuffield and Mr. L. P. Lord are to pay extended visits to Australia.

New Zealand is the third largest market for British cars, but takes only half as many as Australia; financial conditions there have been more stable, however, and British exports of cars in 1951, 33,000, increased by 80 per cent. compared with 1950. Exports of cars to most of the other Commonwealth countries and Colonies also increased in 1951, but this is a reflection of the fall in sales in Canada and Australia rather than evidence of improved demand from the countries concerned. The motor-vehicle industry is very practised in transferring shipments from one market to another and in altering plans at short notice as markets are arbitrarily opened and closed. It is not, however, a hopeful sign for the future course of demand that they are now having to concentrate more and more on the smaller markets. About 70 per cent. of the cars exported in 1951 went to Commonwealth countries, in which British manufacturers enjoy some degree of protection. Falling demand in the major Commonwealth countries will force them more and more into the smaller foreign markets, where they must encounter stiffer competition.

It does not augur well that exports to nearly all the European countries fell in 1951. Sales in some of them have been falling as a result of restrictions in consumer expenditure necessitated by re-armament, but the main reason for the diminution in British exports was increased competition from Continental small cars such as the Volkswagen, the Fiat and the small Renault. Germany exported as many cars in the first eight months of 1951 as in the whole of 1950. The French Renault factory produced 775 vehicles a day in October and was planning to increase this to 800 at the end of 1951 and to 1,000 at the end of 1952. Italian production and exports have also expanded greatly; in the first nine months of 1951, 24,000 motor vehicles were exported, 60 per cent. more than in the corresponding period of 1950. So far, none of these countries has put the same emphasis on exports as the United Kingdom, which exports about 75 per cent. of the total output. In Germany, France and Italy, the proportions exported are about 38, 29 and 23 per cent., respectively. The only other major producers of cars the United States and Canada, export only about 4 per cent. of their output.

Increased sales resistance for the British type of car, in the major export markets, and the growing success of the Continental manufacturers with light cars, suggests that there may have to be fundamental changes in British production policy. The bulk of British car production consists at present of cars in the 20 to 24 cwt. range, with a few of 15 to 16 cwt., striking a medium between the American standard six-seater car of an unladen weight of 29 to 32 cwt., and the light Continental car of 12 to 14 cwt. Shortly after the war, there seemed to be a strong case for a change-over by British manufacturers to a heavier type of car, for which there appeared to be a good market, particularly in the Dominions. Because of British methods of taxation, however, there could be little market for such a car at home and, in any case, British manufacturers could not hope to achieve a scale of production which would enable them to sell at prices competitive with the Americans.

TABLE V.—UNITED KINGDOM: EXPORTS OF NEW COMMERCIAL VEHICLES AND CHASSIS.

—	Number.			Value (£1,000).		
	1949.	1950.	1951.	1949.	1950.	1951.
Complete Vehicles.						
Ireland	947	1,202	3,929	537	361	952
South Africa	1,419	783	1,149	1,077	326	431
Australia	9,597	20,778	14,254	2,899	6,726	4,980
British East Africa	2,285	2,708	3,259	1,086	1,139	1,429
New Zealand	758	1,625	3,957	461	452	1,367
India	1,342	1,164	1,370	634	472	520
Canada	2,734	6,679	2,557	647	1,831	773
Sweden	1,083	3,549	2,137	276	981	916
Netherlands	972	3,635	2,537	326	803	625
Belgium	3,532	3,907	2,241	888	1,085	754
Portugal	1,444	1,688	812	350	482	266
Iran	1,049	783	372	1,345	809	319
Brazil	2,455	3,461	3,513	1,100	1,406	1,424
Others	15,184	21,815	25,610	7,609	10,483	14,727
Total	44,801	73,777	67,697	19,235	27,356	29,483
Chassis.						
Ireland	712	876	1,727	491	505	822
British West Africa	4,154	4,750	2,773	1,770	2,073	1,495
South Africa	1,617	2,695	4,200	1,690	1,646	2,590
British East Africa	2,076	2,184	2,074	981	1,163	1,331
India	3,520	2,837	1,860	1,598	1,776	947
Australia	17,102	27,873	22,022	6,767	11,762	10,913
Canada	—	—	502	—	—	284
New Zealand	4,266	4,565	5,900	1,376	1,633	2,396
Others	14,736	24,860	28,389	8,261	13,767	18,955
Total chassis	48,183	70,640	69,447	22,934	34,325	39,733
Total, Complete Vehicles and Chassis	92,984	144,417	137,144	42,169	61,681	69,216

TABLE VI.—*United Kingdom: Exports of Commercial Vehicles, by Types.*

—	Number.		Value (£1,000).	
	1950.	1951.	1950.	1951.
Complete Vehicles.				
Delivery vans and dual purpose vehicles (utilities)	68,660	62,493	21,261	21,333
Coaches and omnibuses—				
Single deck	384	878	1,247	3,425
Double deck	19	15	81	63
Tractors (other than track-laying and agricultural tractors)	528	506	478	500
Goods vehicles—				
Exceeding 3 tons unladen weight:				
With Diesel and similar engines	210	619	435	1,303
Other	574	629	721	614
Not exceeding 3 tons unladen weight	1,935	1,987	979	1,149
Other descriptions	1,467	570	2,154	1,096
Total	73,777	67,697	27,356	29,483
Chassis.				
Of electric trolley 'buses	109	48	264	121
Of coaches and omnibuses—				
Single deck	3,257	3,082	2,902	3,957
Double deck	207	224	371	436
Of goods vehicles—				
Assembled—				
With Diesel and similar engines	3,649	4,578	3,831	5,549
Other	16,682	14,902	6,797	7,131
Unassembled—				
With Diesel and similar engines	6,123	6,364	6,094	6,825
Other	40,448	40,205	13,965	15,690
Of other descriptions	165	44	101	24
Total	70,640	69,447	34,325	39,733
Grand Total	144,417	137,144	61,681	69,216

It is now clear that an expansion of car sales depends upon attracting potential owners in the lower income groups. United States manufacturers themselves have toyed with the idea of making small and cheaper cars, and, but for the difficulty of making them at prices which would compete with standard cars on the second-hand market, they might have set up production lines. In other countries, there was no traditional market for six-seaters, and the lower running costs of the medium and light cars has been a factor of importance. Present British cars combine a high degree of comfort with cheap motoring for four persons. Continental experience now shows that there is a sound market for the small 7-h.p. type of car, giving the greatest economy of motoring with comfort for two persons. British makers have already taken steps to enter the market. Mr. L. P. Lord has announced that the new Austin 7, which was on view at the Motor Show, will go into quantity production in the spring, if supplies of steel permit. A new final-assembly building has been completed, and a new body component plant installed. Sir John Black, deputy chairman and managing director of the Standard Motor Company, has indicated that the company were also considering a light car. Lord Nuffield, in an article in the *Financial Times* supplement of October 22, argued strongly in favour of the small car, pointing out that a change-over to a smaller car would make possible a high volume of production from which considerable reductions in cost would result; it would be reasonably accurate, he claimed, to expect an increase in production of 30 per cent. from the same amount of material. The Ford Motor Company, however, who kept on with small 8-h.p. and 10-h.p. cars when all other makers, except Morris, were changing to cars of medium size, are now moving in the opposite direction. Most of their production is now of the Consul and Zephyr models, of 1,508 c.c. and 2,262 c.c., respectively. Thus the controversy of small *versus* medium cars for markets outside the United States is by no means over. Another large American-owned company, Vauxhall Motors, Limited, have shown no intention, so far, to abandon their medium-car policy.

Lord Nuffield stresses heavily the advantages of a large volume of production, which he considers the "gateway to success" and the "password by which we arrive at optimum values." The amalgamation of Austin Motors and Morris Motors is thus in line with his general policy. The announcement of the merger in November, however, came somewhat as a surprise, since an agreement between the two companies for "technical co-operation," in 1948, broke down after only nine months. Considerable economies are expected from the pooling of sales and technical resources. Both companies have established large and elaborate selling organisations in the principal export markets, which can now conveniently be fused. A statement issued by the two chairmen claims that unified control would further the export drive and be particularly beneficial to manufacturing and assembly abroad. It will take some time to achieve the full economies expected from the integration of productive resources, for the two companies differ widely in organisation. The Nuffield Group comprises a large number of manufacturing units at Cowley, Coventry, Oxford, Llanelly, Abington and Birmingham. A wide range of components, as well as some machine tools, is produced by the Group's subsidiaries, but it is estimated that bought-out components account for 50 to 60 per cent. of the production work. The Austin Motor Company, on the other hand, have all their production facilities in a single works at Longbridge, and are said to rely less upon bought-out components. It is claimed that their four-line assembly plant, opened in the summer, compares favourably with anything in the United States.

For the moment, at least, it does not appear that integration will go far; in the December issue of *Teamwork*, the works magazine of the Austin Motor Company, it is stated that the closing down of factories and the transfer of labour are not contemplated. The magazine goes on to point out that, though there will be a close liaison to obtain a greater degree of standardisation in production, "it is intended that a spirit of competition shall continue between the two companies." While shortages persist, it is likely to be a considerable advantage to pool steel and other scarce materials to maintain production at the most efficient works or on the most profitable lines. There should eventually be much scope for a reduction in the range of models produced. At present, 13 engine sizes are made (eight by Nuffield and five by Austin) which are used to power 23 models. Some of these will probably be superseded by combining the best features of comparable cars in the two groups. From the national point of view, the amalgamation must have disadvantages as well as advantages. Since the two companies together account for about 45 per cent. of the British production of motor vehicles, they will constitute a very large section of the industry; and, if all the economies expected from the merger are realised, it may lead eventually to further strengthening of the Nuffield-Austin Group at the expense of other manufacturers, or to the pooling of resources by them. If successful, the merger is, in effect, a first step in a reduction of the traditional competitive spirit of the industry.

The drive for lower costs is by no means confined to the Austin and Nuffield organisation; a committee of the Society of Motor Manufacturers and Traders has been studying the possibility of standardising many motor-vehicle components. Mr. J. Masterton, a director of Joseph Lucas, Limited, in another article in the *Financial Times* supplement quoted above, stated that remarkable progress had been made and that "in the case of electrical equipment such as dynamos, starters and lamps, improvement has been phenomenal; in fact, the proportion of factory output of a leading component manufacturer that consists of standard items is now double what it was." A high degree of standardisation has been introduced into re-armament work. In order to cut down the stocks of spares which must be carried in the field, the Services decided to adopt the "B" series of standard engines, designed by Rolls Royce, Limited, for all British combat vehicles. Three engines were on exhibition at the Motor Show, namely, the four-cylinder B.40, developing 80 brake horse-power, for light cars; the six-cylinder B.60, of 120 brake horse-power, for scout cars and one-ton trucks; and the eight-cylinder B.80, of 160 brake horse-power, designed for three-ton and ten-ton lorries and armoured cars. These engines have 61 interchangeable parts, including pistons, oil pumps, starters and motors. An instrument panel and switchboard, which can be installed in any vehicle from a scout car to a tank, has also been designed.

In considering the demand for motor vehicles, the emphasis in this article has mainly been on cars. From Table II it will be seen that the production of commercial vehicles, including vehicles for the Services, was only slightly down in 1951. The number of vehicles exported (Tables V and VI, taken from the *Trade and Navigation Accounts*) was also slightly less than in 1950, though there was some increase in value. The decrease was confined largely to delivery vans and occurred mainly in the Australian and Canadian markets, though conditions also weakened in the European markets. The some market (including the Services) received roughly the same number of vehicles as in 1950. The production of vehicles of less than 15 cwt. fell very slightly, though vehicles up to 3 tons must pay a purchase tax of 33⅓ per cent. The demand for commercial vehicles, both at home and abroad, appears to be rather stronger than for cars. There are, however, some weaknesses, particularly in the case of light vehicles. There is also the prospect of further losses in the Australian market as a result of the trend towards the manufacture of complete vehicles there. The International Harvester Company are proceeding with plans to invest 1*l*. million in a project for making motor trucks and their engines in Victoria.

It remains to consider the problem of steel and raw materials. So far as sheet steel is concerned, there can be no alleviation of the shortage in the first quarter of the year; thereafter, however, there should be considerable improvement. Until the middle of 1951, sheet was scarce because of the lack of rolling capacity, but with the opening of the Margam works, capacity ceased to be a problem. It is, therefore, not of great importance to the motor industry whether the million tons of steel to be imported from the United States comes in the form of sheet or ingots. It may be that shortage of steel will not limit production very greatly. The total deficiency of all grades in 1952 has been estimated at 1·5 million tons, now reduced to 500,000 tons if allowance is made for United States imports. Since, moreover, 750,000 tons of ore (equivalent to 250,000 tons of steel) has also been made available to the United Kingdom, the shortage becomes very marginal indeed. The high price of American steel need cause little concern to the motor-vehicle industry, since there should be ample compensation in the savings made possible by capacity production. There will be, undoubtedly, a shortage of high-tensile steels, particularly the nickel steel used for transmission components and for bolts, studs and pins. The world's production of nickel is expanding, but supplies are likely to be short as long as re-armament lasts. Zinc die-castings are as likely to set a limit to production as steel, but strict economy and the use of substitutes such as plastics should make it possible to overcome most difficulties.

The materials position is much more hopeful than it appeared at the end of 1950. It may be, in fact, that the limiting factor in motor-vehicle production will be demand in the not too distant future. Whether or not the industry will achieve its goal of a million vehicles a year may depend very shortly upon nothing more than its ability to supply world markets with suitable vehicles at suitable prices. This probably means greater emphasis on very small cars with low running costs. There is certainly good evidence that expanded sales of cars at home and abroad depend upon tapping a market among income groups who find it difficult to afford motoring at present. This will require an all-out effort to reduce production costs by standardisation, higher production volume or any other means.

ELECTRONICS COURSE AT HARWELL.—The Atomic Energy Research Establishment, Harwell, is again offering a short course on electronics to physicists and engineers desirous of obtaining a specialist knowledge of the electronic instruments used in nuclear physics, radio chemistry and work with radio-isotopes. Similar courses were held in July and November, 1951. The course, which is additional to those arranged by the Establishment on the uses of radio-isotopes, lasts from May 19 to May 23, 1952. Each morning, there will be lectures and demonstrations by specialists from the Atomic Energy Research Establishment, to be followed by practical work in the afternoons. The design, use and maintenance of counters, pulse amplifiers, scalars and registers, and other automatic equipment, are topics included in the syllabus. Students attending the course will be expected to have a background knowledge equal to that required for a university degree in physics or electronics. The number of students attending is limited to 12, but, should there be sufficient demand, additional courses will be arranged. The tuition fee is 12 guineas and accommodation at a senior staff hostel near Faringdon, daily transport, and morning and evening meals will be provided at a charge of six guineas. The lectures will be given in the A.E.R.E. Isotope School, which is outside the restricted area of the establishment. Applications for admission to the course should be addressed to the Electronics Division, A.E.R.E., Harwell, Didcot, Berkshire.

ABRASION AND WEAR OF RUBBER.*

By J. M. BUIST.

THIS Symposium deals with the wear of different materials in broad outline and my contribution is concerned with the wear of rubber and rubber-like materials under a wide variety of conditions. The aim of all wear-testing, whether in the laboratory or in actual service, is to make accurate determinations of the wear so that the effects of different processes (e.g., mixing schedules), different chemicals (e.g., sulphur/accelerator ratios), and different designs (e.g., tread and sole patterns) can be compared. In work of this kind, it is essential that the test shall give reproducible results, and a great deal of work has been done in the rubber industry to improve the reproducibility of laboratory abrasion tests and also certain forms of service test. It is not sufficient, however, merely to improve the reproducibility of a laboratory abrasion test. Most of the laboratory methods developed for the measurement of the abrasion resistance of rubber do not correlate well with any single service application and I have argued elsewhere† that it is futile to expect that any single laboratory method will correlate well, equally with the wear of tyres, soles, heels, oil seals and proofed rubber garments, to mention only a few applications.

Before it can be decided whether a laboratory method correlates with wear in any individual application, it is necessary for the service wear to be determined with an accuracy of the same order as that applying to the laboratory test. This has not always been the case, and most technologists and statisticians agree that it is difficult to obtain precise information from tests of this kind. The errors associated with service tests are undoubtedly large and often arise from unknown sources. Much more use should be made, therefore, of statistically planned experiments; recent publications‡§ show the value of such work in road wear tests.

The question has often been asked, "Is there any point in carrying out laboratory and service wear tests?" There is considerable reason for the question, as large sums of money and much experimental effort are devoted to these tests annually. In the last 40 or 50 years, the rubber tyre has been improved beyond all recognition, and present-day automobile and truck tyres operate under much more severe conditions of service, and yet have a longer wear life, than was possible years ago. Certainly, the decision that rubber was a suitable material for tyres and footwear may be attributed to sound empiricism and inventive genius, and wear tests, being unknown, can claim no credit. Nevertheless, wear tests have enabled the technologist to improve his product in many ways to meet increasingly stringent conditions.

There is general dissatisfaction with the present laboratory and service tests and this may be due to the following reasons. Too much is expected of the laboratory test, which, while indicating broad differences between compounds, cannot be used to discriminate closely between similar compounds. More and more the technologist is forced to ask the rubber physicist to assess and grade similar compounds, necessitating the laboratory tools being used within a very limited range. Is it reasonable to expect accurate information within this limited range from laboratory abrasion machines?

In the case of tyres, it is known that the type of road surface, changes with atmospheric conditions (temperature, wetness or dryness), speed of running, acceleration and braking, alignment of wheels, are some of the more important conditions which affect the life of the tyre tread. This very restricted list indicates the complexity of the problem, and published reports show that changes in these conditions can alter the order of compounds. It is extremely optimistic, therefore, to imagine that any laboratory abrasion test, carried out under one set of fixed conditions, can correlate with the service life, which is obtained by the integration of the wear under varied (and constantly varying) conditions. It is difficult to see how an "integrated wear life" can be obtained in the laboratory; indeed, in order to obtain an understanding of the mechanism of abrasion, laboratory testing has been designed (in my view, correctly) towards the other end, whereby the contributions of individual factors in the abrasion process can be assessed and analysed. Only a considerable number of laboratory tests, carried out under different conditions, could give as much information as the service test, and then only if the

* Paper presented at the Conference on Abrasion and Wear, held at Delft, Holland, on November 14 and 15, 1951.

† J. M. Buist, *Trans. I.R.I.*, vol. 26, page 192 (1950).

‡ J. M. Buist, R. G. Newton and E. R. Thornley, *Trans. I.R.I.*, vol. 26, page 288 (1950).

§ R. D. Stiehler, M.N. Steel and J. Mandel, *Trans. I.R.I.*, vol. 27, page 298 (1951).

ABRASION AND WEAR OF RUBBER.

Fig. 1.

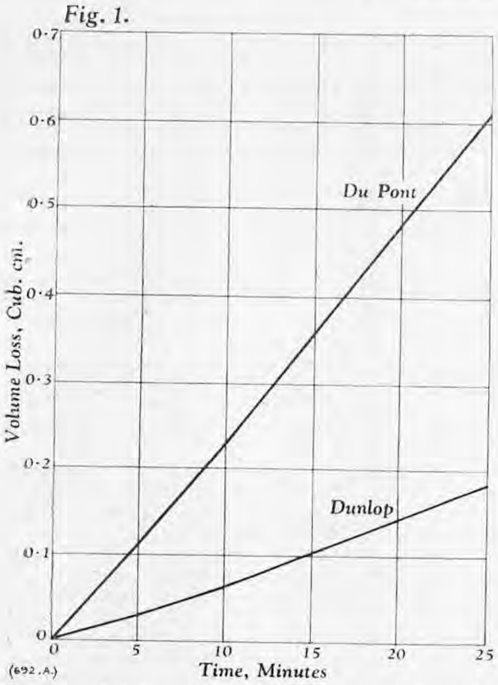
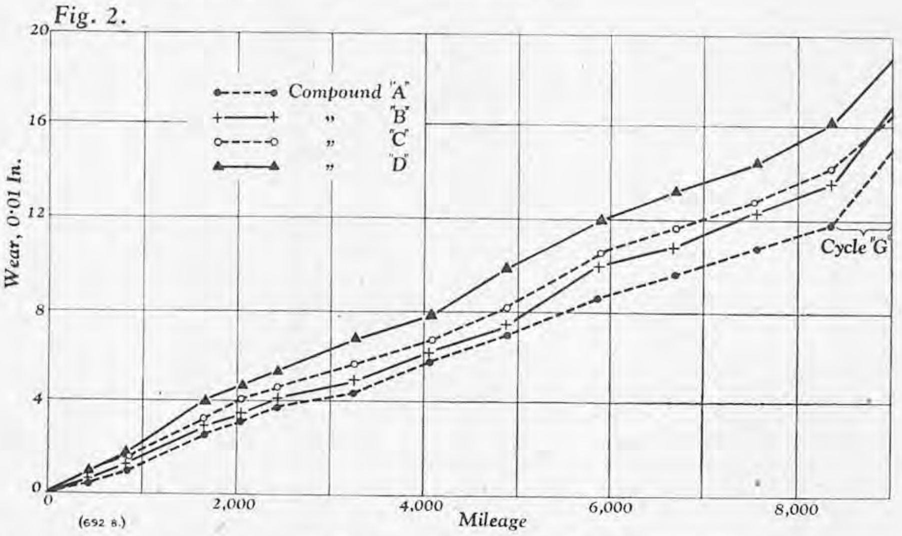


Fig. 2.



difficulty of integrating the laboratory information were overcome.

Laboratory tests are used because they are simpler to carry out, are less expensive, and give a result in a shorter time than the service test. Although such tests are often quoted in specifications, there is always the proviso that the results cannot be used to estimate the service life of the rubber product. This is certainly true, but, nevertheless, they are useful quality-control tests for product specifications as long as it is realised that the test merely assesses the level of abrasion resistance of the compound, rather than denoting any definite value for the "wear life."

Common practice and usage has resulted in laboratory abrasion test results being expressed in one of two forms; either as a loss in a given time, or as a ratio of the loss of one compound to that of a standard compound. Both methods have defects and one of the purposes of the present paper is to draw attention to these defects and suggest a remedy. Either method of expressing the results means that a single figure (e.g., loss in a given time) is used, or, alternatively, the ratio of the loss in a given time to that of a standard compound in the same time. If ratings for two compounds are calculated at progressive stages in a wear test, the rating obtained may not be constant but can vary, depending on the stage reached in the wear curves. Therefore, it may not be possible to characterise the wear of rubber compounds by means of a single figure, and a method of utilising all the information contained in the full wear curve is required.

In any wear trial, it would be useful if there could be an arbitrary end-point to the test, e.g., 5,000, 10,000 or 20,000 miles; from the point of view of expense and convenience, the earlier end-point is desirable. If it were possible to calculate a wear rating at 2,000 miles and to know that such a rating would correspond with that obtained at 20,000 miles, a very great advance in testing tyres would be made.

The author has recently drawn attention* to the fact that wear curves obtained on laboratory abrasion tests and also actual road wear curves could be described by an equation of the power law type $y = a\,x^n$, where y = weight or thickness loss, x = time of abrasion, and a and n are constants which are determined by means of a linear regression of log y on log x, using the method of least squares.

This equation was first applied to the results of the wear of proofed fabrics as measured on the Martindale abrasion tester.† The usual practice was to measure the weight, volume or thickness loss after various times or numbers of revolutions, and the most resistant compositions were tested for periods up to 10,000 or even 20,000 revolutions. It is now possible to measure the loss after 1,000, 2,000 and 3,000 revolutions and, by applying the above equation, to predict with confidence the loss at any subsequent period. The agreement between the measured and calculated wear losses is extremely good and is illustrated by Table I, herewith. The fact that abrasion losses at the longer periods could be calculated in this way had an immediate result, in that considerably more tests could be done on a single Martindale machine than hitherto; this increased the efficiency and utilisation of the testing equipment by 400 per cent., which resulted in a saving of approximately 4,000*l*. over a number of years.

TABLE I.—*Results with Martindale Tester.*

No. of Revolutions.	Measured Weight Loss, Gm.	Calculated Weight Loss, Gm.
1,000	0·036	0·035
2,000	0·066	0·064
3,000	0·094	0·091
4,000	0·111	0·117
5,000	0·133	0·143
6,000	0·161	0·166
7,000	0·190	0·192
8,000	0·214	0·216
9,000	0·240	0·240
10,000	0·266	0·263

Having established that the wear curves were of a form which could be suitably described by such an equation, it is interesting to define more exactly its scope of application. If the wear curves obtained on other laboratory abrasion tests belong to the same family, then it should be possible to describe du Pont* and Dunlop† wear curves by the same equation. In Fig. 1, herewith, wear curves for a natural-rubber tread stock are given for both du Pont and Dunlop tests. The different conditions of test in the two cases alter the values of a and n, but, nevertheless, the wear curves are of the same family. Of even greater significance, however, is the fact that it is possible to use the power law equation to represent the wear curves of the compounds used in three-part tyres. In the road tests, four compounds were tested on the four tyres of a car in a balanced, incomplete block design; the full results of this work have already been published.‡

The wear of compounds was measured by the decrease in tread depth which was observed for each segment of each tyre at a number of mileages. From these results, it is possible to construct a wear curve for each compound, as is shown in Fig. 2, herewith. It will be seen that the wear during cycle G is much more rapid than that obtained in any other cycle. This change in the rate of wear was due to a combination of circumstances and it was not possible to attribute it to any one single factor, although it is pointed out that, among other factors, a change in driver might bring about variations of this kind.‡ If the results available from the earlier cycles (i.e., up to 8,327 miles) are used, it is possible to calculate the constants a and n in the equation $y = ax^n$. Using these constants, the mileage at which the wear at the end of cycle G would have normally occurred can be calculated. If this corrected mileage is used as the starting point for the subsequent periods of wear, the continuous wear curve given in Fig. 3 can be constructed. This shows that the wear in cycle G was quite abnormal, but that afterwards the rate of wear was the same as that found prior to cycle G. Therefore, assuming that the conditions of test in the road tests remain reasonably constant, it is possible to forecast the extent of the wear at, say, 20,000 miles from measurements that have been made during the first few thousand miles running.

One must assume, of course, that the service conditions during the early stages are truly representative of the average conditions met in "normal" life. For example, in Table II, herewith, the measured and calculated values for the wear of the four compounds are given, and it will be seen that excellent agreement is obtained up to 8,327 miles.

Service tests are much more expensive than laboratory tests and any reduction in the duration of these tests is even more valuable than corresponding reductions on the laboratory scale. Data on the actual savings involved in road wear tests are not readily available; however, D. G. Stechert and T. D. Bolt of the Gates Rubber Company, who have also used the power law relationship to describe road wear curves, give numerous results illustrating the validity of the relationship, and their remarks on cost are particularly noteworthy. They state*: "If, in tread wear evaluations, tests were terminated prior to baldness, about 180 dols. could be saved for each passenger tyre tested, and 490 dols. for each truck tyre, for every 10,000 miles. One particular investigation, to determine the effect of three different tyre designs on tread wear, was made at a total cost of 2,200 dols. If all tyres had been tested to baldness, the cost would have been approximately 4,600 dols." In practice, of course, the saving is an indirect one, in the sense that much more information can be obtained for the same expenditure.

Before suggesting how to decide on a safe mileage at which to stop the road test when using the power law, it must be emphasised that the relationship is an empirical one. The present author feels that its use and applicability has been proved beyond doubt, but that it should be tried, nevertheless, over a much wider range of service data. Forecasts of wear must be checked with subsequent measurements before too much is claimed. It does seem, however, that, when the road test is primarily concerned with wear (rather than flex-cracking), it could be stopped in the region of 5,000 to 8,000 miles, provided that sufficient measurements in these early stages give good straight lines on a log-log plot.

From Table II it will be seen that, in the road tests, n is less than 1, whereas in Fig. 1 the value of n is greater than 1 for the du Pont and Dunlop laboratory tests. This point has been checked with a wide range of compounds on the du Pont, Dunlop and Martindale machines, and usually n has been found to be greater than 1. When n is greater than 1, it means that the rate of wear is increasing as the test progresses, and, when n is less than 1, it means that the rate of wear is decreasing. It appears that, in general, laboratory abrasion machines operate under too severe conditions and, for good correlation with service, it is considered that the service wear and laboratory wear curves should have n values of the same order (i.e., either n is less than 1 or greater than 1 in both cases). As n is less than 1 in service, it will be useful to note how various factors in the du Pont test affect the value of n. The normal load applied in the du Pont test is 3·62 kg. and it has been found that this load must be reduced considerably (in certain cases, to as low as 0·5 kg.) before n is less than 1. The method of extracting samples before abrasion testing†‡ is now well known and, using natural-rubber tread, it has been

* J. M. Buist, *I.R.Jl.*, vol. 121, page 180 (1951).

† J. G. Martindale, *Jl. Text. I.*, vol. 33, page T.151 (1942).

* I. Williams, *Ind. Eng. Chem.*, vol. 19, page 674 (1927).

† L. J. Lambourn, *Trans. I.R.I.*, vol. 4, page 210 (1928).

‡ J. M. Buist, R. G. Newton and E. R. Thornley, *Trans. I.R.I.*, vol. 26, page 288 (1950).

* D. G. Stechert and T. D. Bolt, *Analytical Chemistry* (in the press).

† T. R. Griffith, E. B. Storey, J. W. D. Barkley and F. M. McGilvray, *Ind. Eng. Chem. Anal. Ed.*, vol. 20, page 837 (1948).

‡ J. M. Buist, *Trans. I.R.I.*, vol. 26, page 192 (1950).

ABRASION AND WEAR OF RUBBER.

Fig. 3

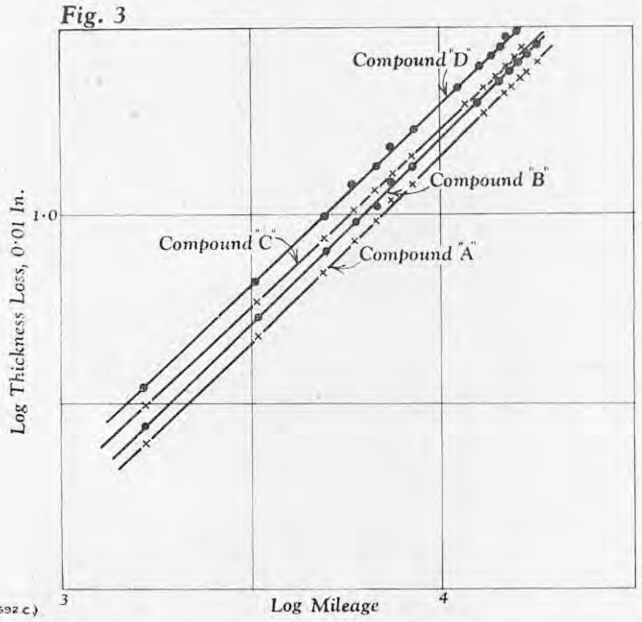


Fig. 4. DU PONT TEST: 100 Gm. WEIGHT.

