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

(*Concluded from page* 163.)

IN concluding below the article on the gas-turbine locomotive recently completed for British Railways by the Metropolitan-Vickers Electrical Company, Limited, we deal first with the auxiliary and control equipment and then describe the locomotive structure and running gear. Last week we reproduced a general-arrangement drawing of the gas-turbine, performance curves for the locomotive and a diagram of the traction electrical connections, to which further reference is made below. In this issue, Plate XI shows the general arrangement of the locomotive, Fig. 22 being a longitudinal section, Fig. 23 a sectioned plan, and Figs. 24 to 29 cross-sections.

Most of the auxiliaries are operated from the 110-volt direct-current supply from the auxiliary generator. The Chloride battery, consisting of 48 lead-acid cells of 384 ampere-hours capacity, is charged from this supply through a contactor which is closed only when the auxiliary generator is operating. Certain of the electrical auxiliaries are battery fed, and can be run at any time, while other are fed from the generator and can be used only when the turbine is running. Fuel and lubricant are supplied to the turbine by a pump set consisting of a 10-h.p. 3,000-r.p.m. motor supplied from the battery and driving a fuel pump overhung from the motor and a lubricant pump mounted on a common bedplate with the motor. There are two of these sets, both carried on the main turbine bedplate. Only one is used at a time, but it is automatically superseded by the other in the event of a failure of fuel or lubricant supply. The fuel pump is of the swash-plate type and can supply 7·5 gallons per minute at 650 lb. per square inch. It was made by Dowty Equipment, Limited, Cheltenham. The lubricant pump is of the "Imo" type, delivering 70 gallons per minute at 50 lb. per square inch, and was supplied by Messrs. Mirrlees (Engineers), Limited, Hillington, Glasgow.

The auxiliary fuel pump supplies fuel from the tank on the locomotive underframe to the suction side of the main fuel pump. It is driven at 1,400 r.p.m. by a battery-fed ½-h.p. motor, the combined set being mounted adjacent to the main turbine bedplate. It is a gear pump rated at 10 gallons per minute at 10 lb. per square inch. The auxiliary lubricant pump is a similar set, mounted on the turbine bedplate, and its duty is to supply lubricant to the turbine and gear bearings during the cooling period after the turbine has been shut down. The auxiliary fuel and lubricant pumps were supplied by Varley Pumps and Engineering, Limited, 97, Standard-road, London, N.W.10.

The heat carried away by the lubricant from the turbine bearings and reduction gear is dissipated in cooling equipment comprising two air-cooled radiators. They consist of rows of tubes of the wire-wound Clayton-Still pattern, extending between top and bottom headers. One radiator is mounted in each side wall of the locomotive body and air ducts of sheet aluminium sweep inwards and upwards to converge at the entry to a 32½-in. axial-flow fan mounted in the roof with its axis vertical. The fan, supplied by Davidson and Company, Limited, Belfast, is driven at 1,480 r.p.m. by a 10-h.p. series motor fed from the auxiliary generator, and draws about 1,600 cub. ft. of air per minute through the cooling elements. The heat dissipation capacity is equivalent to about 120 kW with 70 deg. F. ambient temperature and 180 deg. F lubricant entry temperature.

A Westinghouse two-cylinder single-stage reciprocating air compressor, gear driven by an 8-h.p. motor, supplies compressed air at 100 lb. per square inch for operating the locomotive brakes, the electro-pneumatic control apparatus, sanders, warning horns and window wipers. The compressor is air-cooled and has a piston displacement of 38 cub. ft. per minute at 243 crankshaft r.p.m. or 1,200 motor r.p.m. The motor is supplied from the auxiliary generator. An automatic governor switches the motor on and off to maintain the pressure in the main reservoir between 85 and 100 lb. per square inch. The vacuum-brake equipment for the train operates at 24 in., two reciprocating four-cylinder exhausters providing the brake power. Each is directly driven by a flange-mounted motor at 750 r.p.m. for normal maintaining and application, and at 1,200 r.p.m. for release. Both motors are stopped in an emergency application. The swept volume of each is 82·5 cub. ft. per minute at 750 r.p.m. and the power input is 4 h.p. The two machines are capable of creating a 25-in. vacuum in 45 seconds in a train of 80 cub. ft. train-pipe and cylinder capacity. The motors are battery fed, so that the brakes will not be applied by shutting down the turbine in stations or when coasting.

The three traction motors on each bogie are force-ventilated by a centrifugal blower directly coupled to a 11·25-h.p. motor. The 21-in. runner delivers about 8,000 cub. ft. per minute at 6 in. water gauge total head, at 1,460 r.p.m. The air is distributed to the motors by sheet-aluminium ducts on the underframe and leather bellows, shown in Fig. 19, on page 194, extending down to the motor air-inlet flanges. Steam for train heating is supplied by a vertical fire-tube oil-fired boiler, continuously rated at 1,500 lb. per hour and working at 80lb. per square inch; it was made by Spanner Boilers, Limited, Streatham, London, S.W.16. The operation is semi-automatic, in that the fuel flow is controlled by the steam demand, the feed-pump delivery is regulated by the water level and the fuel is cut off by loss of flame and by low water-level. A special feature, intended to ensure flame stability in spite of air-pressure fluctuations due to high train speed and the effects of bridges and tunnels, is the provision of a high-pressure combustion-air blower in conjunction with flow retarders at the inlet and outlet of the firebox.

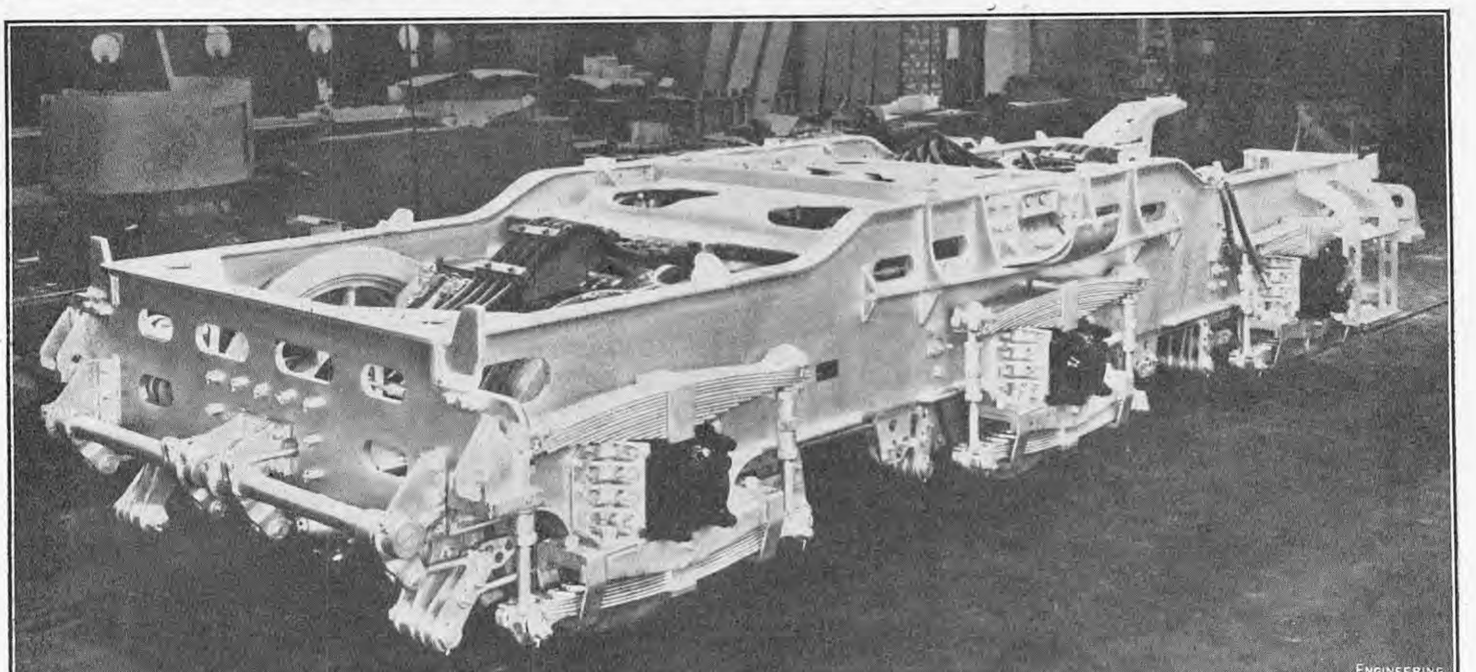


FIG. 17. SIX-WHEELED LOCOMOTIVE BOGIE.

FIG. 18. ONE OF THE DRIVING CABS.

The 40,000 cub. ft. per minute of air required for the gas turbine at full load is drawn through Vokes filters in the side walls of the turbine compartment. These filters are of the dry fabric type and they can be cleaned when necessary either after removal from the locomotive or by reverse blowing in position by compressed-air nozzles on flexible pipes provided in the turbine compartment. It is not expected that this air filtration will eliminate the need for compressor-blade cleaning, but it will materially reduce the rate of fouling.

The auxiliary equipment of the driving cabs, one of which is shown in Fig. 18, on this page, includes pneumatically-operated window wipers, double-note pneumatic warning horns, electric foot warmers, electric food heaters, and a plenum system of cab ventilation and heating. The ventilation air is tapped from the adjacent traction-motor ventilation trunk and conducted by a dual duct to a combined mixing valve and Punkah louvre, set high up in the rear wall of the cab. In one section of the dual duct a thermostatically-controlled electric element heats the air. The driver can manipulate the louvre to get the required