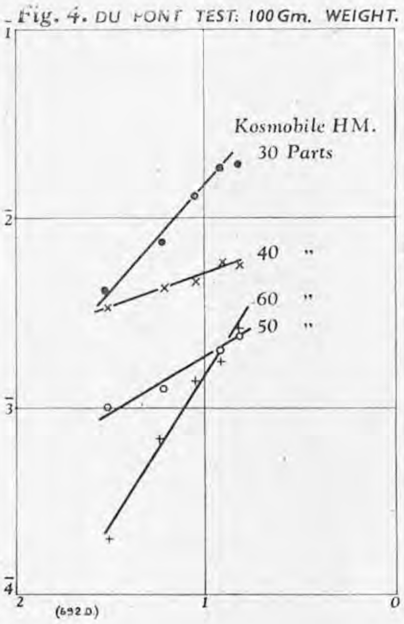


TABLE II.—ROAD TEST RESULTS.

Mileage.	Wear in 1/100 in.							
	Compound A.		Compound B.		Compound C.		Compound D.	
	Measured.	Calculated.	Measured.	Calculated.	Measured.	Calculated.	Measured.	Calculated.
1,651	2·7	2·5	3·0	2·8	3·3	3·1	4·0	3·8
3,266	4·4	4·8	5·0	5·4	5·7	5·8	6·7	6·9
4,864	6·9	6·9	7·4	7·9	8·1	8·4	9·8	9·8
5,896	8·6	8·4	10·0	9·5	10·5	10·1	12·0	11·6
6,698	9·6	9·4	10·9	10·8	11·7	11·4	13·2	13·1
7,527	10·9	10·5	12·3	12·1	12·8	12·7	14·5	14·5
8,327	11·9	11·6	13·5	13·3	14·2	14·0	16·1	15·8
Value of n ..		0·95		0·97		0·94		0·89
Value of a ..		0·0022		0·0021		0·0029		0·0051

found that, after extraction, n is less than 1. This may, therefore, be a partial explanation of why extraction improves correlation with service for certain compounds.

The fact that carbon black reinforces rubber raises the question, " What is the optimum loading of carbon black to confer maximum resistance to wear ? " From service tests it is found that there is an optimum loading in the region of 45 to 50 parts of carbon black on 100 parts of rubber. Laboratory tests on the Dunlop machine confirm this, but tests with the du Pont machine indicate that the abrasion resistance is increased as the amount of black is increased, even beyond 50 parts of black. The rate of wear on the du Pont test is highly correlated with the hardness or stiffness of the stock‡ and this dependence on hardness can only be reduced by operating the test under extremely low loads. Comparisons have been made with natural-rubber stocks containing 30, 40, 50 and 60 parts by weight of channel black (Kosmobile HM) using loads of 3·62 kg. and 100 gm. on the du Pont test. The results for the 100-gm. loading are given in Fig. 4, herewith. It will be seen that, owing to the low loading, the results are erratic, but it is clear, nevertheless, that, with the compound containing 60 parts of black, the initial wear is low due to the hardness of the stock, but that the rate of wear is very much greater than with the other compounds. Nothing is to be gained, therefore, by increasing the loading of black to 60 parts. This experiment illustrates that it is wrong to suggest that a maximum in the abrasion resistance/carbon-black loading is not capable of being indicated by the du Pont test, and also it emphasises that the standard load of 3·62 kg. is too high.

It is not possible, at the moment, to state exactly what conditions of operation should be applied to each of the different forms of abrasion test to ensure that the n value should be less than 1, but there is little doubt that, if this criterion were adopted, it would be found that, with many compounds, most laboratory abrasion machines would operate under too severe conditions for satisfactory correlation with service.

It is recommended that the power law technique should be used with laboratory tests to establish that the rate of wear in the laboratory is comparable to that met in service. If this is adopted, part of the accelerated nature of the laboratory test may be sacrificed, but it is believed that there will be a much greater gain in correlation with service. By utilising all the information from the wear curve, any comparisons made between compounds will be more accurate than is the case at present when a single figure is used. The fact that this empirical equation possesses such a wide application in the wear evaluation of rubber both in the laboratory and in service is of great importance to the industry. Once the rates of wear in service applications are known, the laboratory conditions can be adjusted to produce comparable rates of wear, and from the regression lines the abrasion life of the compound can be estimated. If further work with this technique is successful in the many fields where wear of rubber is important, and if it bears out its early promise, it would appear that laboratory abrasion tests will enter a new era of usefulness and service testing will be of shorter duration.

‡ J. M. Buist and O. L. Davies, *Trans. I.R.I.*, vol. 22, page 68 (1946).

PREVENTING INDUSTRIAL DERMATITIS.—In order to bring to the notice of the engineering industries the advances that have been made within the past 11 years in the development of barrier creams for protecting the hands of operatives handling irritant or toxic substances, Innoxa Laboratories, 1, Eden-street, Hampstead-road, London, N.W.1, recently gave a demonstration, at their Bond-street showroom, to representatives of the trade unions, employers' federations, and the technical Press. The barrier creams fall into two main classes—the water-soluble creams which protect the skin from irritants found in oils, paints, tars, solvents, etc., and which expand when in contact with water so that the superimposed grime may be readily washed away; and the water-repellant creams, which give protection against acids, alkalis and other irritants soluble in water. At the demonstration it was shown that hands suitably protected with a water-resistant cream could withstand immersion in concentrated hydrochloric and sulphuric acids without damage. As a guide to the correct use of barrier creams, a number of industrial booklets are available on application to Innoxa Laboratories, covering engineering, mining, agriculture, paint manufacture, building, and various other industries. The company will also be pleased to provide samples of suitable barrier creams to any organisation that supplies particulars of the industrial hazards encountered.

THE HYDRAULIC TRANSPORTATION OF COAL.*

By R. W. DOUGHERTY.

FROM time to time interest has been evidenced in transporting coal with water in pipelines. About the year 1895, United States patents broadly covering a method of pumping coal with water through pipelines were granted to W. C. Andrews. His process was used to some extent in pumping anthracite culm and waste back into the worked-out portions of the mines. About 1905, W. T. Donnely was granted patents relating to pumping anthracite silt away from the breakers. From about 1913 until 1924, a British engineer, Gilbert G. Bell, used a short pipeline to convey coal with water from barges on the Thames River to the Hammersmith electricity generating station, London. Up to 5-in. coal was transferred 660 yards through an 8-in. pipe. Some trouble was experienced with fine coal, which tended to plug the line. Bell made several proposals to transport coal by pipeline overland from the Midlands to London, a distance of about 100 miles, but these were never adopted.

This survey is concerned mainly with the problems presented by actual pipeline transportation of coal with water. It is assumed that the coal will have been processed to remove most of the abrasive impurities by conventional methods prior to introduction into the line, and that it has been crushed to the required maximum size. Dewatering at the discharge end of the line is considered part of the conventional cleaning process. The maximum economies of pipeline transportation can be effected by moving large tonnages on a continuous basis. Because of high fixed charges, such a system does not lend itself to intermittent or occasional operation and is therefore limited to supply a reasonably steady demand.

The problem of hydraulic transportation of coal was discussed with several manufacturers of centrifugal sand pumps. All felt that coal could be transported economically by pipeline, provided adequate design and performance data could be obtained from laboratory and large-scale tests. Hydraulic heads not to exceed 800 ft. for each pumping station were recommended, because pump packing seals have not been developed to perform satisfactorily above that pressure. Stuffing-box sealing and flushing is accomplished by a flow of clean water maintained during pump operation; dry bearing seals have not proved reliable for long uninterrupted service. Four single-stage pumps operated in series would develop the required operating head at each pumping station. Emergency capacity in the event of failure of one station could be provided, either by a spare pump automatically put on stream at the preceding upstream station or by excess capacity in each station to take up the additional load. Pumping coal is not necessarily limited to centrifugal-type pumps or to the limitations imposed by present designs. The commercial development of pipelines undoubtedly would be accompanied by development of pumps specifically designed for such service. Pumps capable of maintaining higher head pressures would reduce the number of pumping stations with corresponding savings in material, construction costs, and operating costs. Reciprocating pumps offer distinct possibilities in conveying finely-ground coal to markets requiring that type of fuel.

The pump manufacturers are not in agreement about the percentage of coal by weight that can be pumped most readily and economically: opinions ranged from 25 to 40 per cent. For a given maximum size and screen analysis, the optimum coal-water ratio must be determined by test. The maximum amount of fines, less than 100 mesh, that are marketable are desirable, because they appear to " lubricate " the mixture and reduce the power required for pumping. By using a dispersing agent, the Westinghouse Electric Corporation have successfully kept fine coal in suspension and pumped coal-water slurries with greater than 1 : 1 ratio. In a series of experiments, the Standard Oil Company found that fine coal-water slurries up to 35 per cent. by weight pumped as readily as water, with about the same viscosity at 3 to 5 ft. per second lineal velocity. No line plugging was experienced when the system was shut down over night or at weekends. In general, the smaller the maximum size or the finer the material is ground, the smaller the linear velocity required to keep it in suspension.

The Morris Machine Works, Baldwinsville, N.Y., have determined experimentally that the critical velocity for up to 2 in. to 3 in. solids is 7 ft. to 9 ft. per second in an 8-in. inside diameter pipe; a safe velocity is 10 to 12 ft. per second. In a 10-in. inside diameter line, the critical velocity was 8 to 9 ft. per second and a safe velocity 11 to 13 ft. per second. There is no agreement among the equipment manufacturers or in the published literature as to the proper

* United States Department of the Interior. Bureau of Mines Report of Investigations, 4799. Abridged.

tests to be made to predict accurately the performance of large commercial-size pipelines. One hydraulic engineer having many years of experience with the U.S. Army Engineer Corps believes that all necessary information can be obtained from carefully observed results of extensive tests made in $1\frac{1}{2}$-in. and 3-in test loops. On the other hand, one author concludes that the "results of flow in a small line can only be qualitatively used for flow in a larger line."

Several estimates of the cost of transporting coal hydraulically have been made. The most recent was by a reputable pump manufacturer, the Allen-Sherman-Hoff Company, Philadelphia, Pa., in 1947; this was a proposal to convey 500 tons per hour working 8 hours a day, at 2·4 cents per ton-mile. If 24 hours a day operation were maintained at 500 tons per hour, the cost would be reduced to 1·8 cents per ton mile. In this proposal, water is supplied by a parallel line from the coal-discharge end. During 1934 and 1935, W. O. Keeling, Koppers Co. Research Dept., Pittsburgh, Pa., made an extensive study of coal pipeline transportation for 1,000 and 1,500 tons per hour a distance of some 300 miles. Two water-coal ratios were considered, 2 : 1 and 3 : 1, with up to 6-in. pieces. Linear velocities from 4 to 10 ft. per second were chosen, requiring 21-in. to 48-in. inside diameter pipes. The theoretical horse-power required for pumping 1,000 tons per hour ranges from 3,670 to 81,540; for 1,500 tons per hour, from 3,600 to 84,250. Friction head of the coal-water mixture was assumed to be the same as for water.

From information available, it appears that coal may be transported economically in pipelines, especially in large tonnages, to supply a steady industrial market. Before coal pipelines can be constructed, many more actual pumping-performance data must be accumulated. Pumps, either centrifugal or reciprocating, will require much more development. The erosion of pipe and pumps, the degradation of coal, the most economical linear velocities, and the pressure drop in lines must be determined accurately for each coal mixture. There are some literature references generally covering coal pumping, but none giving detailed pump and line performance. There are more detailed references to pumping heavier solids such as sand, gravel, ores, and rock, which have specific gravities twice that of coal. Pumping heavier and lighter solids in water is not analogous because of the difference in energy required to keep each in suspension.

Estimates of construction costs for 100-mile level coal pipelines range from 9·3 to 10·1 million dollars for a capacity of 5,000 tons a day to 18·9 to 25·7 million dollars for a capacity of 36,000 tons a day. The operating costs would amount to 1·28 to 1·91 dollars per ton for the 5,000-ton pipe line and 0·38 to 0·95 dollar per ton for the 36,000-ton line.

Oil Survey Party.—The Anglo-Iranian Oil Company have announced that a survey party of four left on February 2 for Aden. The party is being led by Mr. S. E. Evans of the company's geological staff and will be joined at Aden by another party of four led by Mr. J. McV. Luard. The object of the visit is to investigate the possibility of constructing at Aden a new refinery with a probable annual output of 5,000,000 tons.

Reconstruction of Gretna Railway Junction.—The new 109-lb. flat-bottom rails have been used in the reconstruction of Gretna railway junction, where the West Coast route, between Carlisle and Glasgow, divides into two routes, one through Beattock and the other through Dumfries. The layout has been improved by easing the curves and applying cant by means of "two-levelling," thus permitting higher speeds and easier running throughout the junction and its approaches. The tracks at the junction are double. The old E-type switches and 1-in-16 crossings, with a 1-in-8 fixed diamond, have been replaced by F switches, 1-in-20 crossings and a 1-in-12 switch diamond. The speed restriction on the down main line to Carstairs has been raised from 60 m.p.h. to 75 m.p.h.; on the down branch line to Dumfries from 60 to 65 m.p.h.; and on the up branch line from Dumfries from 40 to 50 m.p.h. The up line from Carstairs remains unrestricted. The remodelling necessitated considerable alterations to the permanent way and signalling, and the points of the new junction are over 100 ft. south of the position of the old points. The 1-in-12 switch diamond is the first to be laid with this material in Scotland. Each pair of diamond switch blades is operated by a separate lever in the signalbox; the facing-point locks are controlled by another lever; and electric detectors, fitted on each side of the switch diamond points, ensure that the signals leading over the switch diamonds cannot be cleared unless the switches are lying in the correct position and bolted. The civil engineers and the signal and tele-communications engineer of the Scottish Region were responsible for the completion of the work, and the switches and crossings were manufactured by Messrs. Taylor Bros., Sandiacre.

HIGH-SPEED PRECISION TAPPING MACHINE.

THE MOTOR GEAR AND ENGINEERING COMPANY, LTD., CHADWELL HEATH, ESSEX.

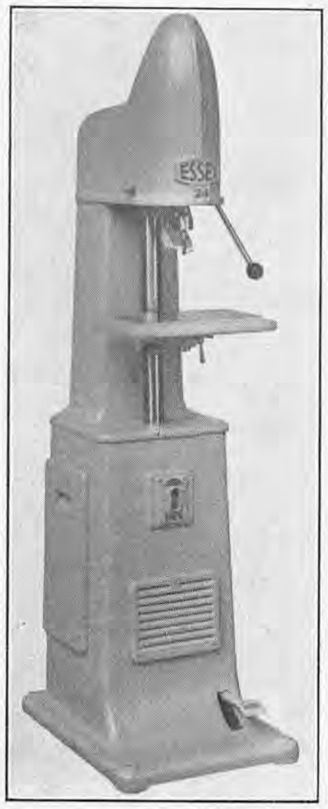


Fig. 1.

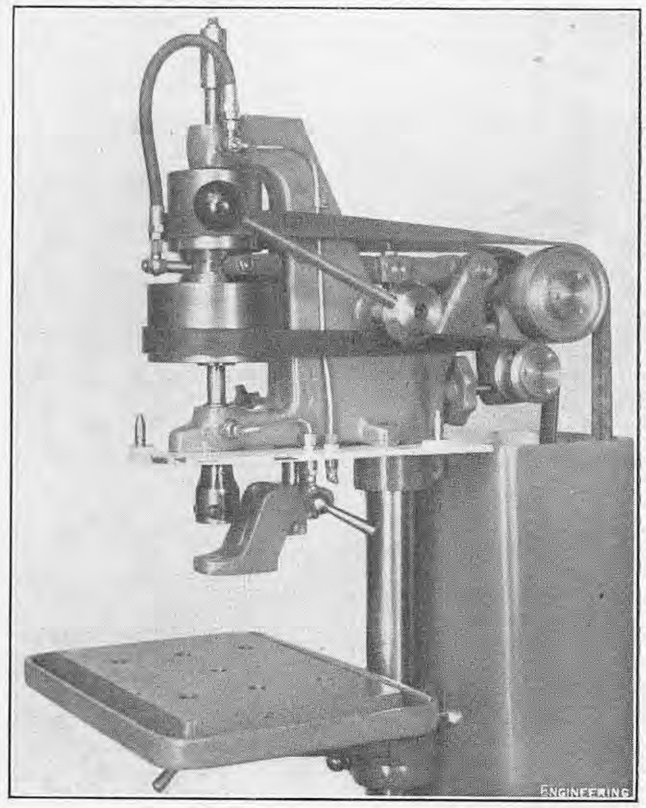


Fig. 2.

HIGH-SPEED PRECISION TAPPING MACHINE.

A high-speed precision tapping machine, the principal feature of which is an accelerated reversing motion that is initiated automatically when the feed handle or pedal is released, has been introduced by the Motor Gear and Engineering Company, Limited, Essex and Corona Works, Chadwell Heath, Essex. It is a pedestal machine, as shown in Fig. 1, above, and is belt-driven by a $\frac{1}{2}$-h.p. motor enclosed in the cabinet base. The range of taps for which it is suitable is 8 B.A. to $\frac{1}{4}$ in. Whitworth in mild steel, and 8 B.A. to $\frac{3}{8}$ in. Whitworth in brass. The spindle speeds are 480, 930 and 1,500 r.p.m. forward, and 690, 1,340 and 2,150 r.p.m. in reverse.

The driving motor, mounted on a hinged baseplate, has a three-speed cone pulley which is coupled to a countershaft in the cabinet by a V-belt. From the countershaft the drive is transmitted by a flat belt. As will be seen from Fig. 2, this belt is arranged to make two loops round the pulleys on the tapping spindle. The lower pulley, being the larger of the two, is used for tapping, and the upper pulley gives the accelerated reverse drive for withdrawing the tap. The drive from each pulley to the spindle is through a cone clutch, running on ball bearings; while tapping is in progress and the handle or pedal is depressed, the lower clutch is engaged, but as soon as the drive is released the upper clutch is engaged and the tap is unscrewed. The tapping spindle, which has a maximum feed of $1\frac{1}{2}$ in., is counterbalanced by a spring at the top of the machine. It is lubricated by means of an oil nipple, mounted externally under the head guard and feeding through a tube and a flexible tube, as shown in Fig. 2. Taps are held in a two-way self-centering chuck of $\frac{3}{8}$ in. capacity.

The work table, measuring 13 in. by $8\frac{1}{2}$ in., is clamped to a ground column and can be swung through a wide arc. A stripper plate is provided, and an adjustable stop in its fixing pillar enables the depth of tapping to be accurately controlled. A follower attachment, which can also be supplied, is required for producing accurate threads, and eliminates any tendency to strip the threads when tapping fine pitches in aluminium or other soft materials. The change-speed cones are reached through a clip-on door at the side of the cabinet base, and the electric wiring and motor through a louvred ventilation cover at the front. The machine has a flush-mounted starter, and it can be isolated by an Isofuse switch on the right-hand side. The flat belt is enclosed by removable covers. The distance from the spindle to the column is $6\frac{1}{2}$ in., and the maximum distance from the table to the chuck is 16 in.

ANTI-SCUFFING PASTE FOR DRY LUBRICATION.

A paste, known as "Ragosine" anti-scuffing paste and recently introduced by the Ragosine Oil Company, Limited, Ibex House, Minories, London, E.C.3, is described by them as a new development in dry lubrication, providing an almost frictionless surface which is resistant to temperatures up to 1,000 deg. F. It prevents galling and seizing at pressures of over 100,000 lb. per square inch at either high or low sliding velocities. The makers recommend its use wherever a dry lubricant is indicated and normal oils and greases cannot be applied, and in cases where loads are extreme and where the heat dissipation provided by circulating liquid is not needed. It is applied by cloth or the finger. The uses to which it has been put include the lubrication of large bearings that are out of alignment, remote cams, splines, pivot bearings and pins, large machine-tool slides, and cocks and valves working at high temperatures or pressures or with solvents. It has also been used with success in the drawing of metals. Suggested applications include screw fasteners, to reduce the torque required for a given tension; threads subjected to high pressures; surfaces which are to be press-fitted; taper collets, to increase the gripping power; high-temperature conveyors and chains; and as an inhibitor of fretting corrosion. Its composition is not stated; it contains a material "similar in appearance to graphite, but containing none, and is much superior in performance to graphite."

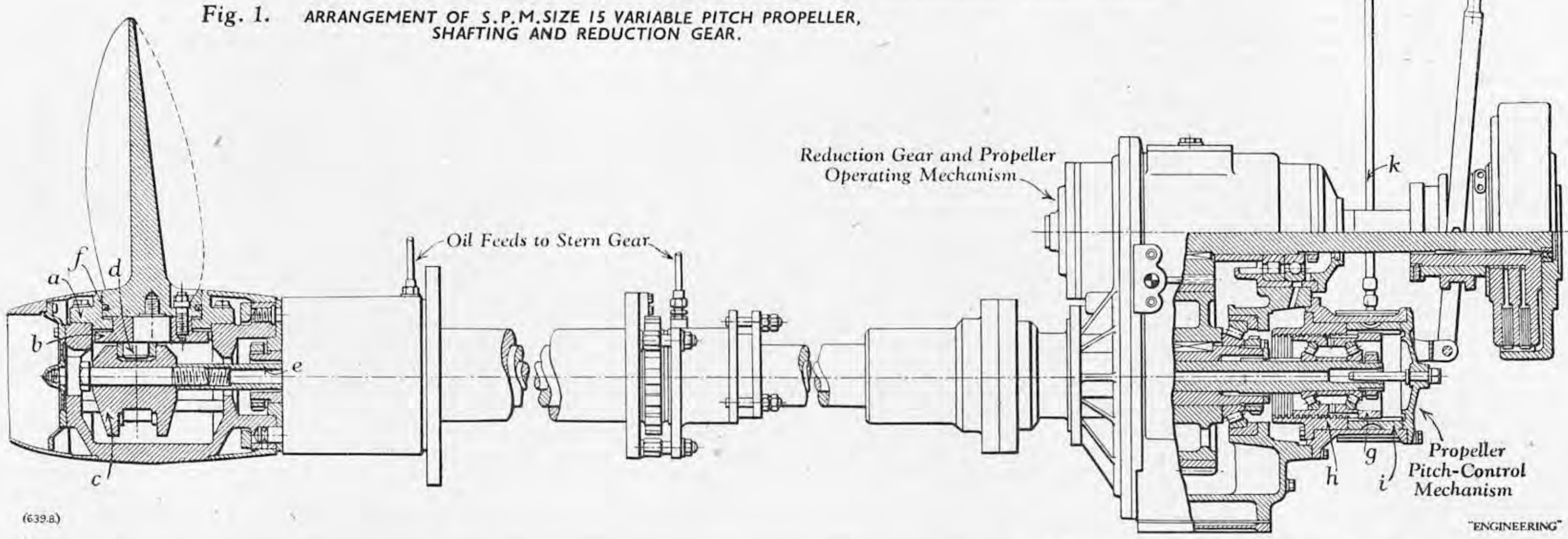
The Late Colonel E. T. Brook, C.B.E.—We learn with regret of the death recently of Colonel E. T. Brook, C.B.E., former Superintendent of Rolling Stock (Railways) of London Transport. At his retirement in 1945, Colonel Brook had held this position for nearly 20 years out of the 41 years that he spent in the service of London's transport.

First "Comet" of B.O.A.C. Fleet Delivered.—On February 4, the first of the fleet of Comet air liners on order for the British Overseas Airways Corporation was formally handed over by the de Havilland Aeroplane Company, Limited, Hatfield, Hertfordshire, to the Corporation at London Airport, where the aircraft had been carrying out acceptance trials. The Comet has been delivered more than six months ahead of the contract date. It is expected that the first jet air-liner service, to Johannesburg, will be opened in the spring. British Overseas Airways Corporation crews have already completed over 750 hours' flying on a Comet air liner lent by the Ministry of Supply.

VARIABLE-PITCH AND REVERSING PROPELLER.

SLACK AND PARR (MARINE), LTD., KEGWORTH, DERBYSHIRE.

Fig. 1. ARRANGEMENT OF S.P.M. SIZE 15 VARIABLE PITCH PROPELLER, SHAFTING AND REDUCTION GEAR.



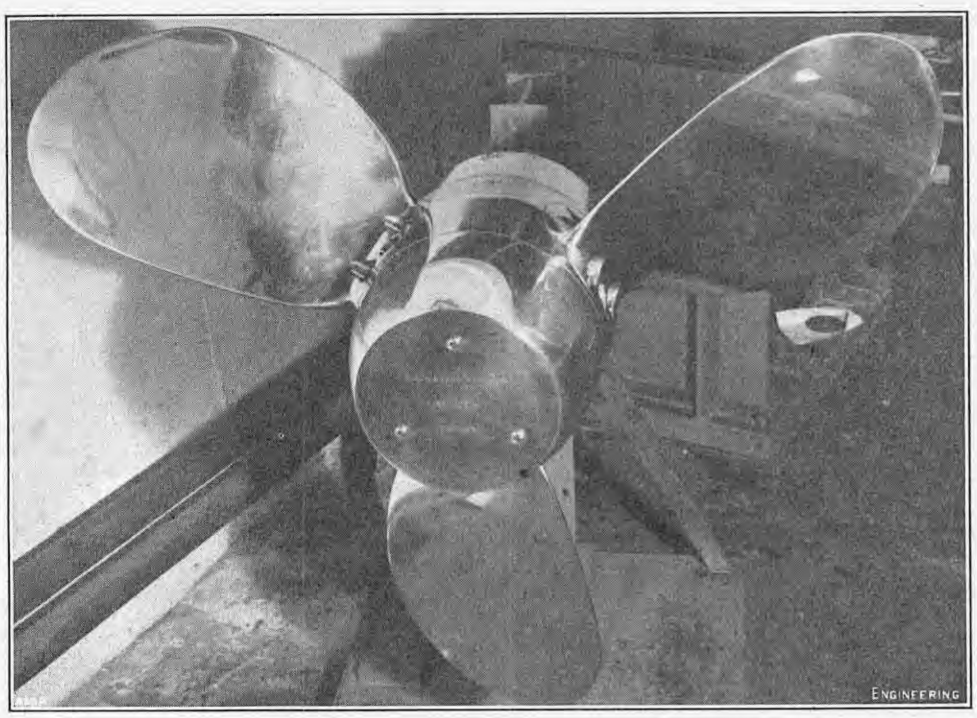


FIG. 2.

THE S.P.M. VARIABLE-PITCH AND REVERSING PROPELLER.

FOR vessels employed on duties involving continuous manœuvring, there is much to commend the use of variable-pitch and reversing propellers as they permit rapid but accurate changes of speed to be made, give exceptionally good manœuvrability and provide a convenient means of obtaining astern power without the use of gearboxes, hydraulic couplings, etc. This last characteristic is particularly valuable in connection with gas turbines, as one of the factors that has to be taken into account when considering their use for ship propulsion is the irreversibility of this form of prime mover. The development of marine gas turbines of the order of 200 h.p. such as the Rover unit, gives added interest, therefore, to the range of variable-pitch and reversible propellers manufactured by Messrs. Slack and Parr (Marine), Limited, Kegworth, Derbyshire, as the largest of these, namely, the SPM size 15, is capable of transmitting such powers and may well be used to advantage with these smaller turbines. It was not introduced, however, for this specific purpose, having been developed in the ordinary course of events to extend their range of standard variable-pitch propellers for use with the smaller classes of fishing and towing craft; the possibility of using it in connection with small marine gas turbines is mentioned merely as an example of its versatility.

The S.P.M. 15 propeller is of simple but robust construction, the design being based largely on the earlier and small units and the pitch-change mechanism being arranged so that it can be controlled electrically, hydraulically or mechanically. It has a 15-in. diameter hub which is designed to accommodate three blades made in different sizes giving propeller diameters ranging from 45 in. to 60 in. The maximum power that can be transmitted is 200 brake horse-power at 300 r.p.m. and the maximum torque 3,500 lb.-ft., but the propeller can run at speeds up to 400 r.p.m. It is illustrated in Figs. 1 and 2, on this page, Fig. 2 showing a complete propeller erected in the factory and Fig. 1 a sectional drawing through the propeller hub and the inboard control gear, and part sections through the reduction gearing and clutch of a mechanically-controlled unit.

The hub body is machined from a high-tensile manganese-bronze casting and, as will be seen from the drawing, is hollow with suitable recesses and apertures for accommodating the blade-bearing housings. These are bolted to the hub and the blades are located by spigots machined on their bases, which fit into corresponding recesses machined in the respective housings; one of the housings is shown in position in Fig. 2, where it is lettered *a*. Each blade is bolted at its root to a ring known as a crank-ring. One of these rings can be seen in Fig. 2, where it is lettered *b*, and it will be noted that a spigot formed on one side passes through the hollow centre of the bearing housing to abut against the base of the blade, thereby forming a circumferential groove which serves to locate the blade radially by engaging with an internal flange machined in the bearing housing. The bending loads are, of course, transferred to the housing through the internal flange and to give freedom of movement, bearing plates are inserted between the rubbing surfaces.

The blades are turned to alter the pitch by means of the crank-rings, each of which is fitted on its lower face with a pin offset from the axes of the propeller blade and the hub. These pins are provided with rectangular shoes which, in turn, engage in lateral grooves machined in the crosshead *c*. One of the pins and its associated shoe is lettered *d* in Fig. 1 and it will be appreciated that, if the crosshead is displaced axially the shoe will be displaced an equal amount. This motion is transferred through the pins to the crank-rings and, therefore, to the propeller blades, the shoes moving laterally within the grooves in the crosshead to compensate for the difference between the linear motion of the crosshead and the circular motion of the crank-rings. The crosshead is moved axially by the operating rod *e* which is arranged inside the hollow tailshaft and actuated by a hand control gear located at a convenient point in the vessel. The operating rod also is hollow, the bore being used to convey lubricant to the pitch-changing mechanism. Entry of sea-water into the operating gear and, conversely, loss of oil from the hub, is prevented by synthetic-rubber sealing rings fitted to the base of each blade root; one of these rings is lettered *f* in Fig. 1.

The propellers are supplied with a combined reduction gear, thrust block and propeller-operating gear, or "jack" as the manufacturers term it. The reduction unit comprises a single set of helical gearwheels the centres of which permit any ratio between the limits of 3 to 1 and 1·5 to 1 to be employed. The pinion is fitted to the end of a solid input shaft which rotates in roller bearings and the spurwheel is keyed to an output shaft carried in two steep-angle opposed taper-roller bearings the capacity of which is adequate to withstand the propeller thrust and the reaction of the operating jack. In accordance with modern practice, the lower half of the gear casing is provided with a cooling-water jacket, lubrication being effected by means of an oil bath.

The propeller-operating jack is situated at the forward end of the gearbox casing on the same axis as the propeller shaft, the output shaft from the gearbox being hollow to form a passage for the operating rod. As will be seen from Fig. 1, the inboard end of the operating rod is fitted with a pair of opposed taper-roller bearings the outer races of which are located in the sleeve *g*. This sleeve is screwed externally and is threaded into the fixed circular housing *h* so that rotation of the sleeve causes it to move in relation to the housing, thus displacing the control rod in an axial direction. Rotation of the sleeve is effected through splines machined on its forward extension, which mesh with corresponding splines formed in the inner surface of the hollow wormwheel *i*. The wormwheel is actuated by a worm installed on the end of the shaft *k* which terminates in the control and pitch indicator assembly. This unit is generally located in the wheel-house and comprises a handwheel mounted on a horizontal shaft which drives the control shaft through bevel gearing. The blade pitch is shown on an indicator and the handwheel is provided with a locking device to prevent "creeping" due to vibration. If required, the control wheel can be mounted co-axially with the helm. The combined propeller-operating gear, reduction gearing and thrust block may be mounted independently on an extension to the engine bearers or, by using an intermediate casing, directly on the rear of the engine. If necessary, a clutch can be fitted to the input shaft as shown in Fig. 2. The weight of the reduction gear, etc., is 1,700 lb. The maximum blade-angle range is 65 deg.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

CONSTRUCTION AND MODERNISATION IN IRONWORKS.—Mr. Duncan Sandys, Minister of Supply, in a letter to the General Council of the Scottish Trades Union Congress, has stated that the construction of a fourth blast-furnace at the Clyde Ironworks, Tollcross, of Colvilles, Ltd., and the modernisation of ancillary plant at the Gartsherrie works of Bairds and Scottish Steel, Ltd., are among the measures planned to increase pig-iron production in Scotland. This is necessary to reduce the dependence of the district on imported scrap. A new battery of coke ovens is almost completed at Tollcross and should be in commission by mid-summer. This will double the number of the firm's ovens. The modifications at Gartsherrie will greatly increase the output from the two furnaces there.

THE BUNKERING TRADE.—An increased trade in exports of bunker coal from Scottish ports occurred in 1951, shipments (including foreign, Admiralty, and for trawlers) amounting to 595,258 tons. This compared with 570,061 tons in 1950. December loadings aggregated 44,250 tons against 51,444 tons in the same month of 1950. Bunkers and export cargoes combined, however, totalled 1,402,899 tons only, in contrast with 1,520,491 tons in the preceding 12 months.

APPEAL TO CONTRACTORS TO POOL RESOURCES.—Sir Patrick Dollan, chairman of the East Kilbride Development Corporation, speaking at the annual dinner of the Scottish Plant Owners' Association, held in Glasgow on January 14, suggested that Scottish contractors for roads, drainage, hydro-electric development, and other projects should pool resources to speed the completion of important works. Contractors and builders had more tasks on hand than they could undertake quickly on an individual basis, with the result that housing schemes, new towns, and other public projects were being delayed unduly.

SHIP'S-CABIN DESIGN COMPETITION.—The first prize of 250*l*. in the ship's-cabin design competition organised by the Scottish Committee of the Council of Industrial Design has been won by Mr. I. M. T. Samuel, of Newtongrange, a student at Edinburgh College of Art. An award of 100*l*. has been won by Professor R. D. Russell and his associates, of the Royal College of Art, London. Three other designs were highly commended.

DRAINAGE SCHEME AT GRANGEMOUTH.—The first sod on the site of a new pumping station, part of a new drainage and sewerage scheme at Grangemouth which is estimated to cost 288,000*l*., was cut on January 29, by Baillie J. Fleming, the convener of the Sewerage Committee. Baillie Fleming said that the scheme would take about 30 months to complete.

THE ENGINEERING CENTRE.—Office facilities for about 20 agents or representatives of engineering firms are being made available at the Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. The facilities include office furniture, the use of the Centre's telephone numbers and address for the receipt of messages, mail, etc., typing services, and the use of the catalogue library and information service.

CLEVELAND AND THE NORTHERN COUNTIES.

ACTIVITIES OF NATIONAL UNION OF MANUFACTURERS.—Speaking at an informal dinner of the northern branch of the National Union of Manufacturers, held in Newcastle-upon-Tyne, on January 24, Sir Leonard Browett, director of the Union, said that manufacturers should not only be able to speak with a united voice, but should be in a position to merit national consultation by the Government while policy affecting them was in the formulation stage. The membership of the Union, however, was only 5,300 out of a total of from 35,000 to 40,000 manufacturing firms, and this was a source of weakness. On the other side of the Atlantic, the Canadian Manufacturers' Association was so strong that no Dominion Government would consider taking any steps relating to manufacture without consulting them.

THE POWER GAS CORPORATION.—In his statement to the shareholders, circulated in connection with the 52nd annual meeting of the Power-Gas Corporation, Ltd., held at Stockton-on-Tees on January 30, Dr. N. E. Rambush, M.I.Chem.E., the chairman and managing director, said that the firm secured contracts worth approximately 5,000,000*l*. during the past year. Since the opening of the present financial year, the rate of booking contracts had been well sustained and during the last few months orders for three large blast-furnace plants and for 23 automatic mechanical carburetted water-gas installations had been secured.

TELEVISION ON THE NORTH-EAST COAST.—In a written reply to a question by Miss Irene Ward, M.P., on January 30, Mr. L. D. Gammans, Assistant Postmaster-General, stated that the opening of a television station at Pontop Pike, Co. Durham, and the provision of a better sound-broadcasting service for the North-East of England were among the first tasks the British Broadcasting Corporation would undertake when capital expenditure ceased to be severely restricted. So far as sound reception was concerned, explained Mr. Gammans, the trouble arose from the fact that North-East England and Northern Ireland shared the same wave-length, and the only solution would be the introduction of very high-frequency broadcasting.

EFFECT OF STEEL SHORTAGE.—Owing to a drastic cut in steel supplies, the Gateshead firm, Anglo-Scottish Tool Co. Ltd. has had to pay off 60 of its 450 employees. The night shift has been dropped for the first time for some years. Mr. R. S. Adams, managing director of the company, commenting on the situation, declared that the allocation of steel had been grossly mishandled. The firm required 165 tons quarterly for making joiners' tools, most of which were for export, and 80 tons for making packaging machinery. For the first two periods this year they had been allocated $9\frac{3}{4}$ tons for tools and for the third period $8\frac{1}{2}$ tons. Later, they were informed that they would get another 62 tons for the second and third periods but nothing extra for the present period. Mr. Adams stated that for the making of packaging machinery they had been allocated 26 cwt. for the first and second quarters and 20 cwt. for the third quarter. He said the rationing system would cause steel users to go on to the black market, which was already flourishing.

LANCASHIRE AND SOUTH YORKSHIRE.

RAILWAY-CARRIAGE BUILDING.—At the carriage-building shops of British Railways at Doncaster, sufficient steel is to hand to complete carriage and wagon repairs that have already been started, but stocks are not sufficient to go beyond that. No new carriage building is to be commenced until the future of steel supplies is ascertained. At present there is no short-time working.

A FAMOUS FORGE.—There are plans to preserve as an industrial museum one of Britain's oldest forges, namely that at Wortley Ironworks, near Sheffield. The Ministry of Works have had the premises inspected by an architect. The "Top Forge," now disused, is more than 300 years old. There is evidence that ironworking on the Wortley site dates back to Roman times. A recent history of the plant, *The Story of Wortley Ironworks*, by the Rev. C. R. Andrews, was reviewed in our issue of March 30, 1951 (vol. 171, page 364).

JAPANESE STEEL FOR SHEFFIELD.—The first consignment of Japanese steel to arrive in Sheffield includes a supply of wire rods bearing a label "Made in Occupied Japan." It is understood that the steel was bought before the contract for steel, to cost 5,000,000*l*., was signed recently by a British steel delegation. There has been a marked shortage of wire rods for some time and this has considerably reduced the production of wire and wire ropes. The imported steel is costing several pounds a ton more than the home product.

A LARGE LADLE.—A ladle of 175 tons capacity, part of an order for 14 placed with Newton Chambers & Co., Ltd., Thorncliffe Ironworks, Sheffield, for Messrs. John Summers & Sons, Ltd., Shotton, is nearing completion. It is the biggest yet built at Thorncliffe, and, with the brick lining, weighs about 67 tons. The ladle is of riveted construction and made up of $1\frac{1}{4}$-in. shell plates and a 2-in. dished and flanged bottom plate. Two cast-steel trunnions weighing about $7\frac{1}{2}$ tons are fitted, and each of the two sets of stopper gear weighs about a ton. The diameter of the ladle is 16 ft. 4 in., and the dept 13 ft.

THE MIDLANDS.

SHORT-TIME WORKING IN THE MOTOR INDUSTRY.—The continuing shortage of iron and steel, particularly wide sheets suitable for motor-vehicle bodies, has caused parts of the Nuffield factories at Coventry to be put on short time. From January 28, some 1,300 employees at these factories have been on a four-day week. So far, rumours that similar action would have to be taken at certain other factories in the Coventry area have been neither confirmed nor denied.

ALTERATIONS AT BINGLEY HALL.—Bingley Hall, Birmingham, one of the few exhibition halls in the city, is to undergo internal alterations to improve public facilities. The hall has at present a gallery extending partly round it, and in the past the layout has caused congestion when large numbers of people were present. Two bridges are to be built, connecting the gallery with a new central staircase, to enable visitors to circulate freely.

NYLON FOR GEARS.—Ega Electric, Ltd., of Wednesbury, have put into production a paint spray gun in which plastics are used for many of the components. The gun is operated electrically, without compressed air, and has been proved in prototype form and marketed with metal components. The present model has small high-speed gears of nylon, and other parts of plastics capable of resisting paints and solvents.

LAND MOVEMENT ON THE BANKS OF THE SEVERN.—A steeply-shelving part of the right bank of the river Severn at Jackfield, Broseley, Shropshire, is moving slowly towards the river, necessitating the evacuation of houses at the riverside. The river at Jackfield is in a deep valley, and the banks overlie clay deposits which have been extensively worked in the past. It is thought that former mining operations may be the cause of the present movement, but the question is to be investigated by engineers and geologists. Similar movements on the opposite bank have affected a road which is closed to all but light traffic.

THE LATE MR. WALTER HADLEY.—The death is announced, on January 31, of Mr. Walter Hadley, of Harborne, Birmingham. Mr. Hadley, who was 85 years of age, was well known in Midland engineering circles as honorary secretary of the James Watt Memorial Institute. He was one of the last, if not the last, of the former apprentices of the old firm of James Watt & Co., Soho Foundry, which went out of business in 1895.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SILTING OF RIVER TAFF.—A deputation from the Cardiff Port Development Association appealed for help in removing what it described as the "creeping paralysis" caused by the silting of the River Taff at Cardiff Docks, at a meeting of the Glamorgan Rivers Board at Cardiff on January 31. Mr. E. C. Roberts, Cardiff city engineer and surveyor, stated that about 120,000 tons of colliery debris had been washed down the Taff, mainly during heavy spates, and deposited at the docks entrance. The chairman of the Board, Alderman P. J. Smith, promised that every effort would be made to combat the pollution of the Taff by coal deposits.

FINANCES OF STEEL COMPANY OF WALES.—Mr. E. H. Lever, chairman of the Steel Company of Wales, has stated that, to September 29 last, the Board had sanctioned expenditure totalling 68,000,000*l*., of which more than 57,000,000*l*. had been spent.

UNEMPLOYMENT FIGURES.—Mr. Owen Taylor, Controller for Wales, Ministry of Labour, told a meeting of the Welsh Board for Industry at Cardiff that January figures of unemployment in Wales would show a substantial increase over the December figure of 25,387. Industries chiefly affected are the iron and steel, textile, clothing, furniture, radio and a number of the metal-using trades. In the heavier industries unemployment is due to a shortage of scrap steel, but in the others it is due chiefly to a fall in the demand for consumer goods.

RESEARCH HELPING INDUSTRY.—That a better relationship and understanding exists to-day than ever before between the world of research and the world of industry was the opinion of Mr. J. S. Fulton, Principal of University College, Swansea, who was speaking at the annual dinner of the Wales and Monmouthshire Industrial Estates held at Cardiff. New industrial activity in Wales, he said, had brought employment to over 50,000 people.

SOUTH WALES SWITCHGEAR, LTD.—During the tenth anniversary celebration of South Wales Switchgear Ltd., Blackwood, Monmouthshire, on January 11, it was stated that the first order received by the transformer section of the company was for a 25-kVA pole-mounting transformer for the Bedwellty Urban District Council. The firm now had on their order book 5,000-kVA 33,000-volt/3,300-volt transformers and many others of varying sizes downwards, for all parts of this country and overseas. At least 50 engineers having degrees or Higher National Certificate qualifications had been brought in to establish the industry. With the help of these experienced men, the company's apprentice training scheme had produced large numbers of engineers, draughtsmen, etc.

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.—Monday, February 11, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Merit Rating and Job Evaluation," opened by Mr. J. J. Gracie. *Western Centre:* Monday, February 11, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Sutton Coldfield Television Broadcasting Station," by P. A. T. Bevan and Mr. H. Page. *North-Eastern Centre:* Monday, February 11, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Domestic Electrical Installations: Safety Aspects," by Mr. H. W. Swann. Also at the *East Midland Centre:* Tuesday, February 12, 6.30 p.m., East Midland Electricity Board's Offices, Derby. *Institution:* Tuesday, February 12, 6.30 p.m., Central Hall, Westminster, S.W.1. Faraday Lecture on "Sound Recording: Home, Professional, Industrial and Scientific Applications," by Dr. G. F. Dutton. (Admission by ticket.) *Radio Section:* Wednesday, February 13, 5.30 p.m., Victoria-embankment, W.C.2. "Factors Affecting the Design of the Automatic Electron Trajectory Tracer," by Dr. K. F. Sander, Mr. C. W. Oatley, and Mr. J. G. Yates. *Scottish Centre:* Wednesday, February 13, 7 p.m., Heriot-Watt College, Edinburgh. "The London-Birmingham Television Radio-Relay Link," by Mr. R. J. Clayton and others.

Institution of Production Engineers.—*Sheffield Section:* Monday, February 11, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "Precision Instruments," by Mr. C. A. Coppack. *Yorkshire Section:* Monday, February 11, 7 p.m., Hotel Metropole, Leeds. "Air in Industry," by Mr. T. R. Mobbs. *Dundee Section:* Tuesday, February 12, 7.45 p.m., Mathers Hotel, Dundee. "Human Relations in Industry," by Mr. W. P. Kirkwood. *Preston Section:* Wednesday, February 13, 7.15 p.m., Swan Hotel, Bradshawgate, Bolton. "Steel Co. of Wales, Ltd., Developments at Port Talbot," by Mr. W. G. Mainwaring. *Southern Section:* Thursday, February 14, 7 p.m., Polygon Hotel, Southampton. "Thread Production and Inspection," by Mr. F. Hodgkins. *Rochester Section:* Thursday, February 14, 7.30 p.m., Sun Hotel, Chatham. "Organisation of Production Administration," by Mr. B. E. Stokes. *West Wales Section:* Friday, February 15, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Recent Developments in Plastics," by Mr. E. M. Elliott.

Institution of the Rubber Industry.—*Midland Section:* Monday, February 11, 6.45 p.m., James Watt Memorial Institute, Birmingham. "Engineering Aspects of Belt Conveying," by Mr. J. J. Hickey.

Association of Supervising Electrical Engineers.—*Central London Branch:* Monday, February 11, 7 p.m., St. Ermin's Hotel, Caxton-street, S.W.1. "Supervisory Remote Control of Electrical Supplies," by Mr. J. D. McNeil.

Incorporated Plant Engineers.—*Dundee Branch:* Monday, February 11, 7.30 p.m., Mathers Hotel, Dundee. Short Talks and Discussions. *East Lancashire Branch:* Tuesday, February 12, 7.15 p.m., Engineers' Club, Manchester. "Use of Creosote Pitch as Boiler Fuel," by Mr. S. C. Swann. *South Wales Branch:* Tuesday, February 12, 7.15 p.m., Institute of Engineers, Park-place, Cardiff. "Modern Pumping Machines," by Mr. J. F. Copp. *Kent Branch:* Thursday, February 14, 7 p.m., Queen's Head Hotel, Maidstone. Discussion on "Utilization of Refrigeration in War." *Newcastle-upon-Tyne Branch:* Thursday, February 14, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Mechanical Equipment at Colombo Harbour," by Mr. C. K. Moore.

Royal Institution.—Tuesday, February 12, 5.15 p.m., 21, Albemarle-street, W.1. "Physical Methods in Meteorology.—III. Weather Systems," by Mr. P. A. Sheppard. Friday, February 15, 9 p.m., "The New World of Aerodynamics," by Professor G. Temple.

Institution of Civil Engineers.—*Works Engineering Division:* Tuesday, February 12, 5.30 p.m., "Construction of Sloy Dam," by Mr. J. Stevenson. *Midlands Association:* Thursday, February 14, 6 p.m., James Watt Memorial Institute, Birmingham. "Highway Design and Layout," by Mr. R. W. Grigson.

Institution of Chemical Engineers.—Tuesday, February 12, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Motion of Solid Particles in a Hydraulic Cyclone," by Mr. D. F. Kelsall; and "The Cyclone as a Separating Tool in Mineral Dressing," by Mr. K. A. Fern.

Institute of Marine Engineers.—Tuesday, February 12, 5.30 p.m., 85, Minories, E.C.3. "Fuels for Use in Marine Auxiliary Oil Engines," by Mr. C. D. Brewer.

Illuminating Engineering Society.—*Cardiff Centre:* Tuesday, February 12, 5.45 p.m., South Wales Electricity Board Offices, Cardiff. "The Tungsten Lamp," by Mr. B. P. Dunning. *Edinburgh Centre:* Wednesday, February 13, 7 p.m., 357, High-street, Edinburgh. "Outdoor Decorative Lighting," by Mr. H. Carpenter. *Leicester Centre:* Thursday, February 14, 6.30 p.m., East Midlands Electricity Board Offices, Charles-street, Leicester. "Lighting of the Queen Elizabeth and Caronia," by Mr. T. Catten.

Institution of Mechanical Engineers.—*South Wales Branch:* Tuesday, February 12, 6.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Air Conditioning in a Modern Textile Factory," by Mr. R. G. Clarke and Mr. J. P. Russell. *Institution (Industrial Administration and Engineering Production Group):* Friday, February 15, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Allocation of Machines to Operators," by Mr. T. F. O'Connor. Automobile Division.—*Luton Centre:* Monday, February 11, 7.15 p.m., Town Hall, Luton. "Carbon as an Engineering Material," by Dr. D. B. Foster. *London:* Tuesday, February 12, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Noise in Private Cars," by Dr. J. R. Bristow.

Institution of Engineers and Shipbuilders in Scotland.—Tuesday, February 12, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Simplified Launching Calculations," by Mr. A. Silverleaf.

Institution of Heating and Ventilating Engineers.—*South-Western Branch:* Tuesday, February 12, 6.30 p.m., R.W.A. School of Architecture, Bristol. "District Heating in France," by Mr. E. A. Pearce. *Institution:* Wednesday, February 13, 2.30 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. Annual Meeting and Presidential Address.

Royal Aeronautical Society.—Tuesday, February 12, 7 p.m., 4, Hamilton-place, W.1. "Flight Test Problems for Civil Aircraft," by Mr. B. P. Laight.

Institute of Road Transport Engineers.—*Western Group:* Tuesday, February 12, 7.30 p.m., Grand Hotel, Bristol. "Use and Abuse of Tyres," by Mr. W. R. Good. *East Midlands Centre:* Wednesday, February 13, 7.30 p.m., Mechanics Institute, Nottingham. "Motor Racing and Engine Design," by Mr. Bob. Gerard and Mr. Reg. Parnell.

Institute of Fuel.—*North-Western Section:* Wednesday, February 13, 2 p.m., Engineers' Club, Manchester. "Modern Steam Generators," by Mr. W. C. Carter. *Scottish Section:* Friday, February 15, 7 p.m., North British Hotel, Edinburgh. "Boilers," by Mr. H. E. Partridge.

Royal Society of Arts.—Wednesday, February 13, 2.30 p.m., John Adam-street, W.C.2. "Television Technique as Aid to Observation," by Dr. J. D. McGee.

Institute of Petroleum.—Wednesday, February 13, 2.30 p.m., and 5.30 p.m., 26, Portland-place, W.1. "Lubrication of Gears." For further details, see our issue of December 21, 1951, page 787.

Royal Sanitary Institute.—Wednesday, February 13, 2.30 p.m., 90, Buckingham Palace-road, S.W.1. Discussion on "Port Health Control," opened by Dr. H. C. M. Williams.

Royal United Service Institution.—Wednesday, February 13, 3 p.m., Whitehall, S.W.1. "Long-Range Jet Flying," by Sqdr. Ldr. A. E. Callard.

Newcomen Society.—Wednesday, February 13, 5.30 p.m., Imperial Institute, South Kensington, S.W.7. "The Macintosh: The Paternity of an Invention," by Dr. H. Schurer.

Liverpool Engineering Society.—Wednesday, February 13, 6 p.m., 24, Dale-street, Liverpool. Meeting with Institution of Mechanical Engineers (*North-Western Branch*). Thomas Lowe Gray Lecture on "Ship Research," by Dr. S. Livingston Smith.

Royal Society.—Thursday, February 14, 4.30 p.m., Burlington House, W.1. "Flow of Gases Through Capillaries," by Mr. J. A. W. Huggill; and "Inelastic Collisions Between Ions and Atoms," by Mr. J. B. Hasted.

Institution of Structural Engineers.—Thursday, February 14, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Fire Endurance of Timber Beams and Floors," by Mr. D. I. Lawson and others.

Engineers' Guild.—*Metropolitan Branch:* Thursday, February 14, 6 p.m., Caxton Hall, Victoria-street, S.W.1. Debate: "That Nationalisation of Industry Does not Adversely Affect the Status of Professional Engineers."

Institute of Industrial Administration.—*London Centre:* Thursday, February 14, 7 p.m., 8, Hill-street, W.1. "Management in Practice": No. 6, "Productivity and Management," by Mr. R. P. G. Kirchem.

Junior Institution of Engineers.—Friday, February 15, 6.30 p.m., 39, Victoria-street, S.W.1. "Arc-Welding Electrodes," by Mr. D. H. Young. *North-Western Section:* Saturday, February 15, 2.30 p.m., 16, St. Mary's Parsonage, Macnhester. Discussion on "Impressions of America," by Mr. Frank Burgess.

Women's Engineering Society.—*London Branch:* Friday, February 15, 7 p.m., 35, Grosvenor-place, S.W.1. Discussion on "The Women's Engineering Society."

PERSONAL.

Colonel H. B. Sankey has been appointed President of the Birmingham, Wolverhampton and Stafford district of the Engineering and Allied Employers' Association. Mr. W. F. Brazener has been made deputy president.

Mr. V. W. Pilkington, M.B.E., M.Eng., M.I.Mech.E., has been appointed chief engineer of the Leyland Motors Ltd. (Ministry of Supply) factory, and will be responsible for the design and development of units associated with that factory.

Mr. J. B. Mavor has been re-elected President of the Glasgow and West of Scotland Section of the Institute of Industrial Supervisors. Mr. T. P. Wyllie has been elected chairman and Mr. J. Murray, vice-chairman.

Following upon the resignation of Mr. H. Nielsen, Mr. E. C. Davies, A.M.I.E.E., has been appointed manager of the heavy plant section of the engineering sales department, the General Electric Co. Ltd., Witton, Birmingham, with Mr. G. F. J. Morgan as his assistant.

Mr. A. J. W. Graham, O.B.E., M.I.C.E., M.I.Mech.E., has resigned his position of technical controller with Messrs. Sandberg, 40, Grosvenor-gardens, London, S.W.1, as from January 31, but is continuing his other activities. His private address is Western House, Middleton-one-Row, Darlington. (Telephone: Dinsdale 54.)

Mr. H. A. MacColl, B.Sc. (Manc.), M.I.Mech.E., F.I.M., head of the Department of Metallurgy at the County Technical College, Wednesbury, has been appointed Principal of the College.

The United Steel Companies Ltd., 17, Westbourne-road, Sheffield, 10, announce that Mr. C. E. Edwards, the commercial manager of their Appleby-Frodingham branch, has been appointed a director of the Appleby-Frodingham Steel Co.

Mr. J. B. Haworth, B.Met. (Sheff.), research metallurgist, Murex Ltd., Rainham, Essex, has been awarded the D.Phil. degree of the University of Oxford.

Mr. B. H. Dyson, until recently deputy general works manager, Hoover Ltd., Hoover House, 211-213, Regent-street, London, W.1, has now been appointed general works manager for the four main factories of the company. He is also a director of Hoover (Washing Machines) Ltd., Mr. Dyson is a member of Council of the Institution of Production Engineers.

Mr. F. C. Gray, A.M.I.Mech.E., has been appointed manager of the Metropolitan-Vickers Electrical Export Co. Ltd., for Spain, as from January 1.

Mr. F. A. Kimberley has been re-elected President of the British Cycle and Motor Cycle Manufacturers' and Traders' Union. Mr. J. Y. Sangster and Mr. H. Evan Price have been re-elected vice-presidents.

Mr. G. P. Belsham, works manager, has been elected a joint managing director of Brookhirst Switchgear Ltd., Chester. Mr. K. N. Swash, B.Sc., A.M.I.E.E., chief engineer, has been elected a director.

Mr. S. L. Hulme, O.B.E., has been appointed Northern Divisional Controller at the Ministry of Civil Aviation's headquarters at Liverpool, in succession to Captain B. L. Huskisson, D.S.C., R.N. (ret.), who has been made chairman of the air-traffic control development staff.

Mr. R. W. Gourdie, O.B.E., F.C.I.S., has been appointed secretary to Acrow (Engineers) Ltd., in succession to Mr. F. V. S. Bartlett, who has retired. Mr. Gourdie commenced his new duties on February 1.

Metro-Cutanit Ltd., 160, Piccadilly, London, W.1, announce that they are extending their range of Cutanit cemented-carbide hard metals by the manufacture of new grades containing tantalum and niobium carbides. Tool tips will shortly be available through Cutanit distributors, William Jessop & Sons Ltd., Sheffield.

James Stott & Co. (Engineers) Ltd., Lee-street, Oldham, have opened a new depot at 14, John-street, Bristol, under the management of Mr. A. W. Teall (Telephone: Bristol 24908.)

Dewrance & Co. Ltd. announce that, as and from January 14, their Manchester office was transferred to 32, Deansgate, Manchester, 3. (Telephone: Blackfriars 9283.) Mr. W. A. Duckworth is the company's manager for this area.

Fenter Ltd., Birmingham, have been appointed world agents, excluding Australia and New Zealand, for the complete range of Denbigh milling and drilling machines, metal saws and presses.

We regret that the postal number of IBM United Kingdom Ltd., Beavor-lane, Hammersmith, formerly International Time Recording Co., Ltd., was given, on page 79, *ante*, as W.8; it should have been London, W.6.

A Midland branch of the Sheet and Strip Metal Users' Technical Association has now been constituted. The chairman is Mr. M. E. Guermont, and the honorary secretary, Mr. E. N. Salmon, of the Austin Motor Co. Ltd. The first meeting of the branch will take the form of a discussion on "Presswork and its Problems," to be held at the Chamber of Commerce, New-street, Birmingham, at 6.45 p.m., on February 13

Photo: Y. Karsh, Ottawa.

HIS MAJESTY KING GEORGE VI.

BORN, DECEMBER 14, 1895: SUCCEEDED TO THE THRONE, DECEMBER 11, 1936:

DIED, FEBRUARY 6, 1952.

TO few is it vouchsafed to achieve such a place in the hearts of men as that attained by His Most Excellent Majesty KING GEORGE THE SIXTH, whose sudden death on the morning of Wednesday, February 6, has shocked so profoundly the millions of his subjects ; and, indeed, millions more, of diverse races, creeds and colours, who owed him no allegiance at all, but who recognised the incalculable significance to the world of the fact that the British Throne was occupied, through years of unexampled stress, by a man whose high principles were matched by his firmness of character.

PRINCE ALBERT FREDERICK ARTHUR GEORGE OF WINDSOR, " by the Grace of God of Great Britain, Ireland, and of the British Dominions beyond the Seas, King, Defender of the Faith . . . ", second son of His late Majesty King George the Fifth and of Her Majesty Queen Mary, was born at York Cottage, Sandringham, on December 14, 1895. Like his father, he was not initially trained to the duties of Kingship, but was able to enjoy the greater freedom and somewhat lesser responsibility of a second in succession to the Throne, whose prospects of succeeding to it might be expected, in the ordinary course, to become more remote rather than otherwise. He was enabled, therefore, to enter the Royal Navy as a serving officer, as did his father ; and, before duodenal trouble obliged him to give up the sea, to go into action at the Battle of Jutland in H.M.S. Collingwood. Later, when his health was restored, he saw service with the Royal Air Force, becoming a qualified pilot. It may be observed, therefore, that he had opportunities quite unusual among highly-placed members of Royal Houses, to mingle at close quarters with men of more ordinary station, and to acquire an amount of technical knowledge almost certainly without parallel among the varied accomplishments of British Monarchs. When, in later years, he began to make a special study of industry, as President of the Industrial Welfare Society, and during his many visits to industrial establishments and great engineering works, he was able to bring to the task a mind already enlightened by considerable practical experience. There can be no doubt that these exceptionally close contacts (for a Royal Prince) with working folk of all grades did much to develop that intimate understanding and warm humanity which were so evident, and so powerfully affecting, in his Christmas broadcasts to the peoples of the British Commonwealth. He was a King—none ever more so ; but he was a man first, a man who daily went " forth to his work and unto his labour " with a constancy and a high spirit of endeavour that few of his subjects could equal and, it is safe to say, none surpassed.

King George the Fifth had those qualities, too, and the advantage of a longer service in the Royal Navy ; but, despite his constant journeyings during the 1914-18 War, and his wholehearted devotion to the duties of the Monarchy, his Kingship—reflecting its earlier date—was something more remote from the work-a-day world, whereas that of GEORGE THE SIXTH seemed to be naturally a part of it. Some of that impression we owe, undoubtedly, to the memory of those war years in which THEIR MAJESTIES shared with their people the bombing attacks of a ruthless enemy ; but more, perhaps, to the glimpses of a perfectly normal and healthy family life, hampered somewhat, like the lives of millions of others, by enforced economies, but one, in which, irrepressibly, " cheerfulness kept breaking in."