quantity, direction and temperature of air. The combined fuel and boiler feed-water tank is slung under the body underframe and between the bogies, as shown in Fig. 26, Plate XI. It is of elliptical cross-section and constructed entirely of welded steel plate. A transverse division plate separates the 995-gallon fuel section from the 620-gallon water section; both sections may be made available for fuel by removing a cover from an aperture in the division plate. Remote-reading tank-contents gauges are operated by tank floats and electrical potentiometers, with indicators in each driving cab and at the tank filling valves. With the exception of the tanks, all the auxiliary equipment is housed inside the body portion and is grouped mainly in the driving cabs and the adjacent ends of the turbine and generator compartments.

The main function of the control equipment is to provide means for the driver to control the speed of the train by regulating the tractive effort developed at the wheels. At the cost of some elaboration of apparatus, the control scheme has been designed to relieve the driver of much of the responsibility for the functioning of the power plant and auxiliaries. The principal electrical circuits were shown in Fig. 4, on page 162, *ante*.

The procedure on taking over the locomotive is extremely simple, consisting of the following operations: operate the key switch; press the turbine starting button, and when the green light appears one minute later (indicating that the turbine is running at idling speed) switch on the brake compressor and exhausters. The locomotive is ready for service after about five minutes warming period if the start has been from cold. To move the locomotive, either light or with its load, the brakes are released, the reversing lever of the master controller moved to the direction required and the power lever set as required. This power lever has no notched positions but can be set and left at any position between no power and full power. For the sake of convenience and simplicity, the same lever has been made to determine the starting tractive effort developed, between the minimum for light locomotive manoeuvring and a maximum determined by wheel-slip considerations. The driver is not required to notch up this lever as the train speed rises; he may do so if he so wishes, but may equally well put it directly in the position he expects ultimately to require.