It is from the appreciation of this background that comes the real depth of the nation's sorrow and sympathy. Such bereavement is something that most have undergone and can understand ; but when to that understanding is added a realisation of the unique burdens—unique in the truest meaning of that often misused word—which are peculiar to the Throne, the sorrow becomes more poignant and the feeling of sympathy towards the Queen Mother, Queen Mary, and the other members of the Royal Family, but especially towards Her Most Gracious Majesty QUEEN ELIZABETH THE SECOND, becomes almost impossible to express.

KING GEORGE, in his Royal patronage of the Arts and Sciences, showed a lively interest in the work of engineers and in the application of scientific research to practical uses. He was not only Patron of the Royal Society, but also of the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers, among other societies ; and—a distinction unique in its kind—Permanent Master of the Worshipful Company of Shipwrights. To the members of all these societies, and of the numerous others to whose activities he lent his Royal support, his interest was a stimulus and a reward ; but to them, as, we believe, to most of his subjects, the memory of KING GEORGE THE SIXTH that will stand out most clearly will be that of a steadfast and far-sighted gentleman, who, in a world that had lost much of its erstwhile trust in princes, established more firmly than ever the principle and the ideals of Constitutional Monarchy.

ENGINEERING

35, & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:
ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:
TEMPLE BAR 3663 and 3664.

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

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

SUBSCRIPTIONS.

ENGINEERING may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

CONTENTS.

ENGINEERING

FRIDAY, FEBRUARY 8, 1952.

VOL. 173. No. 4489.

DRAINAGE OF FIREDAMP FROM MINES.

ALTHOUGH no information has been collected about the amount of methane discharged to the atmosphere every day by all the coalmine fans in Great Britain, it is suggested, by responsible observers, that it may be of the order of 300 to 400 million cubic feet, approximately equivalent in heat content to all the gas produced by the gasworks of the country. In view of this opinion, it is clearly desirable that attempts should be made to collect the gas under controlled conditions, and utilise it, instead of discharging it to waste. Some work has been done on this matter in this country but not as much as on the Continent. At the Hirschbach colliery in the Saar, the gas is burned under a water-tube boiler, some 14,000 lb. of steam being raised per hour at an efficiency of about 80 per cent.; in the Emscher-Lippe colliery in the Ruhr it is used as an addition to coke-oven gas supplied to a gas grid; the methane is also delivered to a gas grid in parts of Belgium. At Luisenthal in the Saar the gas is compressed and delivered in high-pressure containers for use as a motor fuel.

Full particulars of these and other installations will be found in a report* prepared by a working party consisting of four members, all technical experts, two representing the National Coal Board and two, the Ministry of Fuel and Power. The report is an extensive document and contains many diagrams illustrating gas-drainage arrangements in Continental mines. The working party was instructed to study the literature of the subject, examine existing installations and report on what further experimental work should be carried out in this country. The primary advantage of draining firedamp from mines is that the quantity of gas entering the ventilating air is reduced, thus producing safer working conditions and facilitating coal winning in gassy mines. The greater part of the report is consequently concerned with methods of collecting the gas rather than its utilisation. In view, however, of the statement that "it is general experience at the mines we visited where the methane was being utilised that the value of the gas obtained was more than sufficient to pay for the installation, operation and maintenance of the drainage scheme," it would appear that merely on a financial basis it would be desirable to develop and apply drainage systems at suitable collieries in this country.

Experimental work, particularly in Germany, has indicated that the emission of methane from coal seams is greatest when the coal or neighbouring strata are relieved from their original state of stress by mining operations. It is not certain, however, that the relief from stress causes more gas to be issued from the coal; the effect may be due to the increased permeability of the coal and strata caused by the disturbance due to working. Apparently, permeability of the surrounding strata may be an important influence in determining the amount of methane discharged to a mine gallery. It has been found that gas produced in working a lower seam may pass through 60 to 70 ft. of intervening strata into the working of a seam above, with a consequent reduction in the gas discharged into the ventilating air of the lower seam. These observations are of importance as indicating one of the basic factors leading to methane emission into mines but, in general, some strata disturbance cannot be avoided in driving headings, although experiments in this country have indicated that improvement in supporting arrangements, reducing convergency of roof and floor, tends to decrease the emission of gas to the workings.

Three main methods of methane drainage have been developed. These are respectively known as the "cross-measure hole method," the "superjacent heading method" and the "pack-cavity method." In the first, boreholes are drilled, usually close to the working face, to cross overlying or underlying coal seams. The gas from the strata through which the holes pass drains through the holes and is collected in a pipe range. In the second, one or more headings are driven in a seam, which may be workable or unworkable, over an area of coal to be worked later in a seam below. In order to draw as large an area as possible, it is customary to drill a large number of boreholes in the seam from the gas-drainage headings and also holes across the strata, usually upwards. When the heading has been completed and the boreholes drilled, the outby end of the heading is sealed and faced with cement or brickwork, through which one or more pipes are inserted. When the underlying seam is worked, methane is discharged into the heading and drawn off through the pipe or pipes. The third method is employed only in the Saar; cavities are formed in the solid pneumatic packing behind the coal face, the cavities being about 5 ft. wide. A pipe is built into the pack at the top of the face to lead the gas from the cavities into a gas main. Suction is applied to the cavities to draw off the gas. It is pointed out in the report, however, that the existence of the cavities may have a bad effect on the roof conditions at the face.

* *Report by the Ministry of Fuel and Power and National Coal Board Joint Working Party on the Drainage of Firedamp from Mines.* Ministry of Fuel and Power, Westminster House, 7, Millbank, London, S.W.1.

This is not the only critical comment which is made and the respective advantages and disadvantages of the three methods are discussed, the conclusion being come to that the "cross-measure hole method" is the most suitable for general application in Great Britain. This is not to be taken to mean that it is to be applied indiscriminately at any colliery. Although it is laid down that "firedamp drainage should be developed vigorously in Great Britain," it is pointed out that "the number of mines in Great Britain where firedamp drainage could be beneficially applied is probably not large." The most extensive work at present being carried out in this country is at the Point of Ayr Colliery, where methane drainage has been practised for 60 years. The conditions at this colliery are, however, exceptional, large gas flows being associated with high pressures. Experimental work is being carried out by the National Coal Board in Cumberland, North Staffordshire, Scotland and South Wales.

Draining firedamp from mines through pipe-lines, by reducing the amount discharged into the general ventilating air, will tend to greater safety and might, in some cases, permit electrical plant to be used in situations in which it is now essential to employ compressed-air machines. Nevertheless, installation and operation of a system may introduce new hazards which must not be overlooked. In the first place, the system must be reliable, as failure of the drainage arrangements might result in an increase of methane discharge into the ventilating air in situations where it was unexpected. The drilling of cross-measure holes, which are usually 2 in. or 3 in. in diameter and situated about 25 yards apart, may introduce two possible sources of danger; methane might be ignited at the mouth of the hole by a spark from a drill and it is recommended that wet drilling should always be practised, a stream of water passing down the hole outside the drill rods. Another possibility is that there may be a heavy emission of gas from the hole, and it is recommended that at first holes should only be drilled deep enough to permit a stand-pipe carrying a valve to be cemented in.

A complete drainage installation will include a pipe line, exhausters and various control arrangements, a point requiring particular attention being the avoidance of the possibility of an explosive mixture entering any utilisation plant. These matters are dealt with in considerable detail in the report, which lays stress on the importance of a proper installation of indicating and recording instruments. Almost the last words in this authoritative report are to the effect that practical trials in this country need not necessarily be limited to very gassy pits. There is probably a fairly wide choice of suitable sites for trials and it is probable that this report will have a definite effect on practice, which is not always the case with reports on technical subjects. The report is addressed in particular to Divisional Engineers and Area Managers and Engineers of the National Coal Board, but it will be of interest and value to anyone concerned with colliery plant and operations.

NOTES.

Quincentenary of Leonardo da Vinci's Birth.

The Italian "Committee for Observing the Fifth Centenary of Leonardo da Vinci's Birth" have issued a programme in English of the celebrations which are to be held in Italy. Leonardo da Vinci was born on April 15, 1452, in the small Tuscan village from which he and his family took his name, and died at Cloux, in France, on May 2, 1519. In this age of specialisation, 500 years after his birth, the wonder of his manifold genius is perhaps greater than it has ever been, so incredible does it now seem that a man could excel in so many branches of art and learning. In Italy, those cities where he lived and worked are to be the main centres of the celebrations. At Vinci, the condition of some important buildings is to be improved, an art exhibition is to be held, and lectures on Leonardo's work are to be given. The Italian celebrations are to be opened at the Capitol, in Rome, with speeches on various aspects of the master's work, including one on "Leonardo: Inventor," by Mr. Gustavo Colonnetti, President of the National Council of Research; one on "Leonardo: Man of Science," by Mr. Bruno Borghi, Rector of Florence University; and another on "Leonardo and the Flying Machine," by Mr. Raffaele Giacomelli. At Milan, in the cloisters of San Vittore, the scientific and technical exhibition to be held there will attempt to show the ultimate value of Leonardo's inventions. It will be divided into sections dealing with hydraulic machinery, hydraulic works, submarines, bridge building, weapons, military construction, aeronautics, transport, town planning and building, and industrial technology. An exhibition at the Palazzo Grassi, Venice, will "reconstruct the society in which Leonardo lived," dealing particularly with manners and dress; and at Florence it is hoped to stage an exhibition of all Leonardo's paintings (except "The Last Supper," which is a mural), though this is likely to prove difficult. It has been suggested that this collection should later be shown in Paris and London. Manuscripts and notes will be shown at Bologna, and a special issue of postage stamps is to be made.

The Institution of Mechanical Engineers.

At the general meeting of the Institution of Mechanical Engineers held in London on Friday, February 1, a paper on "Powered Flying-Controls; Some Design Considerations," was read by Messrs. F. J. Bradbury and S. M. Parker; a summary of the paper is given on page 183. At the beginning of the meeting, Mr. T. E. Beacham, the retiring chairman of the Hydraulics Group, was in the chair, but after announcing the names of the newly-elected Group committee, he invited the new chairman of the Group, Mr. G. A. Wauchope, to preside. The other Group committee members are as follows: Mr. H. N. G. Allen, Dr. J. S. Blair, Mr. R. Pennington, Mr. L. E. Prosser, and Mr. N. Tetlow. In the discussion which followed the paper, opened by Mr. T. E. Beacham, one of the principal points that emerged was that on modern high-speed aircraft the control loads might be so high that manual emergency control could not be used. Aerodynamic balancing could therefore be eliminated, and an irreversible system would be required which, by providing sufficient stiffness to resist flutter, might make it possible to eliminate mass-balancing of the control surfaces. Full duplication would be required to guard against failure. The general opinion appeared to be that hydraulically-operated controls were at present the most reliable, but there was some support for electric signalling and electro-hydraulic power. Some doubts were expressed on the adequacy of the life of the actuator jacks. Several speakers considered that the ground-testing rig should be more fully representative of the actual aircraft control surfaces and circuits than that described in the paper, and that it should include a means of exciting periodic oscillations in the output circuit to simulate oscillating forces generated at the control surfaces. There was disagreement on stability; several speakers expressed distrust of the hydraulic damper and suggested that the stability problem could be overcome by alternative designs of valve and of jack anchorages, or by adopting derivative control. The authors' view that the effect on stability of flexibility in the output circuit was less serious than in the input circuit was not accepted by two speakers, who considered that greater stability could be obtained by locating the power unit at the control surface rather than at the pilot's control. Increasing the stability of the system by means which caused a reduction in sensitivity might not be acceptable with an automatic pilot in use. In replying to the discussion, the authors said that the standard of life set for a servo-jack was not less than one million cycles, and they believed that this could be improved considerably. They agreed that fully representative test rigs were preferable, but for exploring a number of systems the rig described was more economical. Stability on the rig was a fair guarantee of stability in flight, whereas instability on the rig did not necessarily imply instability in the aircraft.

Black-and-White or Colour Television.

A discussion on whether further development should be concentrated on colour to the exclusion of black-and-white television was opened by Mr. L. C. Jesty at a meeting of the Radio Section of the Institution of Electrical Engineers, on Monday, January 28. The existing black-and-white television services, he pointed out, could be improved by the use of better equipment. This, in turn, would assist the development of colour television, the most important element in which, both economically and technically, was undoubtedly the receiver. The use of electronic scanners for the superposition of the three primary images must be ruled out, unless some auxiliary device was used for ensuring reigstration. So far there had been no demonstration of a receiver or tricolour tube embodying such auxiliary regis ration on a full definition picture. There was no lack of colour television problems and, by concentrating upon them, techniques generally might be improved and developments automatically brought about in black-and-white systems as well. Generally speaking, this contention was supported in the subsequent discusion, it being suggested that both systems should be developed simultaneously; and that the colour system adopted should be such as to provide a satisfactory service to viewers who possessed receivers which were only capable of reproducing a black-and-white picture. Several speakers pointed out that there was plenty of room for improvement in the existing black-and-white system in this country, in order to overcome reductions in the signal strength at the upper end of the frequency range and to achieve better camera technique. It was also argued that additional resources would be necessary to develop a colour system and that these were not at present readily available.

OBITUARY.

MR. J. M. BAXTER.

We regret to record the death of Mr. J. M. Baxter, which occurred in Glasgow on Sunday, January 27, at the age of 63.

John McFarlane Baxter was born in Dundee on October 3, 1888, and was educated at Monifieth public school and the Harris Academy in that city. He subsequently attended the Dundee Technical College, where he obtained the Armistead prizes and silver medal; and the Royal Technical College, Glasgow. In 1904, he began a five years apprenticeship with Messrs. Urquhart, Lindsay and Company, Limited, Dundee, with whom he obtained a wide experience in general engineering and millwright work; and was subsequently employed in the drawing office and on estimating. After further appointments with Fraser and Chalmers, Limited, at Erith, and Aitken and Company, Glasgow, he became a draughtsman in the mechanical engineering department of Sir William Arrol and Company, Limited, in 1914.

He served in this position for six years, during which time he took part in the design of hydraulic plant and machinery for opening bridges and lock gates, as well as of shell-filling presses. He became chief estimater of the firm in 1920 and chief draughtsman four years later; and in 1935 was appointed chief engineer, the position that he was still holding at the time of his death. In that capacity he was engaged principally in the design of a great variety of machinery and mechanical equipment, including a caisson at Singapore, as well as bascule bridges at Yarmouth and across the Mersey. He was also responsible for providing the mechanical equipment for Admiralty landing craft and for the design, development of, and co-ordination of supplies for, three types of anti-aircraft equipment.

Mr. Baxter was elected a member of the Institution of Mechanical Engineers in 1945. He was also a member of the Institution of Engineers and Shipbuilders in Scotland and of the Institute of Welding.

OVERHEAD ELECTRIFICATION EQUIPMENT IN SUBSIDENCE AREAS.

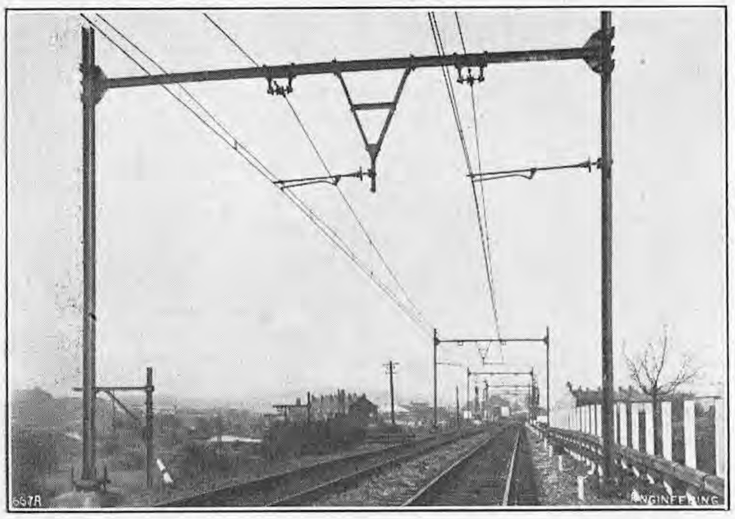


FIG. 1. OVERHEAD STRUCTURE SPANNING TWO TRACKS.

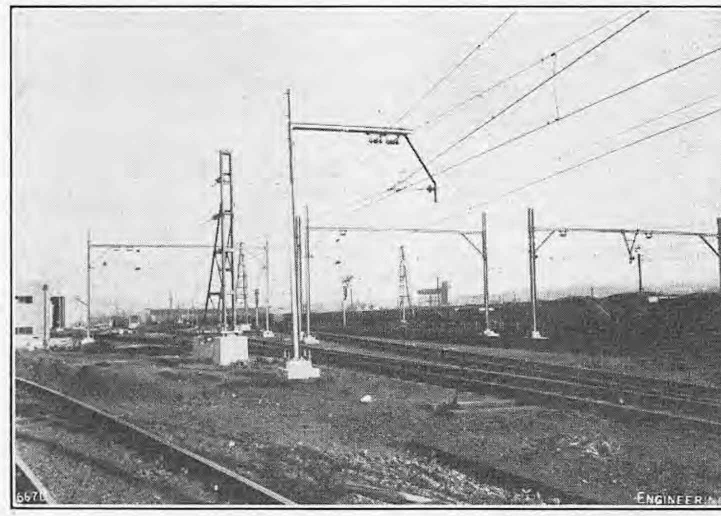
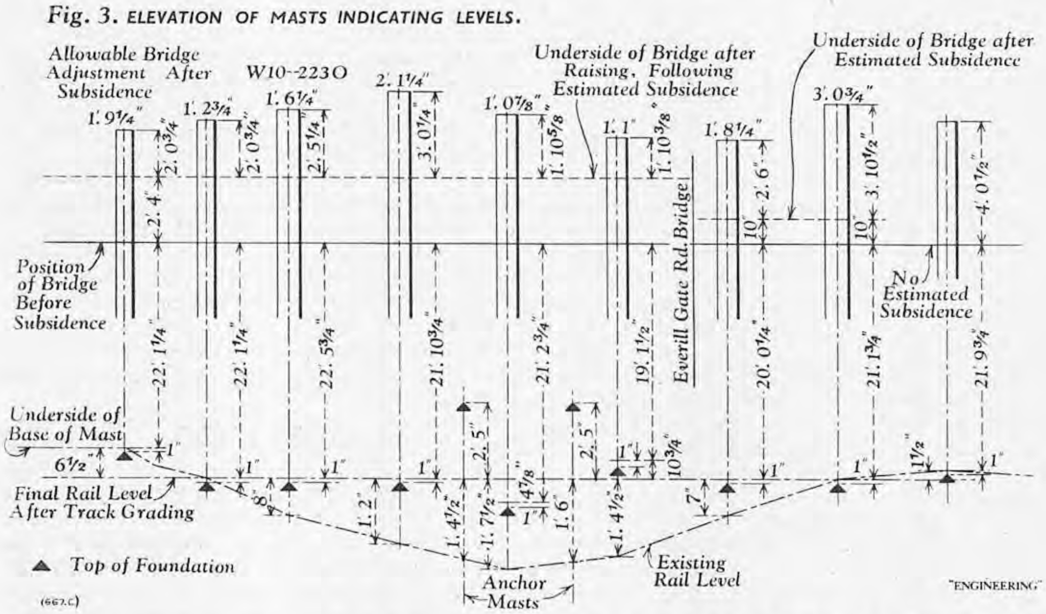


FIG. 2. SINGLE-TRACK CANTILEVER STRUCTURE.

Fig. 3. ELEVATION OF MASTS INDICATING LEVELS.



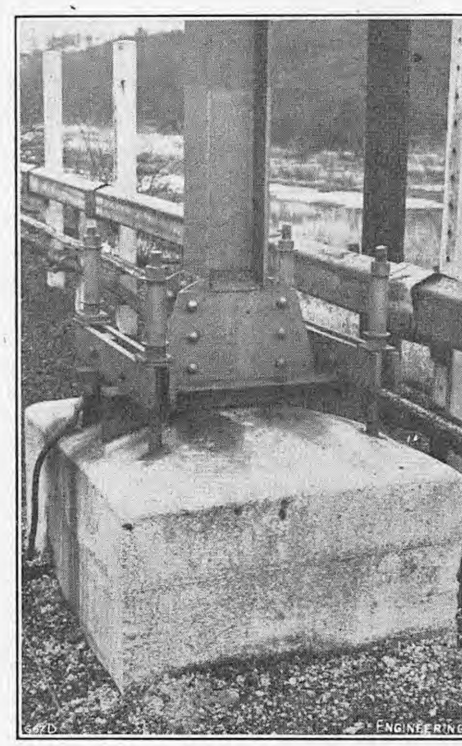


FIG. 4. ADJUSTABLE MAST BASE.

SUMMER MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.—The Summer Meeting of the Institution of Mechanical Engineers will be held in Bristol on Tuesday, Wednesday and Thursday, June 17, 18 and 19. A local reception committee has been formed, under the chairmanship of the Rt. Hon. The Lord Mayor of Bristol, Alderman R. F. Lyne, O.B.E., J.P. An executive committee has also been elected, with Professor J. L. M. Morrison as chairman. Mr. G. H. Beauchamp and Mr. J. G. Remington have been appointed joint honorary local secretaries. Preliminary application forms for the Summer Meeting will be issued with the March *Journal* of the Institution.

AMENDMENTS TO STEEL DISTRIBUTION SCHEME.—The Minister of Supply has issued an Order authorising a number of adjustments in the iron and steel distribution scheme which is to come into operation on February 4. Thus, consumers may use the stock held at the close of February 3 for a purpose for which they hold a control authorisation. The holder of a control authorisation may send material out on loan to be worked up for him. This amendment is designed to cover the "free-issue contract" customary in some trades for outside processing of material. Two new items, namely, wire rod and wire reinforcement fabric mesh, are added to the list of controlled forms of steel. The list of small quantities exemptions has been extended to permit the purchase, without licence, of 5 cwt. a month of these items and also one ton a month of "large spring." The Order is the Iron and Steel Distribution (Amendment No. 1) Order, 1952 (S.I. 1952, No. 172), and is obtainable from H.M. Stationery Office (price 4*d*.). An "Amendment No. 1, February, 1952," to the "Notes for Consumers, January, 1952," is also being issued by the Stationery Office. The Ministry of Supply also announce that, as from April 1, 1952, the separate allocation of non-alloy steel sheet will be abandoned and that thereafter such steel sheet, for allocation purposes, will be merged in general non-alloy steel.

OVERHEAD EQUIPMENT FOR RAILWAY ELECTRIFICATION IN SUBSIDENCE AREAS.

By H. H. STOREY and G. A. WALLACE, A.M.I.E.E.

THE Wath-Dunford Bridge section of the Manchester-Sheffield-Wath railway electrification scheme, of which further details are given on page 166 of this issue, presented a new problem in the design and erection of the overhead track equipment. For about 11 miles of the route the tracks are laid on ground which is liable to subsidence owing to underground colliery workings, and provision is therefore made in the designs for subsidence to take place up to as much as 4 ft. in some areas. The solution of this problem involved close co-operation between the engineers of the Railway Executive and of the contractors, British Insulated Callender's Construction Company, Limited, with whom the authors are associated, owing to the fact that when subsidence occurs the tracks must be packed up to ensure that the grading remains correct. This means that, throughout the mining area, provision has also to be made for the overhead equipment to be raised, in order to maintain a height of 16 ft. between the contact wire and the tracks.

To ensure this, available data on mining subsidence were used to prepare charts showing the estimated subsidence along the route. This varied from 6 in. to 4 ft. To these charts were added details of the track-packing which would be carried out, and it was then possible to make a reasonable estimate of the total amount by which the overhead equipment would have to be raised. A typical chart is reproduced in Fig. 3, and the following example, worked out for location W10 + 2230, shows how it was used. To provide for 16-ft. contact-wire height above the final rail level after grading, the bridge supporting the overhead equipment had to be erected 22 ft. $5\frac{5}{8}$ in. above the final rail level. As subsidence occurs the foundations and masts will sink, but the tracks will be maintained at the "final rail level." The bridge will therefore have to be raised until, after 2 ft. 4 in. of subsidence, it reaches the position shown as "underside of bridge after raising." It was decided to allow at least 12 in. adjustment after all estimated subsidence, and 11 in. is required for the connection between bridge and masts, so the total mast length would be 22 ft. $5\frac{5}{8}$ in. + 2 ft. 4 in. + 1 ft. + 11 in. = 26 ft. $8\frac{3}{4}$ in. The nearest standard mast length, i.e., 27 ft. 3 in., was used, thus giving an adjustment after subsidence of 1 ft. $6\frac{1}{4}$ in. instead of 1 ft. Dimensions other than 22 ft. $5\frac{5}{8}$ in. from bridge to rail are due to special site considerations which required contact heights other than 16 ft.

Three principal methods were used for raising the overhead equipment. Where not more than four tracks had to be equipped, structures with adjustable bridges and mast bases were employed. Where the number of tracks was more than four, towers with adjustable bases and carrying adjustable head-

OVERHEAD EQUIPMENT IN SUBSIDENCE AREAS.

FIG. 5. MULTIPLE-TRACK HEAD-SPAN CONSTRUCTION.

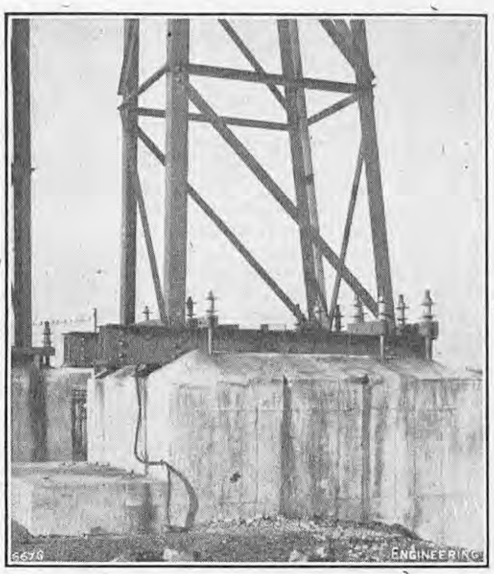


FIG. 6. HEAD-SPAN TOWER BASE.

spans were erected, while separate adjustable anchor masts were provided wherever the equipments had to be terminated.

A typical structure with a 30-ft. bridge spanning two tracks shown in Fig. 1, opposite. It was designed as a plain portal and fabricated from broad-flange beam sections. The adjustable connection between the bridge and the masts is adequate to transfer vertical loads of up to 1,800 lb. and horizontal loads of up to 3,417 lb. from one to the other. This type of connection involved the use of substantial gusset plates, which are welded to the bridge and are secured to the masts by a number of clamping bolts. Structures with 60-ft. bridges spanning four tracks were also designed as portals and fabricated from broad-flange beam sections, but in this case knee-braces were used. The end of the bridge and its knee-brace are bolted to a common plate which is then fixed to the mast by bolts. Several structures of this type can be seen in the background of Fig. 2. The bases of all these structures were made adjustable so that, if subsidence causes the foundations to move out of level, the masts can be set plumb. Fig. 4 shows a base for a two-track or four-track structure on its foundation. After ground subsidence, the masts are re-plumbed by packing under the base, additional lengths of holding-down bolts and distance pieces being provided for this purpose. Great accuracy was necessary in mounting these masts on their foundations, to ensure that no extra stresses were set up in the structures when the bridges were bolted in position.

Where more than four tracks have to be spanned, the equipment is supported from a catenary head-span wire carried on head-span towers, as shown in Fig. 5, in which the insulators carrying the track equipment can be seen just below the upper horizontal wire. The tension in the head-span wire is 10,000 lb. and it is, therefore, attached to the tops of the towers so that no adjustment is necessary to it when subsidence occurs. The two lower wires, which are required to maintain the equipments in position over the tracks, are attached to an adjustable bar which can be raised up the towers as subsidence occurs. As these bars are raised, the vertical "droppers" from the head-span catenary to the insulators are shortened. The lengths of the head-span wires were accurately calculated before erection, so that they could be cut to length on the ground and their terminating clamps fitted. This was essential in order to cause as little interference as possible to traffic during construction work.

Provision has been made in the design of the tower foundations for the front edge of the tower to be jacked up, if necessary. This also is to ensure that, if subsidence causes the foundations to move out of level, the towers can be re-set in a vertical position by raising them and packing under their bases. A view of a tower foundation with base channels extended to take the jack appears in Fig. 6.

The anchor masts used for terminating equipments required very careful design, as the maximum load to be carried by a mast terminating the catenary, auxiliary and contact wires amounts to 12,277 lb. The top of the mast had to be left free of bracing, so that the equipment can be raised as subsidence occurs. The construction finally adopted can be seen in Fig. 2, which shows a mast terminating siding equipment (catenary and contact wire). The clamps, which secure the insulators, can be moved right to the top of the mast as subsidence occurs. As with the structures and towers, the base of this mast is adjustable, so that it can be kept plumb, and sufficient space is left under it to permit jacking.

Special arrangements had to be made at rectifier sub-stations and track-sectioning cabins, where the overhead equipment is connected to sectioning switches. At these places separate structures are provided to carry the switches; and steel bridges (or cantilevers) are provided across the tracks at a height sufficient to allow for any estimated subsidence. The positive feeder cables are carried across these bridges and terminated on pedestal insulators, from which flexible connections are made to the overhead equipment. As subsidence occurs and the track equipment is raised these flexible connections will be cut shorter. Fig. 10, on Plate X, shows a switching gantry of this type.

THE BELFAST MEETING OF THE BRITISH ASSOCIATION.—The meeting of the British Association is being held this year in Belfast, from Wednesday, September 3, to Wednesday, September 10, and, as is now usual, one of the morning sessions of Section G (Engineering) will be devoted to the reading and discussion of short papers by young engineers and students, about 20 minutes being allowed for each paper. Those wishing to submit papers for this session are invited to communicate with the Recorder of Section G, Professor W. Fisher Cassie, University of Durham, King's College, Newcastle-upon-Tyne, 1.

THE FIRST BESSEMER STEEL RAIL.

By ALAN BIRCH, M.A.

THE invention of mild steel (produced in a converter) is commonly identified solely with the name of Henry Bessemer, but metallurgists and industrial historians know that the successful outcome of the experiments and trials, which finally gave the perfected product, depended upon the work of others. With Bessemer's name should be linked, in particular, that of Robert Forester Mushet. However, it is not the purpose of this article to discuss the respective contributions of these inventor-metallurgists who helped to bring about the Age of Steel, but merely to give an account of the laying of the first steel rail, in which Mushet played a vital part.

First it should be pointed out that this innovation was not a commercial trial. The supersession of the iron rail was a very gradual process, and it is incorrect to think of the year 1856 as dating a revolutionary change from wrought iron to steel as the basic raw material of engineering. In the construction of that vast and unprecedented network of world-wide communications, the railways, it was not until the 1870's that the cheapness of steel rails made their substitution for iron a commercial proposition. Rather, the motive of having a steel rail rolled and laid on a railway track was to prove the durability and hardness of a metal which had still to win the respect of engineers. This technical factor, the durability of steel, was to enter commercial calculations, in that the steel rail proved to outlive by several times the iron rail; but the first task of the metallurgist was to establish the reputation of mild or cast steel as a metal. Nowadays, the science of metallurgy has paved the way for the bold experimental use of new metals, but in the middle of the Nineteenth Century there was the conservative suspicion of practical engineers to be overcome. This fact probably accounts for the way in which the circumstances of the innovation have become obscured.

One story, at least, tells of a steel rail being introduced secretly into a track by John Devonshire Ellis, of John Brown and Company, Sheffield, on "one dark and stormy night" in 1860. Sir Allan J. Grant, in the recently published history of this firm, *Steel and Ships: the History of John Brown's*, makes the claim that this was the first Bessemer steel rail laid down. If this story could be substantiated, then, certainly, this would date the first use of Bessemer steel in railway construction. It should be noted that Bessemer himself was unaware of this trial of his steel; it is stated in his *Autobiography* that: "The first steel rail was laid down . . . at the Camden Goods Station of the London and North Western Railway on May 9th, 1862." There is also, it is true, an ambiguous reference to rails at Crewe Station, laid on November 9 and 10, 1861.

However, it seems likely that the first steel rail was laid down as early as 1857. Moreover, this steel was forged and rolled from Bessemer steel, although, again, Bessemer did not know that this had been done. If the rail at Crewe station was the first officially laid, then the earlier episode, to be related, may be recognised as the first unofficial use of the new metal in the permanent way.

To account fully for the circumstances surrounding this first trial would necessitate describing the complicated relationship between Bessemer and Mushet, the two rival metallurgists. In brief, the situation was this. In August, 1856, Bessemer read his sensational paper to the British Association at Cheltenham, having produced, in small quantities, steel in his converter. The enthusiastic reception of this wonderful invention was not confined to the newspapers and the general public, but also included practical ironmasters. Then occurred the disaster, which, as Bessemer himself admitted, came like "a bolt out of the blue." Trials by the licensees of the patent, using different varieties of pig iron (this was the crux of the trouble) resulted only in failure. Several years elapsed and Bessemer had become completely discredited, before experiments and practical experience (particularly those of his Swedish licensee, Göransson) revealed the crucial conditions which had brought initial success and then abysmal failure. The presence of phosphorus and sulphur in pig iron meant that, instead of producing forge steel, the converter contained a crumbling mass of burnt metal. Not until 1879 was this difficulty completely overcome, when Sydney Gilchrist Thomas made possible the production of basic steel from phosphoric ores.

There were, however, other factors which gave Bessemer much trouble, and here he was much indebted to Mushet. Bessemer, despite his subsequent important influence on the development of metallurgy, was, at this time, ignorant of some of the elementary facts of the subject. This he disclosed when he admitted that he had bought the raw material for his experiments "simply as pig iron"; he was unaware, it seems, of the importance of the different qualities of metal on the market. One cause of the burnt metal crumbling and being unsuitable for forging was the superabundance of oxygen, and Mushet, who had been using spiegeleisen, a manganese compound, since 1848, was able to produce ingots of good cast steel The superfluous oxygen was removed as an oxide in the slag and carbon was put back into the metal to replace that burnt out in the conversion.

In fact, and here we come to the occasion of the rolling of the first steel rail in 1857, Mushet, who had been given samples of Bessemer's own cast steel by Thomas Brown of the Ebbw Vale Works immediately after the Cheltenham meeting, was able to forecast Bessemer's difficulties; and, moreover, he had been able to improve bars of metal made by a Bessemer converter at Ebbw Vale into forgeable steel, by means of remelting with spiegeleisen. It was during these experiments that the first steel rail was made in 1857, and laid on the track at Derby station. For this claim, there is the testimony of Mushet's own words, in a letter to the editor of *Iron* (vol. 3, page 44, 1876):

"In the early part of the year 1857, I cast for the Ebbw Vale Iron Company some blooms of Bessemer steel. Some of these were rolled into double-headed rails at the Victoria Iron Works, belonging to that Company, and in the presence of Messrs. T. Brown and Joseph Robinson, partners in that firm. One of these rails was sent to me at Coleford for inspection, and was then sent on to Derby station, where it was laid down at a place where the greatest amount of traffic took place. The rail remained uninjured up to 31st December, 1867. . . ."

This rail was made from an ingot produced by Mushet at Coleford, in the Forest of Dean, from a remelting in 16 crucibles, each of 44 lb. of converted steel together with 3 lb. of melted spiegeleisen, at a time when Bessemer was not in possession of Mushet's secret. The ensuing story of how Bessemer came into possession of Mushet's patents, which had lapsed, need not be pursued, but the foregoing makes it clear that this rail, laid in 1857, was, in all but name, of Bessemer steel.

The most conclusive piece of evidence to support this claim would be, of course, the survival of the actual rail. Mushet himself realised this, and took steps to obtain the rail from the Midland Railway at Derby twice, in 1867 and in 1873. Unfortunately, however, his second attempt, in June, 1873, proved to be too late by about ten days. The engineer to whom he wrote replied that "the rail referred to in your letter . . . was taken out and used up about ten days before the receipt of your note. . . ." Well did Mushet comment: "I think it was a great pity that this Bessemer steel rail—the first cast steel rail that was ever laid, upon any railway—should not have been preserved."

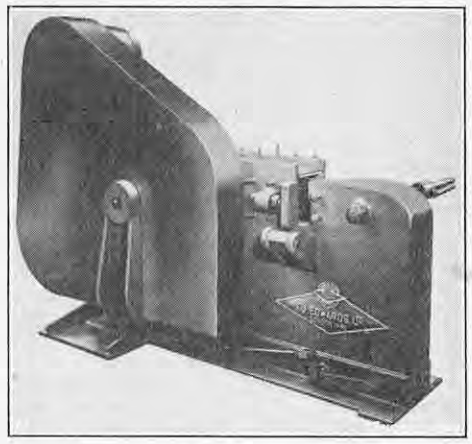
PATENT OFFICE LIBRARY.—It has been decided to continue the extended hours of opening of the Patent Office Library at 25, Southampton Buildings, Chancery-lane, W.C.2. The hours are from 10 a.m. to 9 p.m. from Monday to Friday, and 10 a.m. to 5 p.m. on Saturdays. The extended hours of opening were first introduced on May 7, 1951.

INSTITUTE OF METALS 1952 MAY LECTURE.—The 1952 "May" Lecture to the Institute of Metals will be delivered in March, by Dr. J. J. P. Staudinger, on "The Place of Plastics in the Order of Matter." The meeting will be held in the lecture theatre of the Royal Institution, Albemarle-street, London, W.1, on Monday, March 24, at 6.0 p.m. Visitors will be welcome; tickets of admission are not required.

HEAVY-DUTY BAR-CROPPING MACHINE.

THE range of bar-cropping machines manufactured by Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1, was extended recently by the introduction of a unit capable of cutting round bars up to 2 in. in diameter and flats measuring 3 in. by 1 in. The new machine, which is illustrated below, is known as the Besco model BS60F and has been designed primarily for use in preparing bar material used in connection with reinforced-concrete structures, its versatility in this field being exemplified by the fact that as many as 64 ¼-in. diameter rods can be cropped in one operation. Although designed with this duty in mind, it is equally suitable for normal use inside a works, being capable, by the fitting of special blades, of cutting angle irons, the maximum size of angle that can be cropped being 3 in. by 3 in. by ½ in. In view of the heavy duties it can perform, the machine is considerably heavier than the others in the range; as a consequence, it is not portable but is only suitable for floor mounting.

The construction is quite straightforward and, in general, follows that of the lighter machines. The main frame is fabricated from thick welded-steel plates, and is provided with flanges at the base for bolting in position. A rectangular-section cropping ram is used and this works in bronze bearing surfaces



designed so that they can be adjusted easily. The flywheel is an iron casting machined all over, which, to reduce vibration to a minimum, is balanced both statically and dynamically. It is keyed to a countershaft which, in turn, is supported by roller bearings, the only shaft to be so equipped, all other bearings being of the phosphor-bronze bush type. The drive is transmitted from the countershaft by a pinion and spur wheel, the latter being mounted on the crankshaft and the centre fitted with a bronze bush so that it can rotate relatively to the crankshaft when the machine is not actually cropping. It is connected to the crankshaft by means of a multiple-tooth dog clutch; this is mounted on the crankshaft outside the spur gear and is engaged by coiled compression springs and withdrawn by a foot-operated cam mechanism. The clutch and spur gear are situated at one end of the crankshaft and, to cater for the overhang brought about by this form of construction, an outer bearing is provided. This is fitted to the top of a pedestal, the bearing housing also acting as a carrier for the clutch springs. The crankshaft is machined from a high-carbon heat-treated steel forging and, as previously indicated, rotates in phosphor-bronze bearings. A heavy steel connecting rod transmits the drive to the ram, bronze bushes being fitted to the big-end and the little-end bearings. The machine is driven by an electric motor situated at the top of the machine and connected to the countershaft by multiple V-belts, the belts, gearwheels and flywheel being enclosed by a removable guard. The speed of the motor is 1,500 r.p.m. and that of the flywheel, 800 r.p.m., the ratio of the gearing being such that there are 40 working strokes per minute. A roller is fitted to facilitate the movement of heavy bars into the cutting space and the gauges provided for use when cutting to a constant length are so positioned that they clear the cut lengths as they fall to the ground. The weight of the complete machine is 5,040 lb. and the length, width and height 6 ft. 8 in., 4 ft. 9 in., and 5 ft. 8 in., respectively.

The other machines in the range, namely, the BS32F and BS50F, are smaller and can therefore be mounted on low trucks and used on building sites. The BS32F machine will cut flats up to 3 in. by ¼ in., round bars up to 1 in. in diameter, and square bars up to ⅞ in. Like the larger machine just described, it can cut several smaller bars in one operation; 15 round bars having a diameter of ¼ in., for example, can be cut at the same time. The capacity of the BS50F machine is somewhat greater than that of the BS32F machine, it being possible to crop 3½ in. by ½ in. flat bars, 1½ in. diameter round bars and 1 5/16 in. square bars. Here again, a quantity of bars can be dealt with at one operation, and in this case 36 1¼ in. diameter bars can be cut at the same time. As in the case of the BS60F model, both machines can crop angle irons when fitted with special blades, the BS32F being capable of handling 1¾ in. by 1¾ in. by 5/16 in. angles and the BS50F 2½ in. by 2½ in. by ⅜ in. angles.

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.

Graphical Symbols for General Electrical Purposes.—When making diagrams of connections in electrical-engineering practice, it is necessary to employ symbols to denote the various machines and devices used; moreover, the connecting wires, and the points at which they make contact with the apparatus may be indicated in the diagram. The object of the above specification, B.S. No. 108, now issued in revised form, is to standardise symbols to meet the various needs of the electrical industry, based as far as possible on internationally-agreed symbols. The present new edition has been considerably extended and covers graphical symbols relating mainly to power and lighting applications. The specification is concerned with general and detailed symbols relating to generating and converting plant, conductors, machines, rectifiers, transformers, switchgear, resistors, surge diverters, fuses, relays, lamps, electric clocks, and traction and location symbols for installations. Full lists of code letters are included, and, among new features, are a list of device function-indicating numbers for control equipment and a colour scheme, to distinguish voltages on layouts, maps or diagrams. Several typical diagrams showing the use of the symbols are appended. [Price 10*s*. 6*d*., postage included.]

Tab Washers for Aircraft.—A new specification in the series for aircraft, No. S.P. 41-46, covers tab washers,and replaces A.G.S. 194, 195, 518, 569 and 570. In the new publication, the materials, dimensions and finish of mild-steel and non-corrodible steel straight, right-angle and "left-angle" tab washers are specified. An appendix to the specification gives details of a recommended method of application when washers are fitted into drilled holes. [Price 1*s*., postage included.]

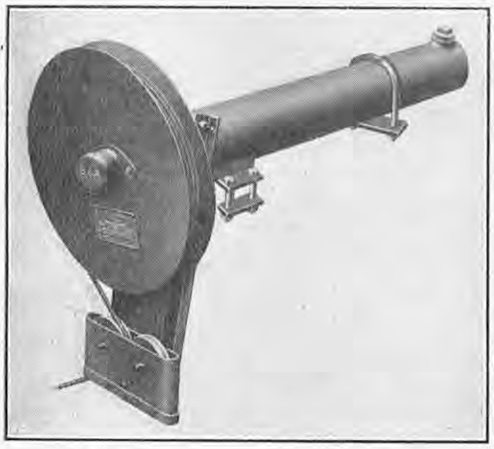
Case-Hardening Steels.—As a result of the present serious shortages of alloying elements for steel, the Steel (Rearmament) Panel of the Ministry of Supply has under consideration the problem of economy in the use of such elements by the replacement of specifications in which their content is relatively high by others stipulating a much lower content. Details of these are given in addendum No. 1 to B.S. No. 970: 1947 covering wrought steels. It is entitled "Emergency Specifications for Case-Hardening Steels," and the reference number is PD 1313. Eight case-hardening steels, designated En. 351, 352, 353, 354 and 355, of the 1 to 2 per cent. nickel-chromium type, some containing also molybdenum, and En. 361, 362, 363, of the "15," "20" and "25" carbon low-alloy case-hardening type, have been substituted for steels En. 33, 34, 35, 36, 37, 38, 39 and 325 of B.S. No. 970, which are of the 2, 3, 4·25 and 5 per cent. nickel and nickel-chromium-molybdenum case-hardening types. [Prices of Addendum No. 1, 1*s*., postage included.]

Bolting for Petroleum Industry.—A further specification in the series which is being prepared for the petroleum industry has now been issued. This, B.S. No. 1750, covers bolting for the petroleum industry and is divided into three parts. The first is concerned with alloy-steel stud bolts, studs, bolts and screws for high-pressure and high-temperature service. Part 2 deals with carbon and alloy-steel nuts for high-pressure and high-temperature service, and part 3, with carbon-steel bolts, stud bolts, studs, and nuts for moderate-duty service. The specification provides for screw threads in accordance with both B.S. No. 1580, which deals with unified screw threads, and B.S. No. 84, which concerns screw threads of Whitworth form. Thus the purchaser can select which thread he wishes to use. Parts 1 and 2 cover material which is equivalent in service to certain grades in specifications A. 193 and A. 194 of the American Society for Testing Materials, and it has been considered desirable, therefore, to have the British material marked in a manner identical with that of the corresponding American material. Each of the three parts contains details of materials, heat-treatment, dimensions, finish, marking and methods of test. In appendices are given tables of the grades of steel to be used for various services and the design stresses applicable. [Price 6*s*., postage included.]

ANTI-TWISTING DEVICE FOR GRABS AND BUCKETS.

THE illustration below shows a device which has been introduced by the B. & A. Engineering Company, Limited, 50, Pall Mall, London, S.W.1, for preventing grabs and buckets from twisting freely on the end of the suspension cable. It is particularly useful where the load has to be dumped into a lorry, a small hopper or railway wagon, since the long sides of, say, the grab can be kept in line with the long sides of the lorry, hopper or wagon, thereby minimising spillage of the material and simplifying the work of the crane driver.

The "automatic grabline," as it is called, is fixed to the crane jib, and a steel wire rope from it, attached to a convenient point on the grab or bucket by a short chain or rope sling, exerts a pull which is sufficient to



prevent the grab from rotating. The device consists of a narrow drum around which the wire rope makes several turns; a short shaft, on which the drum is mounted; and a long helical torsion spring housed in an outer tube. An inner tube is connected at one end to the shaft and at the other to one end of the spring, the other end of which is fixed. Thus, when the crane jib is luffing, and the grab moves outwards or inwards, the wire rope is paid out or wound in under the action of the spring. The pull exerted depends on the number of turns of rope on the drum, but it averages about 120 lb., which is sufficient to steady the grab under all operating conditions, whatever the angle of the jib. All working parts are enclosed in the outer tube, which serves as an oil bath. The device is provided with fair-leads, as shown, and with U-bolts and clamping plates so that it can be fixed to the jib as required.

Three standard sizes are made, to suit grab capacities of $\frac{3}{8}$ to $\frac{5}{8}$, $\frac{5}{8}$ to 1, and 1 to $1\frac{1}{2}$ cubic yards. The standard length of cable is 60 ft. for the first two sizes and 70 ft. for the third.

DESIGN OF POWER-OPERATED FLYING CONTROLS.

SOME of the design features of hydraulically-operated power-assisted flying-control systems, and the difficulties that have been encountered with them, were described in a paper entitled "Powered Flying-Controls: Some Design Considerations," by Mr. F. J. Bradbury, A.M.I.Mech.E., and Mr. S. M. Parker, B.Sc., read before the Institution of Mechanical Engineers in London on Friday, February 1. The main problems in designing a servo-mechanism for operating the control surfaces of an aeroplane, said the authors, lay firstly in the considerable flexibility of aircraft flying controls, which could lead to self-excited oscillations of appreciable amplitude, and secondly, in the need for exceptional reliability. The mechanically-coupled type of servo-mechanism had been most widely adopted for operating the control surfaces. In this system, only a small degree of free movement was provided to actuate the signalling and power units, and the speed of operation of the pilot's control was limited by the speed of movement of the control surface. It could provide a limited degree of manual control in the event of power failure, and it avoided a major change in flying technique. "Proportional" control, in which the correction applied was more or less proportional to the degree of error, was generally used. In a mechanically-coupled system, where the transient error between the input and output movements was small, little improvement in stability could be gained from a more complex mechanism responding to the rate of change of error.

The authors then showed illustrations of two hydraulic servo-control mechanisms, each comprising a piston and cylinder with a three-way plunger-type control valve. The cylinder was connected to the linkage operating the flying-control surface, the piston-rod being anchored to the aircraft structure. The piston-rod side of the piston was at all times connected to a constant-pressure supply. The large-area side of the piston could be connected either to the pressure or return line through the control valve, thus extending or retracting the cylinder to move the control surface in response to the pilot's signal. In the simpler mechanism the control-valve plunger was directly coupled to the pilot's control, whereas in the more complex mechanism movements of the pilot's control were transmitted to the plunger through a differential lever; this offered a simple means of varying the velocity ratio between the control column and the control valve. By connecting the control-surface link to a suitable point on the differential lever, a proportion of the control-surface load could be fed back to the pilot's control to provide "feel"; this also made the system reversible and provided self-centering. The transient error between the pilot's control and the control surface was limited by the movement of the control valve between its stops. Therefore, to operate the control at a speed greater than the specified maximum, the pilot would have to provide the whole of the additional force required; this constituted an effective load warning.

Instability usually resulted from flexibility, or backlash, in the controls. If the anchorage of the servo-unit to the structure was not rigid, for example, and the control valve was very sensitive, any disturbance which displaced the output member would deflect the anchorage, causing the control valve to open, and could thus set up a self-excited oscillation at the natural frequency of the output circuit. When a proportion of the control-surface load was fed back to the pilot's control, flexibility in the input and output circuits could produce self-excitation; this type of instability increased with the proportion of feedback. Hydraulic unbalance of the control valve, combined with backlash in the input circuit, could give rise to a high-frequency "dither."

The sensitivity of the plunger-type control valve depended on the overlap, which was controlled by the width of the annulus in the valve housing and the length of land on the valve itself. Experience had shown that to avoid instability an overlap of at least 0·01 in. was required, and from 0·015 in. to 0·02 in. was desirable. With a velocity ratio of 10 to 1 between the pilot's control movement and the valve movement, an overlap greater than about 0·02 in. could not be used if reasonable continuity of control force were to be obtained. The general response of the system was determined almost entirely by the valve design. The port area was governed by the specified maximum rate of control movement, the maximum valve travel by the allowable maximum transient error, and the valve overlap by stability and feel requirements; the shape of the valve-opening curve was then determined by the profile of the controlling portions of the valve plunger.

Owing to practical limitations, it was often necessary to provide an additional stabilising unit in the system. The damper was usually inserted between the input and output circuits, i.e., between the valve and the valve body. Hydraulic dampers were more satisfactory in service than dry-friction dampers. The damper should preferably work under pressure and should not be greatly affected by temperature changes; it should not affect self-centering, and should not appreciably increase the valve-operating loads at normal frequencies. In an example shown by the authors, the damper piston was formed integrally with the valve plunger. Other hydraulic dampers had been developed which were subjected to an amplification of the relative motion between the valve and valve body; this reduced any backlash in the damper unit, and amplified the damper force.

Tests on the stability and reliability of the control system could be carried out on a single rig in which the inertia and elasticity of the input and output circuits could be adjusted to predetermined values, and the amplitude and frequency of the input motion could be varied. The response of the mechanism was studied from photographic records of the traces on a cathode-ray oscillograph of the input and output displacements; the frequency-response tests should cover a frequency range from zero to at least the natural frequency of the output circuit. The same rig could be used for determining damper characteristics. To ensure the reliability of the control system, it should be bench-tested, before the first flight of the aircraft, for endurance, under pressure fluctuations and external vibrations, and in the presence of grit and swarf. Although no extensive flight experience had yet been acquired on the operation of powered controls in production aircraft, the authors believed that the systems so far developed would meet future requirements. If a satisfactory standard of stability was achieved in severe tests on a new aircraft, there was no reason to fear deterioration with use; friction was likely to increase, and to assist stability, and undue backlash was not likely to develop in the controls, which were lightly loaded except under conditions of power failure. The accuracy of control of mechanically-coupled systems was at present about $\frac{1}{4}$ to $\frac{1}{2}$ per cent.; if this degree of error proved to be unacceptable, more complex systems would have to be adopted.

If the servo-mechanism was attached to the control column, most of the flexibility was in the output circuit, where it was less harmful to stability, but reduced accuracy. The possibility of eliminating mass balance from the control surfaces, by the use of an irreversible control system, would, however, require the location of the servo-mechanism at a point very close to the control surface. In an irreversible system, the effect of a quick transition from movement to rest in the input circuit would cause high inertia loads in the output circuit, limited only by the flexibility of the structure, and it was suggested that irreversible control should only be adopted in systems with low output mass or low operating speeds. Any adverse effect on stability due to locating the mechanism at the control surface would be provided for by varying the damping of the control valve.

EXPLOSIONS IN OIL DRUMS AND TANKS.

THE risks of conducting welding or other operations involving heat on drums and tanks which have contained inflammable liquids have long been known. Sections 28 (4) of the Factories Act, 1937, and 11 (4) of the Factories Act, 1948, have aimed at the elimination of the risk by stipulating that, before repair work is commenced, the atmosphere inside the vessel must be made safe by the removal of any combustible matter by steaming or boiling in water or by rendering it inert by such means as the addition of carbon dioxide. The need for these precautions has been generally appreciated in industry where the liquids involved are of relatively low flash point. Numerous accidents, however, have occurred when work has been done on drums and tanks which have contained liquids of relatively high flash point. Accordingly, at the request of H.M. Chief Inspector of Factories, an investigation on drums which have contained liquids having a flash point above normal atmospheric temperature has been conducted by the Joint Fire Research Organisation of the Department of Scientific and Industrial Research and the Fire Offices' Committee. Experiments have been made in 5 and 19 gallon drums to determine the risk of explosions when repairing drums used for containing liquids such as kerosene, Diesel oil, lubricating oil and linseed and other vegetable oils. A report on the results of the experiments, by Dr. F. E. T. Kingman, Mr. E. H. Coleman and Mr. Z. W. Rogowski, has just been published by the Factory Department, Ministry of Labour and National Service, and is obtainable, price 6*d*. net., from H.M. Stationery Office. Briefly, the experiments have shown that explosions are to be expected with most of the oils tested when a drum which has contained them is heated on the outside at one spot. This, it is added, may be due to the decomposition (or "cracking") of the oil or as a result of the formation of oil mists. In consequence of these findings, it is considered that an explosion hazard exists with a wider range of oils than had previously been realised. Hence, it is pointed out that the precautions required by the Factory Acts of 1937, Section 28 (4), and 1948, Section 11 (4), should be strictly observed whenever tanks are repaired, irrespective of the flash point of the liquid they had contained.

RECONSTRUCTION OF EUSTON STATION.—The re-roofing of No. 6 platform at Euston station—the oldest main-line platform in London—is almost complete, and work has started on No. 8, 9 and 10 platforms. The station is being reconstructed, though the extent of the work is limited by national restrictions on capital expenditure.

NEW BRANCH OF THE INSTITUTE OF PETROLEUM.—The inaugural meeting of a new branch of the Institute of Petroleum, namely, the South-East Branch, was held at Rochester, Kent, on February 5. This is the seventh branch of the Institute to be opened, the others being situated at London, Edinburgh, Manchester, Stanlow, Fawley and Llandarcy.

UNITED NATIONS BULLETIN ON TRANSPORT STATISTICS.—The second annual bulletin on transport statistics was published recently by the Inland Transport Division of the United Nations Economic Commission for Europe. The report shows that there was a general increase in traffic by all forms of transport in 1950 compared with 1949; it also shows that the increase in the number of lorries and 'buses has been proportionately greater than the increase in the private cars. Although figures are not available, regarding the volume of traffic carried by road, it is shown that the number of lorries operating in Europe has increased considerably during recent years. This is illustrated by the fact that the average number of inhabitants per lorry has fallen from 160 in 1938 to 104 in 1950; it is of interest to learn that the United Kingdom has the lowest rate per lorry.

CONTRACTS.

PIRELLI-GENERAL CABLE WORKS LTD., have received an order to manufacture and install an insulated cable for a very high voltage. This will be made at their Eastleigh Works, Hampshire. The order is for a 0·4 sq. in. single-conductor oil-filled cable and sealing ends to form a 750-yard termination for an overhead line in Canada, operating at 301,000-volts, three-phase, with centre point earthed. An order for a similar three-phase termination has been placed with a Canadian cable maker, and this cable will also be of the oil-filled type. The cable will be of graded dielectric construction, with the lead sheath metal-tape reinforced, and served overall with an anti-corrosive finish. The carrying capacity of each cable is 530 amperes, and the three-phase circuit will carry 275 MVA. The cable and all accessories have been designed by Pirelli-General, in conjunction with Mr. Emanueli, of Pirelli, Milan. The cable will be employed in connection with a new melting plant to be built for the Aluminium Company of Canada Ltd., at Kitmat, 400 miles from Vancouver.

THE HAWKER-SIDDELEY GROUP state that delivery of 54 Avro Lancasters to the French Naval Air Arm has commenced. Both Mark 1 and Mark 7 basic types are being used to fulfil the contract which came to A. V. ROE & CO., LTD., Woodford, Cheshire, and Langar, Nottinghamshire, from the Ministry of Supply.

The British Overseas Airways Corporation have exercised their contractual right to take up the full number of 26 " Bristol " Type 175 air-liners, including one prototype. Previously, by agreement, work had been started by the BRISTOL AEROPLANE CO., LTD., Bristol, on the first 15 aircraft only.

JAMES KILPATRICK & SON, LTD., electrical engineers, Paisley, have received a contract valued at 300,000*l*., placed by Scottish Industrial Estates Ltd., operating on behalf of the Ministry of Supply, for the installation of electrical equipment at the new factory of Rolls Royce Ltd., at East Kilbride.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have obtained a contract from the Danish Directorate General of Posts and Telegraphs for a high-power broadcasting installation. The equipment, which will cost 90,000*l*. will be completely air-cooled and it is hoped to open it at Kalundborg at the end of 1953. It will comprise two 100-kW transmitters with paralleling equipment, capable of an output of 200 kW. A great saving in space is afforded by these transmitters as the usual large reservoir and pumping apparatus needed for water-cooling systems is dispensed with.

VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1, announce that as the result of negotiations instituted early last year, an order for one oil-tanker of 32,000 tons deadweight capacity for the Alvion Steamship Corporation, of Panama, has been increased to a total of three vessels. The tankers will be built at the firm's Naval Yard, Newcastle-upon-Tyne, and the propelling machinery for the first, a single-screw double-reduction geared turbine developing 12,500 shaft horse-power in service will be built at their Barrow-in-Furness works. The machinery for the second and third tankers will be similar to that for the first and will be supplied by PARSONS MARINE STEAM TURBINE CO., LTD. The designed service speed is 15¼ knots. The tankers will have a length of 665 ft., a breadth moulded of 85 ft. 6 in., and a depth of 46 ft. 8 in. The summer draught will be 34 ft. 6 in.

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have received orders from the Eagle Oil and Shipping Co., Ltd., and the Anglo-Saxon Petroleum Co., Ltd., for the complete electrical equipment for ten oil-tankers. Each installation includes two 550-kW, 440-volt, three-phase alternators, to be driven through gearing by steam turbines at 1,200 r.p.m. In seven of the ships the steam turbines are being supplied by PETER BROTHERHOOD LTD., and in three by the Fraser and Chalmers Engineering Works of the G.E.C. Each tanker will also have one 200-kW alternator, Diesel-driven at 600 r.p.m., and about 25 motors ranging from 1·5 h.p. to 178 h.p., for pumps, fans, steering gear and other duties. The switchgear will be controlled from a steel cubicle-type main switchboard, having withdrawable air-break circuit breakers, for controlling the generators, power supply and lighting and auxiliary services. Two cubicle-type group-starter switchboards will control the motors. The General Electric Co. has also received a contract from British Railways (Southern Region) to the total value of approximately 2,000,000*l*., for equipment for 52 substations. The apparatus, which is being supplied, forms part of the scheme of frequency conversion and comprises 48 pumpless steel-tank rectifier equipments for 23 substations and 33-kV 750-MVA extra high-tension switchgear for 52 substations. Each rectifier installation is rated at 2,500 kW and will supply direct-current power to the track at 660/750 volts. Included in the contract is the equipment for the central section of the railway system, through which passes the densest railway traffic in the heart of London.

LABOUR NOTES.

CIVIL servants are to be encouraged to retire later. It was announced at the beginning of this week that Mr. R. A. Butler, the Chancellor of the Exchequer, had informed the staff side of the Civil Service National Whitley Council that he had decided to bring into operation immediately new rules for retirement from the Civil Service, and that the general aim of these new rules would be to employ all civil servants for as long as practicable. This meant that 60 would become the minimum age for ceasing work and would no longer be regarded as the normal retiring age. In future, late retirements would take place at the wish of Government Departments. Ministries would apply tests of efficiency to civil servants as they approached the age of 60, and at regular intervals afterwards if they continued to work beyond that age. Civil servants who did not attain an acceptable standard of efficiency would be retired, but no stigma would be attached to them in these circumstances. Employees would not be compelled to remain in the service after reaching the age of 60 ; but would be free to retire then or at any time thereafter.