For the driving technique to be thus simplified, the control equipment must perform the following functions during normal operation. (1) Start up the turbine, which involves the sequence of starting the auxiliary fuel pump, starting the main fuel and lubricating pumps, switching on the turbine igniters, opening the fuel isolating valve, connecting the starting battery to the main generators, adjusting the generator field strength as the turbine speed rises, and eventually disconnecting the battery at the appropriate time and switching off the ignition. (2) Start the lubricating-oil cooler fan. (3) Start the traction-motor blower motors. (4) Control the recharging of the battery. (5) Open the fuel control valve in accordance with the position of the driver's power lever. (6) Adjust the field strengths of main generators and traction motors to the changing speed of the train and in accordance with the power-lever position. (7) In the event of the locomotive speed being too low for the power selected, resulting in excessive tractive effort, to limit the tractive effort to the maximum determined by the power-lever position and to adjust the fuel valve accordingly. (8) For any power-lever position, to adjust the turbine speed to that most economical for the power demanded. (9) For any demand for power increase, to regulate the rate of increase of fuel within the limits for compressor stalling and turbine maximum temperature. (10) After shutting down the turbine, to control the running of the auxiliary lubricating-oil pump to avoid excessive bearing temperatures. (11) After shutting down the turbine, to control a series of periodical low-speed runs by battery power to prevent turbine-rotor distortion during cooling. In addition, the control equipment must deal with emergency conditions such as the following.

RESILIENT SUSPENSION ON LOCOMOTIVE BOGIE.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, MANCHESTER.

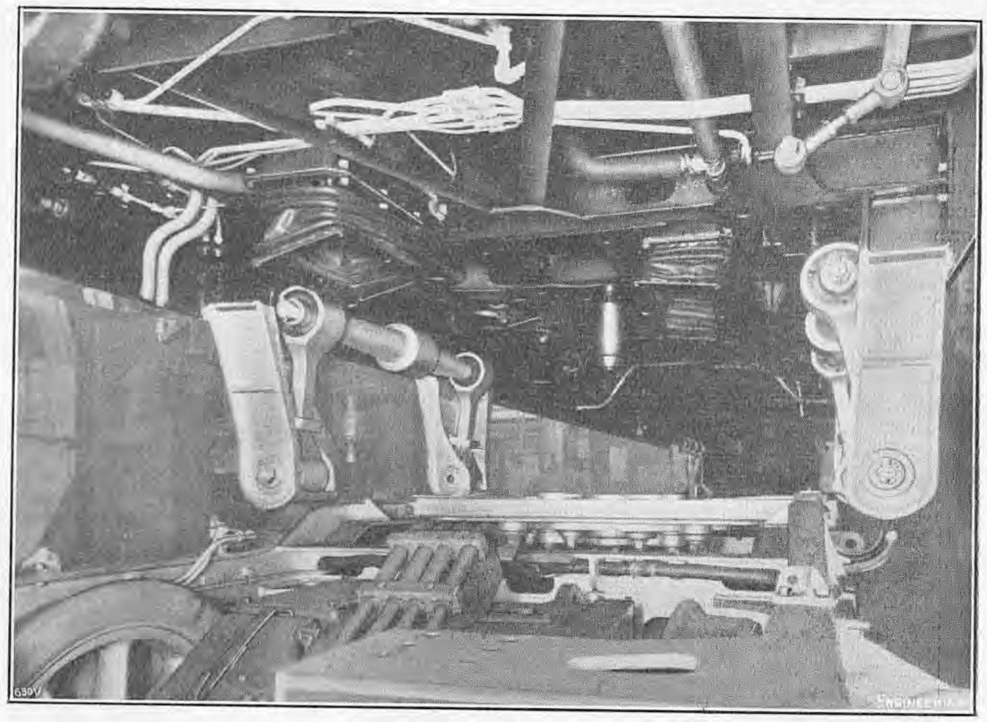


FIG. 19. LOCOMOTIVE BODY LIFTED OFF BOGIE.