The text of the letter sent by Mr. Butler to the staff side of the National Council was issued subsequently. In this, the Chancellor of the Exchequer states that he had been informed by the Financial Secretary of the Treasury that the staff side would be prepared, with some misgivings, to concur in the immediate promulgation of the statement of principles, given above, subject to two amendments : namely, that members of junior grades of the service should automatically retire at the age of 60, but be given the opportunity of re-employment in a lower rank ; and, secondly, that members of senior grades should be retired automatically and finally at ages to be laid down. The rule in the case of the senior members to be, the higher the grade the lower the age to be specified.

The acceptance of these amendments, however, Mr. Butler contends, would frustrate the objects of the statement of principles. The statement, with those amendments added, would introduce into the retirement arrangements a rigidity which did not exist at the present time, instead of making them more flexible, as was intended. Mr. Butler's letter mentions that it it is important to get the present reductions in the Civil Service into a proper perspective in relation to the long-term objectives which the statement is intended to achieve. The present situation affected retirement policy in the Service in two rather different ways. It might be that, in some parts of the Service, the reductions would involve the retirement of a few people over 60 who might otherwise continue at work. The statement was a flexible instrument, however, and had provided explicitly for that possibility. It was of the utmost importance that the Service, in common with all other employers, should reduce as far as it could its continuing demands upon the nation's man-power resources, and that could be achieved by extending the individual civil servant's working life.

As was only to be expected, Mr. Butler's decision to retard the retiring ages of civil servants was not well received by the Civil Service trade unions. Mr. T. R. Jones, the secretary of the staff side of the National Whitley Council, said, after the publication of the decision, that the staff side recognised that later retirement might become necessary owing to the changing age distribution of the country's population, but considered that the present was not a suitable time to introduce the change, as extensive cuts in the number of civil servants were in prospect. Further, the change should not have been brought forward without some transitional measure to lessen its impact on promotion and careers. Mr. Butler had been pressed to rule that civil servants who remained in the Service after 60 should do so in a lower grade, but had declined to accept the proposal, on the ground that it would introduce a rigidity into retirement arrangements which did not exist at present. Mr. L. C. White, the general secretary of the Civil Service Alliance, expressed concern at the effect of the decision on promotion prospects and declared that all the civil service unions opposed the scheme when it was first put forward by Mr. Hugh Gaitskell.

Fears of growing unemployment in Wales were expressed during a debate on Welsh affairs in the House of Commons on Monday last. Sir David Maxwell Fyfe, the Home Secretary and Minister of Welsh Affairs, when introducing the debate, referred to the anxiety which had been caused by the depopulation of the country's rural areas. For over half a century there had been a steady migration from Wales, especially from the rural areas, and the Government was anxious that this trend should be halted and, if possible, reversed. It would be the Government's policy to place the maximum number of rearmament contracts in the Welsh development areas and to encourage Government contractors to adopt a similar policy regarding sub-contracts. The Government was aware of the special difficulties of the situation and would do everything it could to maintain the level of employment in Wales.

A number of Members expressed their concern at the possibility of a rise in the Principality's unemployment figures. Mr. G. O. Roberts, the Member for Caernarvon, said that two years ago the figure had declined to about 20,000, the lowest on record in peace-time, and a feeling of cautious optimism had arisen, but it had been replaced recently by a fear of higher unemployment and mass migration across the border. Most of the new factories which had been erected in Wales produced goods for home consumption, and were susceptible to restrictions in relation both to credit and the supply of raw materials, in view of the existing rearmament and export drives. Welsh country people were much concerned about the incursions into good farming land which had been made by the War Office and by the activities of the Forestry Commission, which seemed incapable of planting trees without uprooting whole communities.

Mr. George Thomas said that light industries in South Wales were already feeling the effects of competition from German and Japanese sources, and he urged the Government not to allow the employment situation in Wales to deteriorate. Another Member asked that the Government should look into the possibility of Welsh tin-plate operatives being displaced. In his reply to the debate, Sir David stated that the number of persons engaged in new industrial development in South Wales since 1937 was over 105,000. Some 60 per cent. of that total were employed in the production of raw materials of one kind or another, or in the engineering industries of the capital-goods and equipment types. Only about 36 per cent. were employed in the consumer-goods industries, and these were not restricted to a narrow range of manufactures.

Three trade-union organisations announced on Tuesday last that they had decided to withdraw from the London Trades Council. The bodies concerned are the London Society of Compositors and the London sections of the Transport and General Workers' Union and the National Union of General and Municipal Workers. It is estimated that these three organisations represent about 50,000 members out of the total affiliated strength of 650,000 claimed by the London Trades Council.

Work was resumed on Monday last by the five hundred joiners who had been on strike at Southampton since January 24. The men, who belong to the Amalgamated Society of Woodworkers, are employed at six of the town's principal shipbuilding yards. They ceased work when a dispute arose between Messrs. John I. Thornycroft and Company, Limited, and joiners in their employ over the allocation of the installation of a 1-in. plywood flooring in a new naval vessel. It was contended on the men's behalf that the work, which had been given to shipwrights, should be done by themselves. The executive committee of the A.S.W. and representatives of the local shipbuilding employers' association met on Monday last to discuss the difficulty.

Owing to the shortage of steel and the consequent limitations in railway-construction programmes, some 150 men employed at the carriage and wagon works of British Railways at Derby have been declared redundant and given a week's notice, which was due to expire to-day. Those affected comprise skilled as well as unskilled employees, and, in the main, are engaged in the fitting and welding grades. The men were working on a 44-hour week, without overtime, basis. It is anticipated that further dismissals by British Railways on redundancy grounds will take place in the near future. It is reported, also, that the construction of new passenger coaches has been stopped and that the building of all-steel wagons is to be reduced by an additional 10 per cent. It may be recalled that the construction of these wagons was recently cut by 50 per cent.

The Minister of Fuel and Power, Mr. Geoffrey Lloyd, stated recently in a written reply to a Parliamentary question that the Government considered that the time had arrived when responsibility for the production of opencast coal should be transferred from the Ministry to the National Coal Board. The Board had agreed to take over both operational and financial responsibility for such production, Mr. Lloyd continued, with effect from April 1, next.

SHIP RESEARCH.

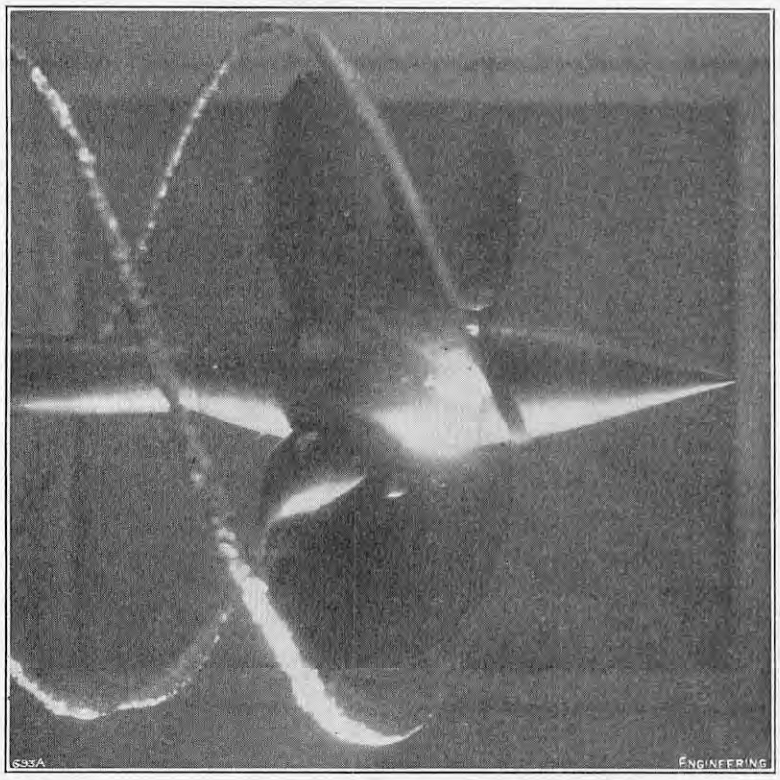


FIG. 22. Cavitation number $\sigma = 0\cdot75$. Advance coefficient $J = 1\cdot05$. Nominal ship speed, knots $= 34\cdot8$. Nominal ship r.p.m. $= 341$.

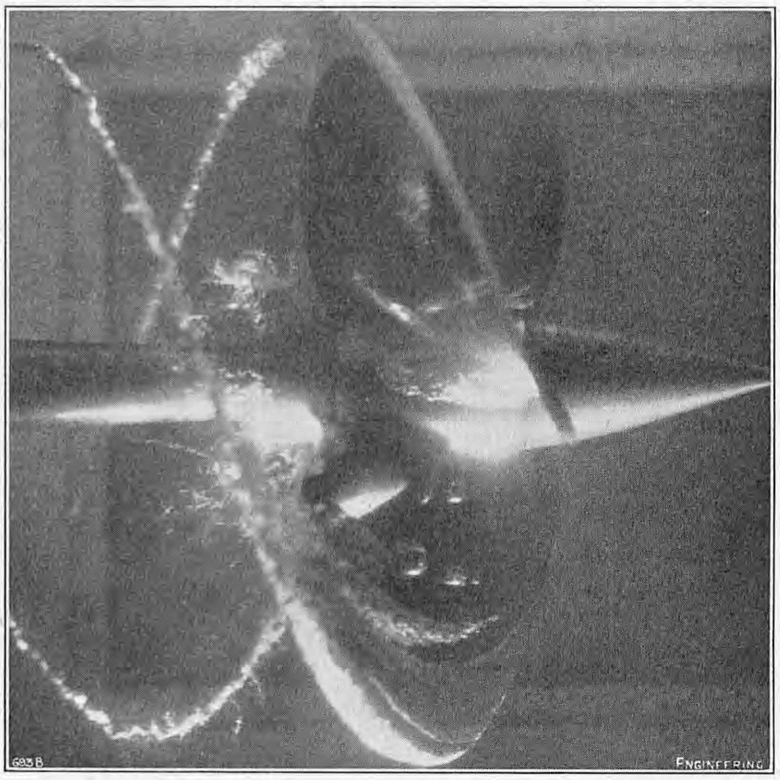


FIG. 23. Cavitation number $\sigma = 0\cdot45$. Advance coefficient $J = 1\cdot05$. Nominal ship speed, knots $= 44\cdot9$. Nominal ship r.p.m. $= 441$.

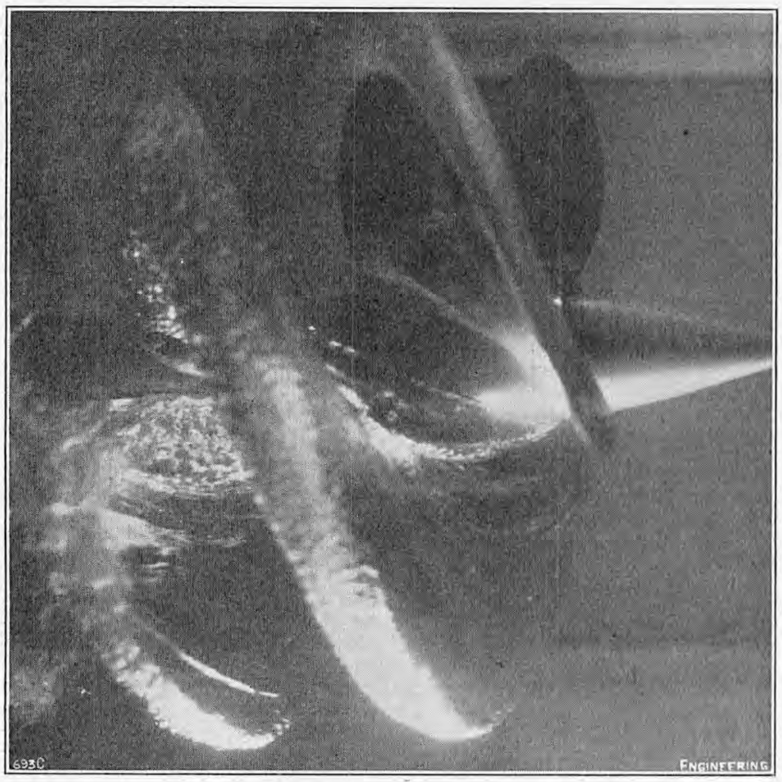
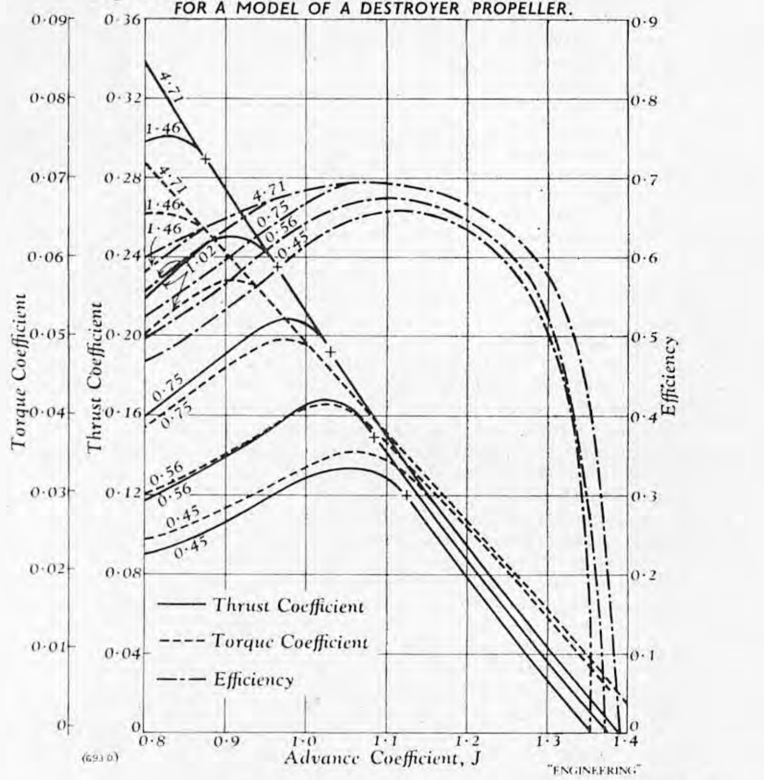


FIG. 24. Cavitation number $\sigma = 0\cdot45$. Advance coefficient $J = 0\cdot80$. Nominal ship speed, knots $= 44\cdot9$. Nominal ship r.p.m. $= 578$.

Fig. 25. CAVITATION TESTS FOR A MODEL OF A DESTROYER PROPELLER.



SHIP RESEARCH.*

By DR. S. LIVINGSTON SMITH, C.B.E., M.I.Mech.E.

(*Concluded from page* 160.)

EXCEPT for relatively minor and uncommon vessels, the screw propeller remains the accepted method of propelling ships. Propellers are generally designed in practice from the results derived from methodical "open water" tests in the experiment tank, in which the thrust and torque are measured, and the propeller is towed in such a way as to be free from interference from the hull. The joint performance of propeller and hull as a combination can be obtained on the model scale by "self-propulsion" tests on the tank carriage, in which the model is power-driven by its own motor.

A good deal of research on propeller problems is going on. Cavitation, from which highly loaded fast-running propellers may suffer, is the formation of a vacuous space or spaces in the surrounding fluid, arising from low pressures. Cavitation increases with speed, and eventually results in loss of thrust, torque, and propeller efficiency. The development of propeller theory has proved very useful to the designer of cavitation-free propellers, but the action of cavitation has so far proved too complicated for a methodical solution, though some progress has been made.

Understanding of the phenomenon has been greatly advanced by research in cavitation tunnels—that is, closed water channels—much of which has been done by the Admiralty. High-speed photography plays an important part in the research and Figs. 22 to 24 show examples of the results obtained around the model propeller of a destroyer; Figs. 22 and 23 indicate cavitation when the model propeller is working at the same slip as the propeller on the ship; and the full spread of cavitation at excessive slip and high speed is indicated in Fig. 24. The corresponding changes in propulsive characteristics are indicated in Fig. 25, from which it is evident that the thrust and torque are reduced by cavitation at high speed.

As a result of cavitation research, the optimum design of propeller for any class of ship to suppress or reduce cavitation can be confidently determined. There are, however, still some unknown factors, and, under the auspices of the International Conference of Ship Tank Superintendents, a comprehensive research is in progress in different countries to obtain a closer approach to ship conditions by tunnel research. The results of these tests may be expected to throw a good

* The 24th Thomas Lowe Gray Lecture, delivered to the Institution of Mechanical Engineers at a meeting held in London on Friday, January 18, 1952. Abridged.

deal of additional light on the phenomenon, and on the allowance that should be made for such factors as the restriction of the flow to the propeller due to the boundary walls of the tunnel.

Naval architects interested in suppressing propeller-induced vibration have designed propellers with five blades, instead of the more usual three or four blades. Greater cavitation can result from blade interference, and more frequent pressure changes if the number of blades is increased. Cavitation research has guided the production of designs of multi-bladed propellers which compare satisfactorily as regards efficiency with propellers of fewer blades, and has thus contributed to the suppression of vibration.

Form design has developed from the empiricism of sailing-ship days to the new empiricism of model tests. In the former, efforts towards improvement were spasmodic and unco-ordinated. In the latter, experiment is guided by the application of fundamental principles to well-defined aims. An optimum hull to suit given conditions has ceased to be a matter of conjecture and has become a problem capable of exact solution, by experiments with models and by the parallel investigation of ship performance. The analysis of service results is essential if model and full-scale performances are to be correlated. For example, ships are no longer built with the high block coefficients which were so popular in the earlier days of steel shipbuilding; sea experience has shown that excessive fullness leads to bad performances in rough weather at sea. The present use of high-speed oil engines with fast-running propellers is a typical example of engineering progress affecting the design of hulls and propellers.

In merchant shipbuilding, the owner usually specifies the speed required either on trial or in service, more generally the former. Clearly, for competitive designing the builder requires an accurate estimate of the power required to attain a specified speed. Tank tests are invaluable for this purpose, enabling the builder to shoulder his contractual responsibilities with some measure of confidence. Contract requirements relating to speed, power, and fuel consumption are usually checked by measured-mile trials with the completed vessel. All such trials should follow a standard code of procedure. Such a code was formulated by the British Shipbuilding Research Association and found ready acceptance in Great Britain.

Progressive speed trials over a measured course are made in the best conditions available with a clean and freshly painted hull. Ship performance must be reduced to a fixed datum and the only possible datum of external conditions is the condition of ideal weather. Instruments for measuring torque and thrust are commercially available, but until recently little was known regarding their degree of accuracy under marine conditions. This situation has recently been rectified by a series of trials carried out by B.S.R.A., which showed that errors in measurements of both torque and thrust in the two types of instrument selected as most suitable will not normally exceed ± 2 per cent. The comparison of the speeds, revolutions, thrust, and torque obtained during loaded trials with the corresponding values predicted from model tests is of vital importance.

One of the most momentous steps in the history of the marine turbine was taken in 1944 with the formation of the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada), which is supported by the collective effort of all the shipbuilding and engineering firms manufacturing marine turbines in British shipbuilding centres. This association is energetically conducting research into numerous problems concerning the marine application of both steam and gas turbines, together with transmission systems and associated auxiliaries. Pametrada Research Station at Wallsend includes facilities for testing full-scale prototype machinery with powers up to 60,000 h.p. per shaft, and already four series of full-scale trials of high-powered steam-turbine machinery have been completed. The value of these trials cannot be overestimated, since they not only enable faults to be eliminated before the machinery is installed, but also provide confirmation of design data and opportunities for research on full-scale equipment. Unique data, obtained during some of these trials, regarding transient phenomena during astern operation, has recently been published. Research work on steam-turbine blading, nozzles, and diaphragms has enabled new and improved forms of these components to be incorporated in the designs prepared by the association for its member firms, and over 80 per cent. of the machinery now under construction embodies these improvements.

It seems likely that one of the main developments of the future will be the use of higher temperature steam at the turbine inlet, and it is interesting to note that Pametrada have under construction an experimental turbine designed to operate at 1,200 deg. F. and 1,100 lb. per square inch pressure. Improvements in efficiency of marine steam-turbine main propelling machinery are becoming more difficult to obtain, but auxiliary machinery has not been developed to the same extent and may well provide a fruitful field for research and investigation.

SHIP RESEARCH.

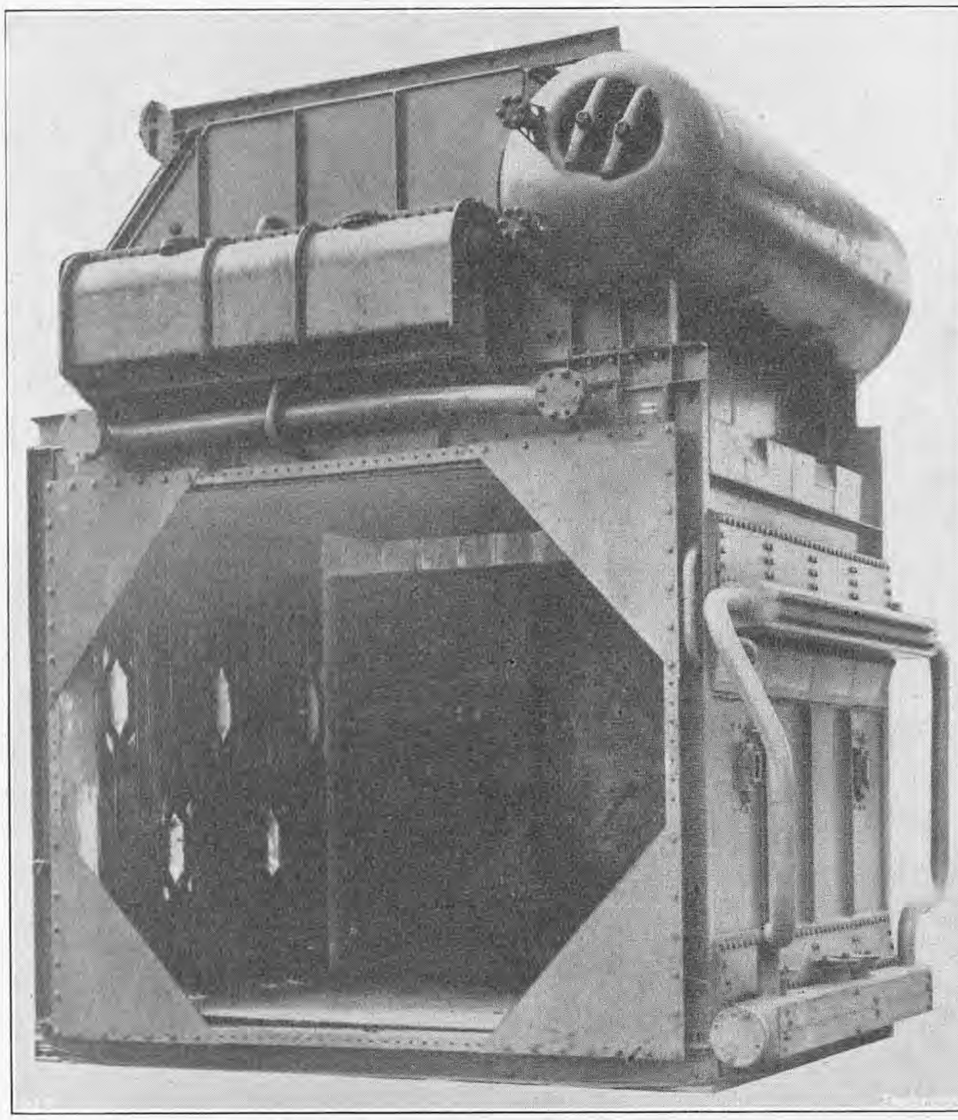


FIG. 26. LA MONT BOILER AT ADMIRALTY EXPERIMENTAL STATION.

Development of the gas turbine was greatly accelerated by the 1939-45 war, but the problems to be solved before it can become established in the marine field are still numerous. Researches are being actively pursued by private firms, Pametrada, and Government establishments both in Great Britain and abroad. Meanwhile, it is a matter of some pride to Great Britain that the first naval and mercantile vessels to be propelled by gas turbines have been fitted with machinery of British design and construction.

The chief problems still requiring solution are: the ability to burn oil of the same quality as used in the furnaces of vessels with steam-turbine machinery, the attainment of higher thermal efficiencies, and means of manœuvring. Fouling or corrosion of turbine blading and heat-exchanger surfaces by fuels containing vanadium and sodium salts is still a problem, and its successful solution may govern the degree to which gas turbines can replace existing forms of machinery for main propulsion, and how soon this can happen. At the present time, gas turbines under development for marine propulsion utilise materials suitable for temperatures of 1,200 deg. F. and have thermal efficiencies of the order of 30 per cent., corresponding figures for thermal efficiency of modern steam turbine and Diesel machinery being about 25 and 38 per cent., respectively. The possibilities of increasing gas-turbine efficiency by higher inlet temperatures of the order of, say, 2,200 deg. F., have been interesting many investigators.

Much research is in progress on the design and operational problems encountered in marine water-tube boilers. The principles of natural circulation, tube materials for advanced steam conditions, optimum tube thickness, methods of tube expanding, methods of superheat control, automatic combustion and complete boiler control, combustion problems, corrosion, and feed-water treatment are all the subjects of research and development.

To allow a more extensive study of combustion of furnace fuel oil, a specially designed forced-circulation combustion test boiler, converted from a La Mont steam gunboat boiler, has been installed by the Admiralty. With this boiler a full-scale study can be made of the effects upon flame size and shape and combustion efficiency, of such factors as register design, draught loss, oil and air temperature, oil-droplet size, air or air-steam atomisation of the oil, ratio of refractory to cooling surface, and mixing of flames for multiple registers. This boiler will also be used for the development and test of equipment for future designs of boilers.

Fig. 26 shows a general view of this boiler. Except for the front wall, on which any registers can be fitted, the furnace is completely water-cooled; the back wall (Fig. 27, opposite) is adjustable to give furnace lengths from 7 ft. 6 in. down to 3 ft. The front, sides, and back of the furnace are fitted with twelve observation holes, and any amount of furnace floor or walls can be covered with refractory as required. The boiler can accommodate burners up to 10,000 lb. of oil per hour, and forced-draught fans capable of supplying air for this quantity at 200 in. water gauge are being provided. The draught loss through the boiler and preheaters being only 20 in., the larger part of the total pressure is available for register draught loss. Air preheat temperature can be varied by damper by-pass from atmospheric to nearly 600 deg. F., and the fuel pumps for this boiler will deliver up to 1,500 lb. per square inch.

The respective merits of forced and natural circulation for water-tube boilers has long been the subject of extensive study, but in the marine field natural circulation continues to more than hold its own. Nevertheless, we are still without a full understanding of the fundamental principles of natural circulation. A study of these matters in an actual multi-tube boiler presents considerable difficulty, as does also model testing, since there is a very pronounced scale effect which makes it almost impossible to simulate all the variables concerned. The British Shipbuilding Research Association therefore decided to study the problem on a full-scale two-tube boiler, designed for a maximum

SHIP RESEARCH.

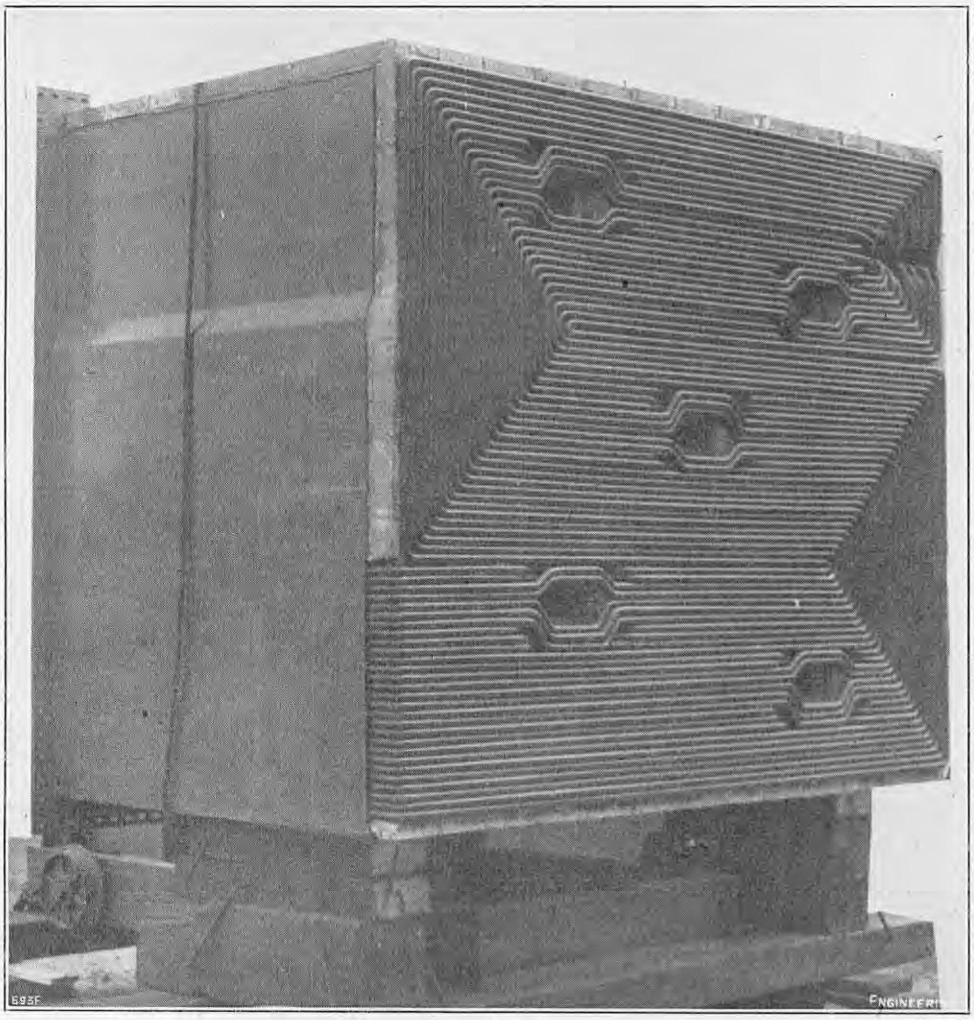


FIG. 27. BACK WALL OF LA MONT BOILER.

working pressure of 1,500 lb. per square inch with a steam generation of 1,200 lb. per hour, when operating with a tube of $2\frac{1}{4}$ in. outer diameter, heated length 10 ft. 6 in. and a heat input rate of 120,000 B.Th.U. per square foot per hour generated by a 250-kVA electric furnace. Provision is made for altering the tube length, diameter, and inclination, and also the heat input rate. Later, it is proposed to go to higher rates of heat input with the aid of gas heating.

The plant may be operated as a simple closed system in which the steam generated is condensed in a condenser integral with the steam drum, the condensate re-fluxing back into the steam drum. Alternatively, it may be operated on the more orthodox system, which comprises a hotwell, feed pump, and feed heater. In this, the steam, after passing through the feed heater, enters the atmospheric condenser and flows through the measuring tank to the hotwell. This boiler is now in operation and should provide valuable data regarding the effect of pressure and heat input upon circulation rates, together with the effect of such variables as tube diameter and inclination, and "downcomer" to "riser" area ratio. Data on heat transfer are being obtained and it will also be possible to examine the effects of rapid pressure changes.

At the present time, about two-thirds of the tonnage of ships under construction in Great Britain are to be propelled by Diesel machinery. One of the main developments with this type of engine since the 1939-45 war has been the increasing tendency to use heavy boiler oil as fuel in place of high-grade Diesel fuel. It has long been known that many slow-speed marine oil engines are capable of operating with heavy boiler oils, and, indeed, over the last 25 years, a number of ships have operated with such fuels. It is only since the war, however, that the difference in price between the two classes of fuel has been sufficient to encourage shipowners to use heavy oil, in spite of the increased capital investment needed for the provision of purifying equipment and the possibility of increased upkeep charges, especially for liner renewals. This development has received a notable impetus from research carried out in Great Britain by the Royal Dutch Shell group, which included experimental work ashore with a full-size single-cylinder engine, followed by extensive sea trials on a number of different types of engine in the company's tanker fleet. So far, attention has been concentrated upon the use of heavy oil in the main propelling machinery. Consideration is now being given to the problem of utilising the same fuel in Diesel generators, as it is obviously disadvantageous to have to carry two grades of fuel. Owing to the trunk-piston construction and higher rotational speeds employed in Diesel generators, it has always been considered that the use of heavy oil would impose a more difficult problem than with main engines, but encouraging results are being reported from experiments both ashore and afloat.

As a result of a disastrous explosion in the engine room of a quadruple-screw British passenger liner, much attention has been given in the last four years to the question of crankcase explosions, and research is being energetically pursued. The problem logically calls for three stages of investigation. In the first place, the nature of the explosive medium must be established and the potential sources of ignition identified. In the second place, precise information is necessary regarding the conditions under which the explosive medium may be ignited and continue to react explosively, so that preventive measures can be devised. Finally, exact data must be obtained regarding means of limiting the effect of the explosion should it occur in spite of preventive steps. A systematic investigation on these lines is being carried out at the Imperial College of Science for the British Shipbuilding Research Association, and considerable progress has been made.

From analysis of the details of explosions which have occurred in various types of reciprocating engine, both Diesel and steam, it is now generally accepted that they are caused primarily by overheating of some part of the engine, and that the lubricating oil and air in the enclosed crankcase form the source of the explosive medium. The exact mechanism leading to the formation of an explosive oil and air mixture was not clear, however, until it was pointed out that lubricating oil coming into contact with an overheated part will condense, on mixing with the general crankcase atmosphere, to a fine mist which will be liable to ignition by the same hot part that caused its formation. This suggestion, first advanced after work on explosion hazards in badly ventilated machine shops, fits in with the fact that, just before many crankcase explosions, white "smoke" has been observed. In such a condensed mist, the oil is more finely divided than in the mechanical spray normally present and it is therefore likely to be more readily ignited, to have a wider range of inflammable concentrations, and to burn more rapidly, thus giving rise to greater pressure effects in the closed crankcase.

After a thorough investigation of the combustion properties of condensed mists from typical lubricating oils, the relief of crankcase pressure has been investigated. Until recently, the only guidance available on this aspect came from some American experiments and from experiments carried out in Great Britain by the British Internal Combustion Engine Research Association. This problem unfortunately has a significant scale effect and, as both these sets of experiments were carried out with vessels considerably smaller than the crankcases of large marine oil engines, the results cannot be applied directly to the marine problem. This situation has recently been remedied by B.S.R.A. with a series of explosion experiments in a vessel of 200 cub. ft. using condensed mists as the explosive medium.

Machinery-space ventilation has been the subject of a good deal of research in recent years. The naval problem is probably more severe, but even in merchant ships the tendency towards increased speed, with resultant concentration of power, together with the post-war tendency of engine-room staff to leave the sea for more attractive working conditions ashore, has caused shipowners to take a keen interest in methods of improving environmental conditions in machinery spaces. The results of a four-year investigation of the problem by B.S.R.A. throw a great deal of light upon environmental conditions for the efficient working of engine-room staff, and upon the improvements obtainable in steamships by reducing the main sources of moisture escape, improving the insulation of hot surfaces, and increasing mechanical ventilation. Unfortunately, the law of diminishing returns applies with special force in this problem and we may well be forced, in the future, to adopt a limited degree of air conditioning to engine-room spaces.

Another aspect of ventilation which has been engaging the attention of shipbuilders and shipowners recently is cargo-space ventilation. The practice of natural ventilation of cargo spaces continues to give satisfaction, but sweat damage to cargoes and hull is by no means unknown, particularly in certain trades, and therefore increasing attention is being paid to the advantages obtainable from mechanical ventilation and air drying. Mechanical ventilation and drying is now also being tried in the oil-carrying spaces of tankers with the object of prolonging the life of the ship's structure.

The last decade has seen notable advances in the standard of accuracy of marine gearcutting; this has not only led to improved reliability, but promises to pave the way for further advances in design and materials which in the near future are likely to cause a reduction in size and weight for a given application. Research and development on these lines is proceeding actively in Great Britain under the auspices of the Admiralty-Vickers Gearing Research Association (AVGRA) and Pametrada. At the latter establishment, several sets of gears have been tested to failure by pitting and final tooth breakage from fatigue. These important tests have allowed some evaluation of the effect of gearing errors and surface finishes. Much interest is being shown also, both in Great Britain and America, in the possibilities of epicyclic gearing for marine use, and a good deal of research has been carried out.

As the stresses arising in propellers and shafting in service are complex, the scantlings of these components are at present largely determined by empirical calculations founded upon experience. Advances in the technique of measurement, however, will place calculations on a sounder and more scientific basis, and a number of authorities are carrying out researches with this object. During recent trials on H.M.S. Savage, extensive measurements were made of transient values of torque, thrust, revolutions, etc., during manœuvring conditions, using instruments developed for the purpose by the Admiralty. The instruments were mounted on a miniature gauge board and photographed at one-second intervals. When going from full ahead to full astern, or vice versa, maximum transient values of torque and thrust reached about 175 per cent. of the steady astern and ahead values. These quantities were recorded at the conventional position for torsionmeters and thrustmeters, so that inertia effects must lead to rather greater values of the maximum torque at the gear teeth and still more at the turbine blading. It was also found that the maxima depend almost entirely on the turbine receiver pressures and are little affected by differences in the initial speed. Further measurements, made when turning with full rudder at high power, showed that both thrust and torque on the propeller on the inside of the turn reached maxima of nearly 130 per cent. of the steady values at the corresponding speed.

ECONOMIC PLANT SIZES AND BOILER-SET GROUPINGS ON THE BRITISH GRID.*

By BRYAN DONKIN, B.A., and P. H. MARGEN, B.Sc.(Eng.).

(*Concluded from page 155.*)

THE plant groupings examined in the paper are shown in Fig. 9. Groupings *a*, *b* and *c* are on the "unit" system, where each boiler is associated with one turbo-alternator and normally operates isolated from the remaining units and turbo-alternators. Grouping *a* has no cross-connections and will be referred to as the "simple" unit grouping. In grouping *b* the units are coupled in pairs, mainly in order to enable the annual boiler overhauls to be co-ordinated with the less frequent but longer turbine overhauls without excessive losses in output. In grouping *c* all units are linked by a "steam tie-bar" though not normally connected to it. In the event of the outage of any turbo-alternator occurring simultaneously with the outage of a boiler from a different generation unit, the healthy boiler and turbo-alternator of the affected generation units can be connected to the tie-bar, thus forming a new generation unit. Groupings *d* and *f* have one boiler per turbo-alternator plus one spare boiler per station. Groupings *e* and *f* have two boilers per turbo-alternator, groupings *f* being distinguished by having in addition one spare boiler for the station. The plant sizes marked on Fig. 9 are the calculated economic sizes for the loading conditions given in column 2 of Table I, on page 155, *ante*. These sizes are used for the economic comparison of the groupings. A glance at the unit groupings shows them to be symmetrical, and it follows that there would be no case for adopting any other grouping if the cost/size relations, reliabilities and availabilities of boilers and turbo-alternators were identical. If, however, increases in the sizes of turbo-alternators would produce greater economies in capital outlay than increases in the sizes of boilers, or if turbo-alternators were found to be more reliable than boilers, there might be a case for adopting larger turbo-alternators than boilers, e.g. grouping *e* in preference to groupings *a* to *c*. Standby boiler plant would tend to be justified if boilers had appreciably worse availabilities than turbo-alternators, as the spare boiler would then achieve the best degree of utilisation of both boilers and turbo-alternators.

TABLE II.—*Total Charges for Various Plant Groupings.*

Item.	One Boiler Per Turbine.	Two Boilers Per Turbine.
A. *Sizes of plant units, MW*		
1. Turbo-alternators	100	133·3
2. Boilers	100	66·7
B. *Basic annual charges—£ per MW of winter demand per annum—*		
3. Turbo-alternators and associated buildings	1,750	1,739
4. Boilers and associated plant and buildings	2,151	2,179
5. Other works	500	500
6. Total	4,401	4,418
C. *Additional charges—£ per MW—on*		
7. Coupling pipes	18	—
8. Entire steam tie-bar	23	26
9. Spare boiler	269	182
D. *Total charges—£ per MW—for*		
10. Simple unit grouping = (6)	4,401	—
11. Coupled unit grouping = (6) + (7)	4,419	—
12. Steam tie-bar grouping = (6) + (8)	4,424	4,444
13. Groupings with spare boilers = (12) + (9)	4,693	4,626

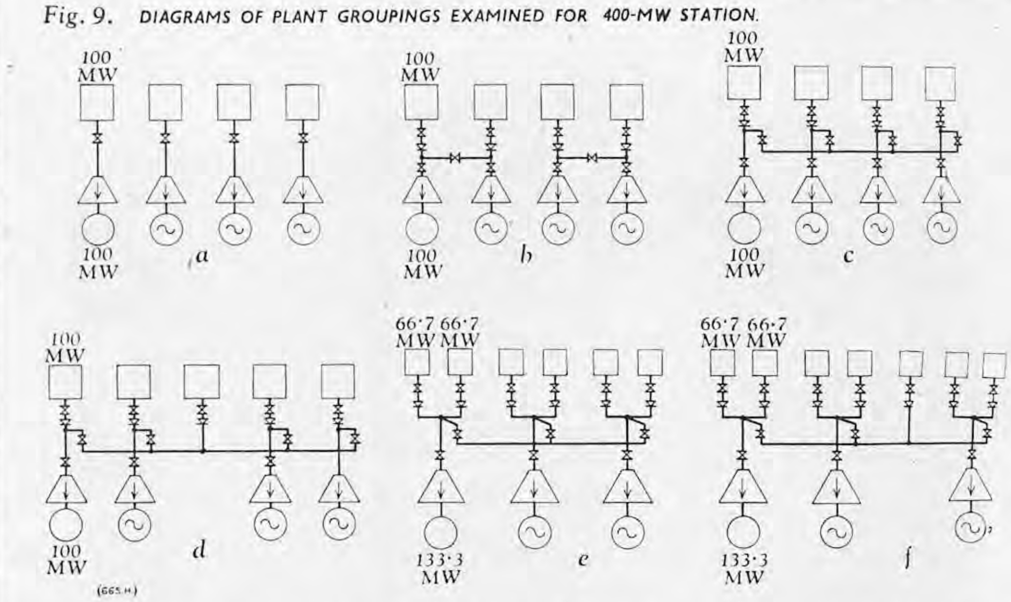
The cost of generation for these groupings may be compared under the following headings: the total charges on the generating plant per kilowatt of the rating of the stations; the total charges on the interconnecting transmission network designed for a given degree of security of supplies on the system; and the costs incurred by the average routine and forced plant outages, which may necessitate the installation and operation of additional generating plant or cause the transfer of load to older and less efficient plant.

The term "total charges" denotes the sum of the capital charges, the costs of staffing and maintenance, and any component of the fuel costs affected by changes in plant size, per kilowatt of winter demand. These charges may be subdivided into a basic component, a component for steam cross-connections, and a component for spare boiler capacity. The basic component is calculated using similar annuity rates for all groupings, and is shown by item 6 of Table II. Items 7 and 8 of Table II show the estimated capital

* Paper read before the Supply Section of the Institution of Electrical Engineers on Wednesday, January 30, 1952. Abridged.

ELECTRICAL PLANT AND BOILER GROUPINGS.

Fig. 9. DIAGRAMS OF PLANT GROUPINGS EXAMINED FOR 400-MW STATION.



charges and maintenance costs for typical steam and feed cross-connections. The values shown take account of the simpler operation and maintenance of the "simple" unit groupings. Nothing is allowed for additional space for the piping, because the simple piping arrangements required for the "coupled" or "steam tie-bar" groupings should not affect the overall building dimensions. The provision of spare boiler capacity in any station allows all boilers to be shut down more often for inspection and maintenance, and to steam for shorter periods or at lighter loads, thus reducing the rate of deterioration of the plant. This in turn increases the economic retiring age of the installation, which, at the present stage of design, appears to be influenced as much by boiler deterioration as by the general rate of progress in design. This advantage of spare boiler capacity tends to offset part of the capital charges, and for that reason only 50 per cent. of the normal capital charges, staffing and maintenance costs on the spare boiler capacity have been included in item 9. Items 10 to 13 summarise the estimated "total charges" for the various groupings.

Plant outages may be conveniently classified under three headings according to the urgency of taking the unit out of commission: "periodic complete overhauls" which are not urgent and can be scheduled to take place during a season of low demand; "general maintenance" which can be delayed to await the week-end, the passing of a spell of particularly cold weather, or the recommissioning of some other item of plant; and "forced outages" which cannct be delayed to await non-critical conditions.

Present British practice for major plant overhauls and inspections is about four to six weeks each year for boilers, and about six to eight weeks in alternate years for turbo-alternators, but these figures are likely to be reduced with further developments in plant design, corrosion prevention, and organisation of the overhauls themselves. Possible improvements in this direction are indicated by current practice in the United States, where recent overhaul practice is said to be about 14 days for boilers each year and 24 days for turbo-alternators every third year. The annual inspection of boilers is governed by law in both countries. Taking overhaul periods of four weeks in each year for boilers and six weeks in alternate years for turbo-alternators, the average reduction in station availability due to this cause is four weeks and six weeks in alternate years with simple unit grouping, giving an average of five weeks per annum. With coupled unit grouping it is four weeks each year, since only one turbo-alternator of each "pair" would be overhauled annually, thus occupying a shorter overhaul period than the aggregate period for two boilers. The same would apply for the steam tie-bar groupings. In the case of groupings with standby boilers, the average would be three weeks per year, since turbo-alternator overhauls would then become the sole criterion of loss in output caused by overhauls. The maximum overhaul programme which can actually be accommodated in the seasonal demand trough at the present time is about seven weeks per plant item, and this amount is far in excess of the requirements of five, four and three weeks per plant item derived above. Therefore, in future, when the shorter overhaul periods have been achieved, periodic overhauls should not necessitate additional plant capacity, though they will continue to incur costs owing to the transfer of load to inferior plant.

The average loss in station output resulting from forced outages can be calculated, if they can be regarded as "random" occurrences, i.e., if the outages of different plant units are not connected. Calabrese* gives some statistical evidence suggesting that most forced outages fall into this class. If the average forced outage times of boilers and turbo-alternators are, for instance, 4 per cent. and 3 per cent. of the scheduled duty periods respectively, the average loss in station output with a unit boiler-set grouping is $(0{\cdot}04 + 0{\cdot}03 - 0{\cdot}04 \times 0{\cdot}03) = 6{\cdot}88$ per cent. of the scheduled duty period, while the average loss with four boiler turbo-alternator units linked by a steam tie-bar is only 6·57 per cent. Where boiler maintenance occupies on the average five week-ends per boiler per year, and turbine maintenance three week-ends per set per year, and where each maintenance outage can be delayed to the nearest but one week-end, the average loss in capacity with the simple unit grouping would be 7·4 week-ends per year, and with a steam tie-bar grouping 6·5 week-ends per year. Coupling of units in pairs raises the station availability by 2·24 per cent. of the year, while a complete steam tie-bar achieves an improvement of 2·65 per cent. The addition of one standby boiler to each station increases the availability approximately by a further 6 per cent. of the year.

On a system where plant is installed and retired according to a long-term economic programme, a small increase in reserve generation capacity can be obtained by deferring the retirement of some old plant by a short period. If the additional reserve capacity is required throughout the year, this deferment might involve additional annual costs of some 1·4*l*. per kW for occupation of site, staffing and maintenance of the plant, and fuel for occasional banking and test operation. If the reserve capacity is required only during a short period in the winter, the station need not be staffed for the remainder of the year and the costs would be lower, say 0·7*l*. per kW. In neither case would such deferment of plant retirement introduce additional capital charges. The same costs would result if the reserve capacity were obtained, not from a small increase in the retirement age, but from an increase in the rate of installation of new plant, provided that the retirement age were approximately at the economic value. For, in these circumstances, a small change in the retirement age does not produce a noticeable change in the total effective system costs of generation, as the additional capital charges are offset by reductions in the costs of fuel, repairs, etc.

If a plant unit is not available for duty then the system generation costs are affected as follows: (*a*) load has to be transferred to inferior plant, thus causing increases in the costs of fuel, staffing and maintenance, and additional wear of the inferior plant; (*b*) during the outage period the plant item itself is not subjected to operational wear and tear, and is thus not being depreciated in value as quickly as it would otherwise; and (*c*) some fixed components of staffing, maintenance and overhead costs on the plant item would continue during the outage period, so that there would be an increase in the system plant capacity subjected to staffing and maintenance costs. The total costs incurred by this reduction in the availability of the plant would thus be the sum of the first and third factors (*a* and *c*) less the second factor (*b*). If the

* *Transactions of the American Institute of Electrical Engineers.* Vol. 66, page 1939 (1947).

plant item were unavailable for a whole year, the average value of factor (*a*) should be approximately equal to the annual capital charges of the plant item, say 3·0*l*. per kW. This follows from the fact that the plant purchase could not be justified economically unless the average benefits obtained from the plant item, in the form of reduced system costs of fuel, maintenance, etc., were at least equal to the average value of the capital charges. The values of the factor in individual years would, however, vary appreciably; it would be very high for new base-load plant and very low for peak-load plant. The second factor (*b*) is difficult to assess, but might be expected to have an average annual value of the order of 1·2*l*. per kW, and the third factor a value of say 0·6*l*. per kW. This would give a net cost of $(3 \cdot 0 - 1 \cdot 2 + 0 \cdot 6)l.$ per kW = 2·4*l*. per kW for a plant item which is unavailable for one entire year. Strictly speaking, this figure represents the costs of losing only the expected availability of the plant item during the year, i.e., the cost of losing, say, 44 weeks of service time per annum. The average costs per kilowatt-year of reduction in availability would thus be $2 \cdot 4l. \times \frac{52}{44} = 2 \cdot 84l.$

This cost would apply for outages which take place throughout the year, such as forced outages. Periodic maintenance outages which take place during non-critical seasons would cost somewhat less, provided that the load trough is adequate to accommodate the entire overhaul programme without incurring the need for any additional installed plant capacity. The reduction in costs would then amount to the annual costs of winter standby capacity plant, estimated at 0·7*l*. per kW as mentioned above. The costs per kilowatt-year of periodic overhaul outages would thus amount to $(2 \cdot 4 - 0 \cdot 7)l. \times \frac{52}{44} = 2 \cdot 01l.$ The costs of general maintenance outages at week-ends are slightly lower still, since the very low week-end loads usually permit some old plant to be shut down even after the requirements caused by the maintenance programme have been met. The costs of these outages have, therefore, been taken as 90 per cent. of the costs of periodic overhauls, i.e., as 1·81*l*. per kW-year.

The security margin required is, of course, highest with the simple unit system where each forced outage causes a loss in capacity. The provision of steam cross-connections avoids some cumulative losses in capacity resulting from the simultaneous outage of a turbo-alternator with a boiler from a different unit. The provision of two boilers instead of one boiler per set also reduces the required security margin for a given size of turbo-alternator, but actually increases the security margin when the turbo-alternator sizes for each grouping are adjusted to the optimum values, e.g., 100 MW for the one boiler per turbo-alternator arrangement, and 133·3 MW for two boilers per turbo-alternator. The annual costs of electrical interconnection are 98·2*l*. per MW of winter demand for grouping *a*, 89·4*l*. for grouping *b*, 81·2*l*. for grouping *c*, 74·2*l*. for grouping *d*, 93·7*l*. for grouping *e*, and 97·1*l*. for grouping *f*. The component of the security margin which can be supplied by generating plant is practically identical for all groupings owing to the large number of plant units on the grid, and the costs of this reserve plant are not, therefore, included.

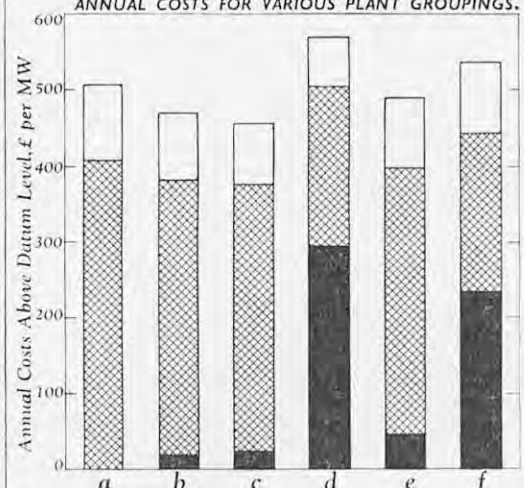
With the constants assumed for this investigation, spare boilers would not be justified for either the unit or the two boilers per turbo-alternator groupings. The case against spare boilers is particularly strong with the grouping employing one boiler per turbo-alternator, owing to the smaller number of boilers employed per station. It would appear that trends of developments in plant design, plant treatment, and overhaul technique, will all tend to create improvements in boiler availability; and this would result in a further strengthening of the case for omitting the spare boiler in the future. It is suggested that the cross-connections of boilers in pairs is amply justified and will continue to be justified even with very large improvements in boiler availability. The complete cross-connection of all units by means of a simple "tie-bar" gives still better results with the assumed outage constants. Improvements in future boiler and turbo-alternator forced-outage rates in relation to the assumed values, may, however, reverse this conclusion in favour of the coupled grouping. It might also be mentioned that reheating would considerably increase the costs and inconvenience arising from steam cross-connections, so that the simple unit grouping would usually be the economic solution with reheating stations. The one boiler per turbo-alternator grouping gives a net saving in the capital charges on the station, as well as a reduction in the costs of electrical interconnectors. This is because the increase in the size of the turbo-alternators from 100 to 133·3 MW has a greater influence on the required security margin of reserve capacity than the reduction in the capacity of boilers from 100 to 66·7 MW. The unit grouping with a steam tie-bar is therefore the most economic of all the groupings considered in the paper. The order of merit of the different groupings can be judged from Fig. 10.

There are certain temporary factors which may sometimes make it desirable to deviate from solutions derived on the basis of stable economic conditions. The most important of these at the present time are the shortages in generating plant and manufacturing capacity of new plant, and the restrictions on the national rate of capital investment. In times of plant shortage, supply cuts are unavoidable. The best means of gradually reducing their severity is by selecting a plant grouping which permits a high rate of manufacture of generation capacity, i.e., plant units of large sizes with a simple grouping, even though such plant would in normal circumstances require a larger margin of system reserve capacity. Above all, standby boiler capacity at individual stations should be avoided, since such boilers would be raising the system capacity for only about two months a year during seasons of low demand, assuming an eight-boiler station and the overhaul periods quoted above. Limitation of capital investment has the same effect in that it makes it all the more desirable to reduce capital cost per kilowatt.

The first and second Report and Accounts of the British Electricity Authority show that these considerations have already been appreciated, as there are a number of 60-MW and a few 100-MW turbo-alternators with unit grouping in the present plant programme. The programme, however, also contains stations with spare boiler capacity, but perhaps the

Fig. 10.

ANNUAL COSTS FOR VARIOUS PLANT GROUPINGS.



a Simple Unit Grouping
b Coupled Unit Grouping
c Steam Tie-Bar Unit Grouping
d Unit Grouping Plus One Boiler as Station Standby
e Double Boiler Grouping
f Double Boiler Grouping Plus One Boiler as Station Standby

■ Annual Charges in Excess of Those for Simple Unit Grouping
▩ Costs of Plant Unavailability
□ Costs of Electrical Interconnections

(685 1)

addition of the spare unit will be delayed until the present shortage has passed—and be omitted altogether if experience with the new plant shows satisfactory boiler availability.

The methods described permit the optimum sizes and groupings of plant units to be found for given load distributions and site conditions on the system or area of supply considered, and for given size/cost relations and plant outage performances. Using cost relations and performance constants which appear conservative in relation to the unfortunately rather limited amount of data available for large plant units, sample calculations indicate the following conclusions regarding plant to be designed during the next few years for the British grid. Developments in plant design, load growth, siting of stations, and nature of distribution and transmission networks all tend to increase the economic plant sizes on the grid and to simplify the economic plant groupings. For plant designed during the next few years, few regions or conditions on the grid appear to call for unit sizes of less than 100 MW. A large fraction of these units would have to be capable of performing shift operations at a later stage of their life, so that designs giving the necessary flexibility would have to be developed. One boiler per turbo-alternator of equal capacity with a simple type of steam tie-bar appears to be the most favourable grouping for most conditions. In stations using reheat cycles, cross-connections are expensive and should generally be omitted. The use of large units on sites of restricted total capacity might result in stations having only two generation units. This is economically sound. Single-unit stations should generally be avoided because they lack the advantages of steam cross-connection for the co-ordination of boiler and turbo-alternator overhauls. Certain pithead sites of very limited capacity may prove exceptions to this rule.

Conclusions on future economic plant sizes and groupings, once reached, would guide development work and construction programmes for many years, so that it is particularly important to investigate this problem in the light of all experience available. In this connection it would be of the greatest value if plant designers and users were to publish additional data and views on capital-outlay/size relations and on the starting and load-changing performances of large plant units.

THE USE OF COLOURS FOR HAZARD WARNINGS.

For many years, we have devoted a certain amount of space to outlines of newly-issued specifications and other publications of the British Standards Institution, with the object of assisting in making them known throughout industry. Now, and we believe for the first time, the Institution authorities have requested us to give prominence to something which they have not done, and to indicate the reasons for their inaction. The matter at issue was the preparation of a "safety" colour code. During recent years, industry has devoted increasing time and thought to drawing attention, by means of colour codes, to danger points in factories. Thus, high-voltage lines, toxic gases, and obstructions such as low doorways and steps are indicated in this manner, and a committee of the British Standards Institution, representative of a wide variety of experience, were given the task of considering the possibility of preparing a safety colour code in order to secure unification of the present different practices. After an extensive inquiry, however, made on behalf of the committee by the Royal Society for the Prevention of Accidents, and, as a result of other investigations, it has been decided to abandon the attempt to prepare a code. As the reasons for this decision will be of interest to all sections of industry, they are worth putting on record.

The committee state that the examination of the problem showed that a distinction must be made between a safety colour code and an identification colour code. The purpose of the former is, broadly, to classify types of risk or hazard and to give warning of them by colour. On the other hand, the object of an identification code, as exemplified in British Standards Specifications No. 1710, covering pipelines, and No. 349, concerned with gas cylinders, is primarily to identify, by colour, the nature of the contents, and any application to safety is incidental. It was a safety colour code that the committee had to consider, and it was realised that many colours had traditional connotations, which, while not always consistent, were so well known that they could not be reconciled. A second difficulty was that the only truly satisfactory method of ensuring safety is to eliminate a hazard, and the committee felt that a code might encourage the identification of hazards by colour instead of their removal. In the third place, the increase in the scientific use of colours for decoration, to secure better light and to improve working conditions, detracted from the effectiveness of a safety colour code. Moreover, these schemes of colour treatment were considered to have shown their effectiveness in the reduction of accidents. A fourth and important point, it is emphasised, has arisen from positive evidence submitted, namely, that the significance of colour codes when put into effect had been quickly forgotten by some individuals. The committee felt that while this is relatively unimportant in the case of an identification colour code, where time is not vital, it would militate seriously against the use of a safety code, where the recognition and significance of a colour must be immediate and instinctive.

Welsh Steel and Iron.—Although steel output in Britain last year was down, production in South Wales increased from 3,407,000 tons in 1950 to 3,475,200 tons last year. This was the highest annual production ever recorded and was due to the starting up, in the summer, of the Steel Company of Wales's new plant at Margam. South Wales pig-iron production was also higher, last year, its total being 1,350,700 tons against 1,231,700 tons in 1950.

Concrete Floors.—We have received from Concrete Ltd., 16, Northumberland-avenue, London, W.C.2, a handbook containing design data and descriptions of the types and uses of Bison pre-cast concrete floors. Entitled *Bison Information Book, Volume II*, it is in fact a revised edition of *Volume I*, which was issued in 1946, and includes data on their prestressed slabs which have been in production since 1948. *Bison Information Book, Volume II*, is available from the above address at a price of 21*s*.

LAUNCHES AND TRIAL TRIPS.

M.S. "EGREMONT."—Twin-screw ferry to carry 1,750 passengers, built by Philip and Son, Ltd., Dartmouth, for the Liverpool, Seacombe and New Brighton service of the Wallasey Corporation. Second vessel of an order for two. Classed and equipped for carrying 700 passengers when on cruising service on the River Mersey. Main dimensions: 145 ft. between perpendiculars by 34 ft. by 12 ft. 3 in.; mean load draught, 7 ft. 4 in. Two eight-cylinder two-stroke Diesel engines, together developing 1,280 b.h.p. at 370 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester. Speed, about 13½ knots. Launch, December 10.

S.S. "LORD WARDEN."—Twin-screw ferry, carrying 120 motor cars and 700 passengers, built by William Denny and Brothers, Ltd., Dumbarton, for the Dover-Boulogne service of the Southern Region, British Railways. Main dimensions: 361 ft. 6 in. overall by 59 ft. by 29 ft. 6 in.; gross tonnage, 3,300. Two sets of geared turbines, giving a speed of 20 knots. Launch, December 14.

M.S. "CERES."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Rederiaktiebolaget Ceres, Stockholm. Main dimensions: 496 ft. between perpendiculars by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, 16,371 tons on a summer draught of 29 ft. 0¾ in.; oil-tank capacity, 15,623 tons. N.E.M.-Doxford five-cylinder single-acting two-stroke opposed-piston reversible oil engine, developing 5,500 b.h.p. at 114 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Trial trip, December 27.

M.S. "WHEATFIELD."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Eden Tankers, Ltd., Newcastle-upon-Tyne. First vessel of an order for two. Main dimensions: 496 ft. between perpendiculars by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, 16,300 tons on a summer draught of 29 ft. 0¾ in.; oil-tank capacity, 15,600 tons. Fairfield-Doxford five-cylinder single-acting two-stroke opposed-piston reversible oil engine, developing 5,500 b.h.p. at 112 r.p.m. in service, constructed by the Fairfield Shipbuilding and Engineering Co., Ltd., Govan. Speed, 14 knots. Launch, December 29.

M.S. "GAVINA."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for J. Marr & Son, Ltd., Hull. Main dimensions: 123 ft. 6 in. between perpendiculars by 26 ft. 6 in. by 13 ft.; gross tonnage, 300. Seven-cylinder four-stroke direct-reversing Diesel engine, developing 695 s.h.p. at 228 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by Amos and Smith, Ltd., Hull. Launch, January 14.

S.S. "KIRKELLA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for J. Marr & Son, Ltd., Hull. Main dimensions: 189 ft. by 32 ft. by 16 ft. 3 in.; gross tonnage, 800. Triple-expansion steam engines and one oil-fired multi-tubular boiler, constructed and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, January 15.

S.S. "UGANDA."—Twin-screw liner carrying 167 first-class and 133 tourist-class passengers, and cargo, built by Barclay, Curle & Co., Ltd., Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 540 ft. overall by 71 ft. by 38 ft. 6 in.; gross tonnage, 15,000. Steam turbines with single-reduction double-helical gears, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Launch, January 15.

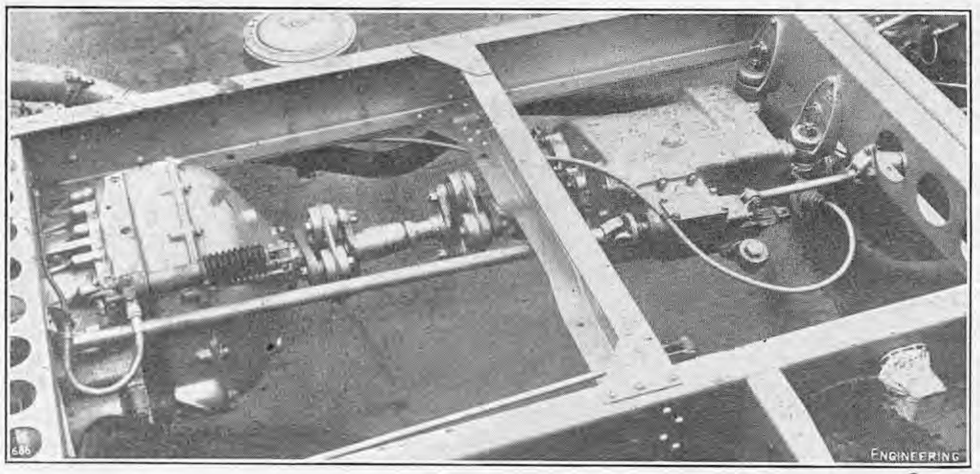
S.S. "BRITISH SKILL."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 610 ft. between perpendiculars by 81 ft. by 44 ft. 6 in. to upper deck; deadweight capacity, about 28,500 tons. Compound double-reduction geared turbines developing 12,500 s.h.p. at 112 r.p.m.; and two Babcock and Wilcox oil-fired water-tube boilers, also constructed by the shipbuilders. Launch, January 16.

M.S. "FLOWERGATE."—Single-screw cargo liner, built by Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Turnbull Scott Shipping Co., Ltd. (Managers: Turnbull, Scott & Co.), London, E.C.3. Fifth vessel built for these owners. Main dimensions: 441 ft. 3 in. overall by 56 ft. 8 in. by 38 ft. 3 in. to shelter deck; deadweight capacity, about 9,400 tons on a draught of 25 ft. 10 in. Harland-B. and W. four-cylinder two-stroke single-acting heavy-oil engine, developing 3,300 b.h.p. at 125 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock, and installed by the shipbuilders. Launch, January 28.

M.S. "ONITSHA."—Single-screw cargo vessel, carrying twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 415 ft. between perpendiculars by 62 ft. by 33 ft. to shelter deck; gross tonnage, about 5,100. Harland-B. and W. five-cylinder two-stroke single-acting Diesel engine. Launch, January 29.

SYNCHROMESH GEARBOX.

A.E.C., LIMITED, SOUTHALL, MIDDLESEX.



SYNCHROMESH GEARBOX FOR "REGAL" MARK IV CHASSIS.

As an alternative to the fluid flywheel and pre-selective type of epicyclic gearbox normally fitted to their Regal Mark IV passenger chassis, A.E.C., Limited, Southall, Middlesex, have developed a four-speed synchromesh unit for use with this vehicle. The standard Regal Mark V passenger chassis, which was described in ENGINEERING, vol. 169, page 1 (1950), is a four-wheel vehicle fitted with an under-floor engine located at approximately the mid-length, but to one side, of the chassis frame. The gearbox is an independent unit, the drive being transmitted from the engine by means of an open propeller shaft, a similar shaft taking the drive from the gearbox to the rear axle. This is of the offset underslung-worm type, the worm and wormwheel assembly being fitted into a one-piece drop-forged axle casing which also serves as the load-carrying member. The front axle is an I-section alloy-steel forging, and semi-elliptical leaf springs are employed for both the front and rear suspension systems.

Fitting the synchromesh gearbox in place of the epicyclic unit does not alter materially the arrangement of the chassis, the layout being almost identical in each case and the only major change, apart from the gearbox, being the fitting of a single dry-plate mechanical clutch in place of the fluid flywheel. The clutch is integral with the flywheel assembly and is enclosed in a detachable bell housing in the normal manner; this can be seen in the illustration above, which shows the centre portion of the chassis. Friction discs are riveted one at each side of the clutch plate and the plate is fitted with a broached centre piece which mates with a splined hub keyed to the clutch shaft; this construction was chosen as it facilitates renewal of the splines should wear develop, it being only necessary to change the hub. Power from the engine is transmitted to the clutch plate through a detachable rubbing plate bolted to the flywheel, pressure being imposed by 20 coiled springs mounted on the pressure plate. The clutch-withdrawal bearing housing slides on a sleeve on the clutch shaft and is prevented from rotating by a peg spigoted into the clutch housing. The inner race of the bearing carries the toggle-lever thrust pad, the race and the pad rotating with the clutch when the engine is running. Clutch withdrawal is effected by four toggle levers mounted on needle-roller bearings and actuated by a fork pivoting in the clutch housing in the normal manner. To avoid the complicated linkage usually associated with clutch-withdrawal on vehicles with under-floor engines, a Lockheed hydraulic system has been adopted. The clutch pedal is connected to a 1¼-in. master cylinder fitted to the chassis frame immediately below the driver's floor-plate and, when the pedal is depressed, the master cylinder supplies fluid under pressure to a slave cylinder and piston mounted on the clutch housing, the piston of which is connected to the clutch-withdrawal mechanism. With this method of operation, it is not necessary to carry out periodic adjustments to the clutch withdrawal mechanism.

As will be seen from the illustration, the gearbox is mounted separately in the chassis and is connected to the clutch by a short propeller shaft fitted with flexible joints. The gearbox casing is an aluminium-alloy casting which is divided along the plane of the main shaft and layshaft; it is supported in the chassis through a three-point suspension system embodying resilient pads. The selector forks and associated shafts are contained in a separate casing bolted to one side of the gearbox and the complete assembly is located longitudinally by a link which connects the selector casing to an adjacent cross member and resists longitudinal movement of the gearbox during gear changes. Straight spur-type gears are used, the gearwheels being made from case-hardened alloy steel with ground profiles to give quiet operation. All forward speeds are engaged by involute-spline dog clutches sliding on splined shafts, synchronising rings of the inertia-lock type being provided to ensure that engagement of the gears cannot take place until the speeds are the same. To permit slight angular movement of the collar, and thereby give a degree of self-locking, the male splines are partly relieved so that, when a gear is fully engaged, any tendency to move out of mesh is resisted by the edges of the relief. This construction avoids the need for strong selector springs and gives easier gear changing.

Apart from the first-speed layshaft pinion, which is integral with the shaft, the gearwheels are pressed on to their respective shafts and the drive is transmitted through keys. All shafts are supported by ball or roller bearings which, to prevent them from working loose in the aluminium casing, are carried in steel housings. The moving parts are lubricated by a gear pump driven from the second-speed layshaft pinion, which delivers the oil into the hollow mainshaft whence it is distributed to the bronze bushes of the constant-mesh gearwheels. Oil seals are fitted at the ends of the main shaft and a magnetic filter is incorporated in the drain plug. The gears are selected by means of a ball-type lever, mounted in an oiltight casing and operating the selector shaft through two tubes fitted with universal joints.

INQUIRY INTO PRESUMED LOSS OF BATTLESHIP "SAO PAULO."—The Minister of Transport has ordered a formal investigation into the presumed loss, on or about November 4, 1951, of the former Brazilian battleship Sao Paulo, with eight persons on board, while being towed from Rio de Janeiro to the United Kingdom.

NEW POWER STATIONS FOR THE BRITISH ELECTRICITY AUTHORITY.—The British Electricity Authority have received the consent of the Ministry of Fuel and Power to the establishment of a power station to be known as the Wakefield (New) generating station at Wakefield, Yorkshire, and to the extension of Dalmarnock generating station at Glasgow. The Wakefield (New) station, which will stand on a site of approximately 126 acres, will have a capacity of 240,000 kW, comprising four 60-MW turbo-alternators and four boilers, each with an evaporation of 550,000 lb. of steam an hour. The Dalmarnock extension comprises two 60-MW turbo-alternators and six boilers, each to evaporate 200,000 lb. an hour.

CLEANING OF CELLULOSE SURFACES.—The introduction of silicone-based car polishes has presented a new problem to those concerned with the re-cellulosing of cars, as it is difficult to ascertain with any degree of certainty whether or not such polishes have been used on any surface to be repainted. If the surfaces have been so treated, difficulties are experienced in making a bond between the new and old finishes, particularly if the panels have had to be beaten into shape. To overcome this difficulty, E. R. Howard, Ltd., Stowmarket, Suffolk, have introduced a surface-cleaning preparation known as "Shim," which is claimed to remove wax, grease, tar, silicones and all other incompatible elements from painted, lacquered, cellulosed and similar surfaces.

ELECTRIC-BATTERY VEHICLES FOR ORE MINING.

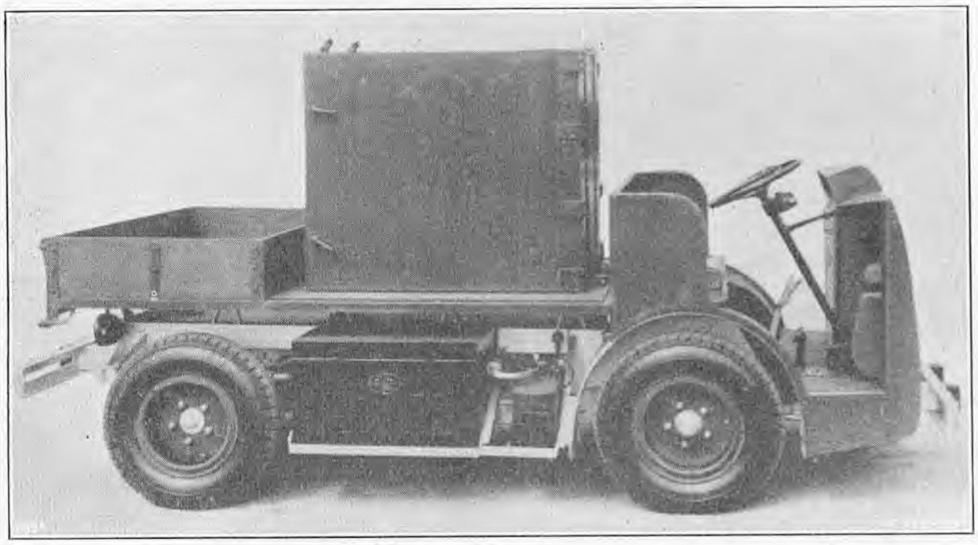


FIG. 1. TRUCK FOR EXPLOSIVES.

FIG. 2. TRUCK WITH TELESCOPIC TOWER.

ELECTRIC-BATTERY VEHICLES FOR ORE MINES.

THE photographs reproduced on this page illustrate two electric-battery vehicles recently supplied by Smith's Electric Vehicles, Limited, Princesway, Team Valley, Gateshead-on-Tyne, 11, for use by the ore-mining branch of the United Steel Companies, Limited, at the Dragonby mine, Scunthorpe. The truck shown in Fig. 1 is employed to carry explosives from the magazine on the surface of the mine, and sand for stemming, to the face of the headings, while that shown in Fig. 2 is fitted with a telescopic tower so that the roofs of headings up to a maximum height of 18 ft. can be examined and any loose stone scaled from them. The truck can also be used for setting girders up to 20 ft. long at the same height and for carrying explosives in a transit magazine. The first truck is a modification of the makers' 30-cwt. model and the second is similar to their two-ton vehicle; the power-operated tower on the latter was supplied by the Eagle Engineering Company, Limited, Warwick. Both the vehicles and their equipment comply with the requirements of H.M. Inspector of Mines.

To meet the special needs of underground working the trucks were designed for a maximum speed of 4 m.p.h. and are equipped with two batteries, one of which is on charge while the other is in use during a shift. The necessary changeover can be quickly carried out by means of a hand-operated elevating platform truck. The hardwood crates containing the batteries, are protected with steel sheeting against damage by stones and rough handling. The cabinets housing the controllers in the driving cab are also protected from falling stones by a cowl and are totally enclosed against dripping water. The platforms are of hardwood and heavy-section angle-iron bumpers with rubber buffers are mounted on the front and rear main chassis members. Towing jaws, suitable for either chains or ropes are also provided at both ends of the trucks. The lighting equipment consists of two headlamps, two rear lamps and an automatic reversing lamp, the latter being a standard headlamp operated by an auxiliary switch on the main reversing switch.

In order to limit the speed to 4 m.p.h., the battery only consists of 18 cells and while the usual full parallel-series control has been retained, the push-button normally fitted to effect the changeover has been isolated by a key-operated switch in the controller cabinet. In service, the battery is divided into two halves which are connected in parallel, and the vehicle is brought up to its rated speed in three steps when the driver presses a pedal. If required, however, the speed can be approximately doubled by releasing the high-speed push-button with a key switch and thus connecting the two halves of the battery in series.

The battery is made up of Exide Ironclad 1-MW 17-C "Loco" cells and has a capacity of 258 ampere-hours at the five-hour discharge rate. The cells are fitted with double copper-cored terminal pillars to reduce the voltage drop and temperature rise. The headroom for the acid has also been extended to increase the cooling. Battery charging has been facilitated by the use of double-pole concentric plugs and sockets of the Anderson type. These sockets are mounted directly on the ends of the battery trays and comply with the requirements of the Mines Department for battery isolation in emergency. Additional protection against short circuit and overload is provided by special double characteristic main fuses. Current for charging purposes is obtained through metal rectifiers and provision is made for this operation to be effected with the batteries in position on the vehicle.

The motors, which were constructed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, are of the series-wound fan-ventilated traction type with outputs of 10·6 h.p. and 12·6 h.p., respectively, on the one-hour rating. They are connected to the axles through a propeller shaft with a "Layrub" rubber coupling and spiral bevel gearing. A separate 81-ampere-hour 12-volt battery is mounted on each truck to supply the lighting load, which is unusually heavy owing to the constant employment of the head and tail lamps and the frequent use of the automatic reversing lamp. A spare battery is provided for each truck and arrangements are made for easy interchange or for charging in position from the rectifiers mentioned above.

The transit magazines, one of which is shown in position in Fig. 1, carried on the vehicles, are of $\frac{1}{4}$-in. welded steel and are provided with lifting lugs and clamps to secure them to the platform. They are divided into compartments for the transport of cartons of explosives and are lined with 1-in. hardwood covered with felt. The same material is used on the doors at each end. All the nuts, screws, hinges, locks, keys and other fittings are of brass to eliminate the danger of explosion, and, as a protection against fire or heat from the chassis or wiring, the platform is covered with a $\frac{1}{4}$-in. sheet of armoured asbestos.

On the 30-cwt. chassis, Fig. 1, the sand for stemming is carried in a container with hardwood sides behind the magazine. In addition to a magazine, the two-ton truck has, as already mentioned, a power-operated telescopic tower, which is mounted on a sub-frame directly over the rear axle. This tower, which is fitted with a revolving platform, has a closed height of 9 ft. and a maximum extended height of 14 ft. It is operated by a 2-h.p. 36-volt motor, which is placed under the driver's seat and is coupled to an oil pump for operating a hydraulic ram. The motor, which is supplied from the traction battery with both halves in series, is controlled from the main forward and reverse switch, interlocks being provided to prevent the tower from being moved accidentally while the vehicle is running or the batteries are being charged *in situ*. A lamp is carried on the vehicle to illuminate the roof of the headings.

ELECTRIC COOKERS FOR THE BLIND.—A simple mechanism, which has been invented by Mr. G. W. D. Currey of the General Electric Co., Ltd., Kingsway, London, W.C.2, is designed to enable a standard electric cooker to be operated by blind persons. It consists of a trip mechanism, which indicates the temperature settings on the "Simmerswitch" and thermostat controls; and a relay, which, when energised, causes a button to protrude through the switch panel on the cooker and rings a bell to indicate that current is switched on. When the temperature set by the thermostat is reached a second bell is rung and the button recedes. It is therefore only necessary for the operator to turn the switch dial of the thermostat, which is indented at various depths spaced at 50 deg. F., intervals before using the cooker.

DOW PRIZE COMPETITION IN ILLUMINATION.

IN memory of John Stewart Dow, and in virtue of a bequest by him, the Illuminating Engineering Society offer a prize which will be awarded to the winners of a competition intended to encourage collaboration between students of illuminating engineering or those branches of engineering concerned with illumination, and students in other fields in which applied lighting plays an important part. John Stewart Dow was associated with the Illuminating Engineering Society since its formation in 1909, first as assistant honorary secretary, and, from 1928, as honorary secretary. He was President of the Society in 1946 and died in August, 1948. He was keenly interested in the training of students and in the encouragement of collaboration between lighting engineers and architects. The newly-instituted competition, therefore, is a fitting memorial to him, and, while entries from individuals are not excluded, the competition is primarily intended for students working in collaboration. The winning entry will receive a total cash award of 75*l*., and a certificate will be presented to each member of the winning team. Certificates of commendation will be awarded to any other entries of outstanding merit. The competition will be set and judged by a panel of assessors, appointed by the Society, in co-operation with the Royal Institute of British Architects and the Institution of Electrical Engineers.

The subject for the 1952 competition is the layout, artificial lighting and decoration of a ground-floor showroom. The relevant documents, with instructions concerning the form which entries should take, will be available on April 1, but forms of application may now be obtained from the secretary of the Society, 32, Victoria-street, London, S.W.1. The competition is open to anyone who, not having completed his 26th year by the opening date, namely, April 1, can show that he is taking, or has taken, a course of instruction or has had equivalent training, of a nature appropriate to the subject of the competition. All members of a team of competitors must comply with these conditions. Candidates must have been born on or after April 1, 1926. The last date for the submission of entries is November 30, 1952, and afterwards candidates may be required to give to the assessors a verbal explanation of their schemes. In the event of there being no entry of sufficient merit, the award may be withheld.

THE LATE MR. W. H. WILLIAMS: ERRATUM.—We regret that, in our obituary notice of Mr. W. H. Williams, on page 115, *ante*, his name was incorrectly given as Walter instead of William Hugh Williams.

NOTES ON NEW BOOKS.

Resistance Strain Gauges.

By J. YARNELL. "Electronic Engineering," 28, Essex-street, London, W.C.2. [Price 12s. 6d. net.]

THE wire resistance strain gauge, deservedly popular and astonishingly versatile, needs care and experience to yield the best results of which it is capable; and the justification of a new book on a subject that has inspired much excellent technical writing during the past ten years resides in the author's background of first-hand knowledge of strain-gauge technology. His experimental work in the Vibration Department of de Havilland Propellers, Limited, enables him to deal convincingly with the often troublesome problems of measuring strains in rotating machinery and in components subject to alternating stresses. It has helped him, also, to apply a critical judgment to the commoner applications of strain analysis where such practical factors as adhesion, moisture-proofing and temperature compensation make all the difference between accuracy, or error which is the more serious for being unsuspected. He devotes an instructive chapter to the theory and practice of strain-indicating lacquer, rightly regarding it as mainly of qualitative value, but an economical preliminary to resistance-gauge analysis in cases where the directions of principal strains are uncertain. Other chapters deal with methods of gauge construction, cements for attaching gauges to test surfaces, electrical circuits and apparatus for measuring and recording strains, and the theory and technology of two-dimensional strain analysis. The text is primarily concerned with the temporary use of gauges for engineering experiment, to the exclusion of similar, though significantly varying, techniques employing the principle of the wire strain gauge for force measurement in permanent equipment. On his own admission, the author has restricted his survey to matter which will appear elementary to many research workers, though few of these will fail to pick up a useful practical hint here and there. On the other hand, experimental engineers to whom the subject is new will find Mr. Yarnell's critical introduction both instructive and stimulating.

A New Approach to Engineering Tolerances.

By J. GILSON, A.M.I.Mech.E., A.M.I.Prod.E. The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1. [Price 10s. 6d.]

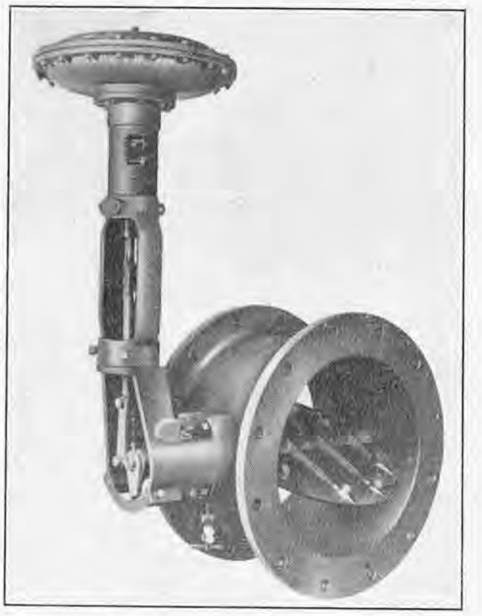
IN the sub-title of this book—*A Critical Presentation of the Considerations Necessary for the Allocation and Maintenance of Realistic Tolerances in Modern Economic Production*—the operative words are "realistic" and "economic." The author probes deeper into the question of tolerances than is general in engineering. He faces up to the fact that there is often a difference between what the drawing-office staff specify and what the machine shop and fitting shop actually produce. At the same time, to the specifying of tolerances he applies the theory of probability in a practical, common-sense way that should appeal to designers and producers whose strong point is not mathematics. He holds that "the more the drawing can be accepted as a *bona-fide* statement of minimum acceptable standards, the greater will be the control which it exerts over product quality," and if such confidence in the drawing is to be achieved the specified tolerances must take account of what is reasonable and practicable in the shops. In an examination of the effect of tolerances on fits, he concludes that a simple empirical frequency-distribution curve of semi-circular form is more appropriate as a basis for formulating tolerances than the better-known normal frequency-distribution curve. The complication of the problem where more than two parts are assembled in such a way that the tolerances are cumulative is also considered. Typical tolerances are suggested for various production processes and advice is given on the method of expressing tolerances on drawings. In a chapter on standard limit and fit systems, he applies his arguments in a critical review of B.S. 164, and then outlines a recommended procedure for establishing an efficient system.

DIAMOND TOOLS.—A lecture on "The Technology of the Machining of Diamond" will be delivered by Mr. P. Grodzinski, A.M.I.Mech.E., at the South-East London Technical College, Lewisham-way, London, S.E.4, on Monday, February 18, at 7 p.m.

"LAUNCHES AND TRIAL TRIPS": ERRATA.—In reporting, on page 128, *ante*, the launch of the M.S. Corato, we stated that the main engine was being constructed by the Wallsend Slipway and Engineering Co., Ltd. This information, given to us by the builders of the ship, we now learn is incorrect, as the engine is being built by Scott's Shipbuilding and Engineering Co., Ltd., Greenock. The vessel is to the order of the Hadley Shipping Co., Ltd., whose managers are the Immingham Agency Co., Ltd., not Houlder Bros. & Co., Ltd.

PNEUMATICALLY-OPERATED BUTTERFLY-VALVE.

THE illustration below shows a pneumatically-operated butterfly-valve recently added to the range of control mechanisms made by the Fisher Governor Company, Limited, Century Works, Lewisham, London, S.E.13. These valves may be employed to control the mass-flow of liquids and gases passing through pipes under comparatively low static pressure, and are so used in the coal-gas and producer-gas industries, as well as in steel-works, oil refineries, chemical plants, etc. Fisher butterfly valves are available in sizes from 4 in. to 24 in. in diameter. The flow is controlled by means of a disc which is connected to a diaphragm



motor which is operated pneumatically. The valve disc is suitably shaped and ribbed to combine mechanical strength with a low resistance to the passage of the fluid when the valve is open. With the valve in the closed position, the clearance area between the disc and body of the valve does not exceed 0·5 per cent. of the total cross-sectional area of the pipe. The connection between the disc and the diaphragm is formed by a stout crank and a lever with accurately ground pins, so that the lost motion in the mechanism is negligible. The pressure range for the standard diaphragm supplied with the valve is 3 lb. to 15 lb. per square inch. Automatic regulation can be obtained by mounting a Fisher Wizard pilot control on the diaphragm casing. The Fisher Positrol valve positioner can also be fitted if required.

TRADE PUBLICATIONS.

Brick Drying.—Publication No. 4705 of the Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, deals with the drying of bricks, tiles and heavy clayware. The use of waste heat, of which clay works generally have ample supplies, is advocated, and tunnel and zone drying systems are described.

Steelworks Products.—Dorman, Long & Co., Ltd., Middlesbrough, have sent us a copy of an attractive brochure they have issued, giving particulars, with numerous illustrations, of their principal activities during 1951. As will be readily appreciated, their chief difficulty has been to maintain the supply of raw materials, but some of the firm's sources of ironstone, limestone, coal and scrap are illustrated, and notable plant developments in their iron, steel and engineering works are described. Examples of bridges and other structures completed during the year are illustrated and reference is made to the production of sheets and wire, and certain by-products such as resins, benzole, etc.

Pick-up Devices and Strain-Recording Equipment.—Kelvin and Hughes (Industrial), Ltd., 2, Caxton-street, London, S.W.1, have prepared a list of the names and addresses of makers of pick-ups of the inductance-change, differential-transformer and other types for obtaining records of various physical quantities, such as displacement, fluid pressure, force, strain, etc. The list of pick-ups is intended primarily for the convenience of users of Kelvin and Hughes strain-recording equipments. It is accompanied by descriptive catalogues of high-speed pen recorders, amplifiers and apparatus for special applications, including recording the landing speeds of the cages of colliery-winding gear, and the tension in textile yarns and threads. The pen recorders will record many transient or oscillatory phenomena, which had previously to be recorded by an oscilloscope and photography.

BOOKS RECEIVED.

Ministry of Transport. Railway Accident. Report on the Collision which Occurred on 21st April, 1951, between Pollokshields East and Queen's Park in the Scottish Region British Railways. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9d. net.]

Living in Flats. Report of the Flats Sub-Committee of the Central Housing Advisory Committee. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]

Overseas Economic Surveys. Bolivia. By H. J. LEGG. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]

"Hütte." Des Ingenieurs Taschenbuch. Twenty-seventh revised edition. Vol. III. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 15 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 26s. 3d.]

Anschauliche Verfahren zur Berechnung von Durchlaufbalken und Rahmen. By PROFESSOR ROBERT V. HALASZ. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 28·50 D.M. in paper covers, 31·50 D.M. bound]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 49s. 11d. in paper covers, 55s. 2d. bound.]

Hydraulik und Wasserbau auf neuen Grundlagen. By A. SCHÄFER. Franckh'sche Verlagshandlung, Pfizerstrasse 5-7, (14a) Stuttgart-O, Germany. [Price 35 D.M.]

Hydrodynamische Grundlagen zur Berechnung der Schiffsschrauben. By DR.-ING. M. STRSCHELETZKY. Verlag G. Braun, Karl-Friedrich-Strasse 14, Karlsruhe, Germany. [Price 12 D.M.]

Carburation. By CHARLES H. FISHER. Third revised edition. Vol. II. *Carburettors: Their Installation and Service Adjustment.* Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 36s. net.]

The Science of Flames and Furnaces. By M. W. THRING. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 42s. net.]

Earthing Principles and Practice. By R. W. RYDER. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 15s. net.]

The Early History of the Electric Locomotive. By F. J. G. HAUT. Published by the author at 2A, Monahan-avenue, Purley, Surrey. [Price, printed version, 20s.; stencilled version, 15s.]

National Building Studies. Bulletin No. 13. *Fire Endurance of Timber Beams and Floors.* By D. I. LAWSON, C. T. WEBSTER, and L. A. ASHTON. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]

Tables of the Bessel Functions of the First Kind of Orders Seventy-Nine Through One Hundred Thirty-Five. By the staff of the Computation Laboratory. Harvard University Press, Cambridge 38, Massachusetts, U.S.A. [Price 8 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 52s. net.]

The British Plastics Federation. A Comparison of the Flame-Retardant Properties of Plastic-Insulated and Rubber-Insulated Electric Cable. Report of a special investigation by the Fire Research Station of the Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organisation. Offices of the Federation, 47-48, Piccadilly, London, W.1. [Price 2s. 6d.]

Welding Practice. In three volumes. Edited by E. FUCHS and H. BRADLEY. Vol. I. *Welding Methods and Tests.* Published, in association with Imperial Chemical Industries, Limited, by Butterworths Scientific Publications, Limited, Bell Yard, Temple Bar, London, W.C.2. [Price 17s 6d. net.; the three volumes, 55s. net.]

Electrical Instruments and Measurements. By W. ALEXANDER. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 12s. 6d.]

Prospection Géophysique. By EDMOND ROTHÉ and PROFESSOR J.-P. ROTHÉ. Vol. II. Librairie Gauthier-Villars, 55, Quai des Grands-Augustins, Paris (6e). [Price 6,000 francs.]

The College of Aeronautics, Cranfield. Report No. 50. *Theoretical Stability Derivatives of a Highly Swept Delta Wing and Slender Body Combination.* By T. NONWEILER. The Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5s.]

L'Air Comprimé. Vol. I. Production. By JEAN LEFÈVRE. J. B. Baillière et Fils, 19, Rue Hautefeuille, Paris (6e). [Price 3,500 francs.]

Über Bodenuntersuchungen bei Entwurf und Ausführung von Ingenieurbauten. By DR. BRUNO TIEDEMANN. Fourth edition, revised by PROFESSOR KURD VON BÜLOW. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 8.50 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 14s. 11d.]