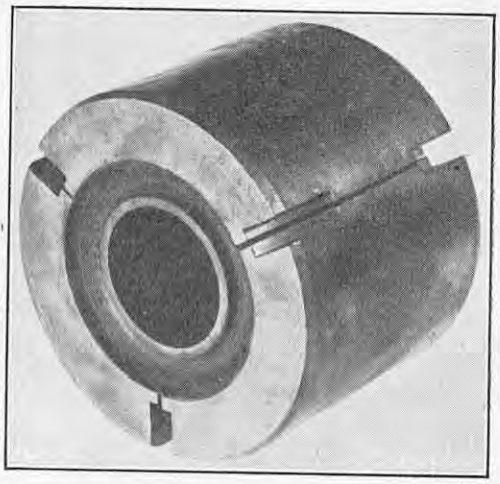
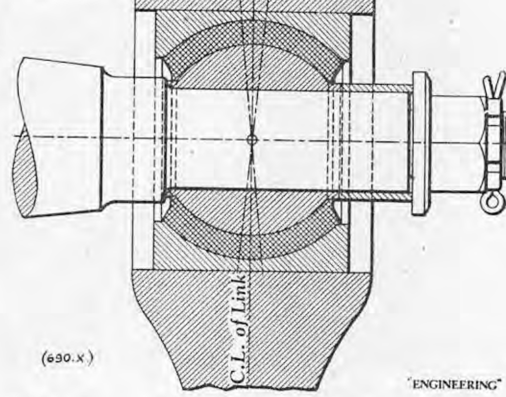


FIG. 20. RESILIENT BUSH.

Fig. 21.



(*a*) In the event of the battery state of charge being insufficient to start the turbine, to provide means for utilising external power in the form of towing by another locomotive to effect a start. (*b*) In the event of a breakdown of the automatic output control (item 6 above), to provide a simple form of output regulation at reduced power on the natural characteristic of the generators. (*c*) In the event of failure of the running main fuel and lubricant pump set, to start up the stand-by set. (*d*) In the event of excessive turbine-inlet gas temperature, to reduce the fuel supply rate. (*e*) In the event of overspeed of the turbine, to cut off fuel. (*f*) In the event of electrical insulation failure or overcurrent, to open the electrical circuits and cut off fuel.

It is not proposed to discuss here in detail the methods by which each of these functions is performed. The general method, however, is to relate to each quantity to be regulated, a proportionate voltage, and to cause that voltage to control relays and electric servo means for adjusting the quantity to the required value. For example, in the case of item 6, if the traction conditions change, so as to demand a higher tractive effort, as in reaching a rising gradient, the increase of current to the traction motors from the main generators causes the turbine speed to drop. This is immediately reflected in a reduction of voltage from a tachometer generator driven by the turbine and this, through the medium of a voltage relay, weakens the excitation of the generators to reduce their output voltage in the ratio of the increased current demand, thus maintaining the turbine output at the value selected by the power lever of the master controller.

The sequence and timing of the various events in the process of starting up the turbine (item 1) are determined by a drum-type sequence controller driven by an electric motor. Similar means are employed to regulate the periodic running of the turbine during cooling (item 11). The auxiliary lubricant-pump operation (item 10) is under thermostatic control. For the emergency condition of item (*b*), the assistant driver performs the function of a governor by keeping the turbine speed roughly constant, using a manual fuel valve located adjacent to a tachometer on the turbine instrument panel. With the turbine speed regulated in this way, the power output varies with train speed in accordance with the inherent characteristics of the generators, exciter and motors, as determined by the combination of the three exciter field windings, and, though never reaching the normal value, is adequate for an emergency.

In the case of the battery being unable to start the turbine (item (*b*)), certain electrical connections may be changed so that pushing or pulling the locomotive by another causes the traction motors to supply the power normally available from the battery. Electrical faults are dealt with by over-load relays and an earth-leakage relay in the main circuits, and by fuses and circuit-breakers in the auxiliary circuits. In the main power circuits the apparatus used is the same as for an electric locomotive. For example, each traction motor

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Fig. 22. GENERAL ARRANGEMENT OF GAS TURBINE LOCOMOTIVE.

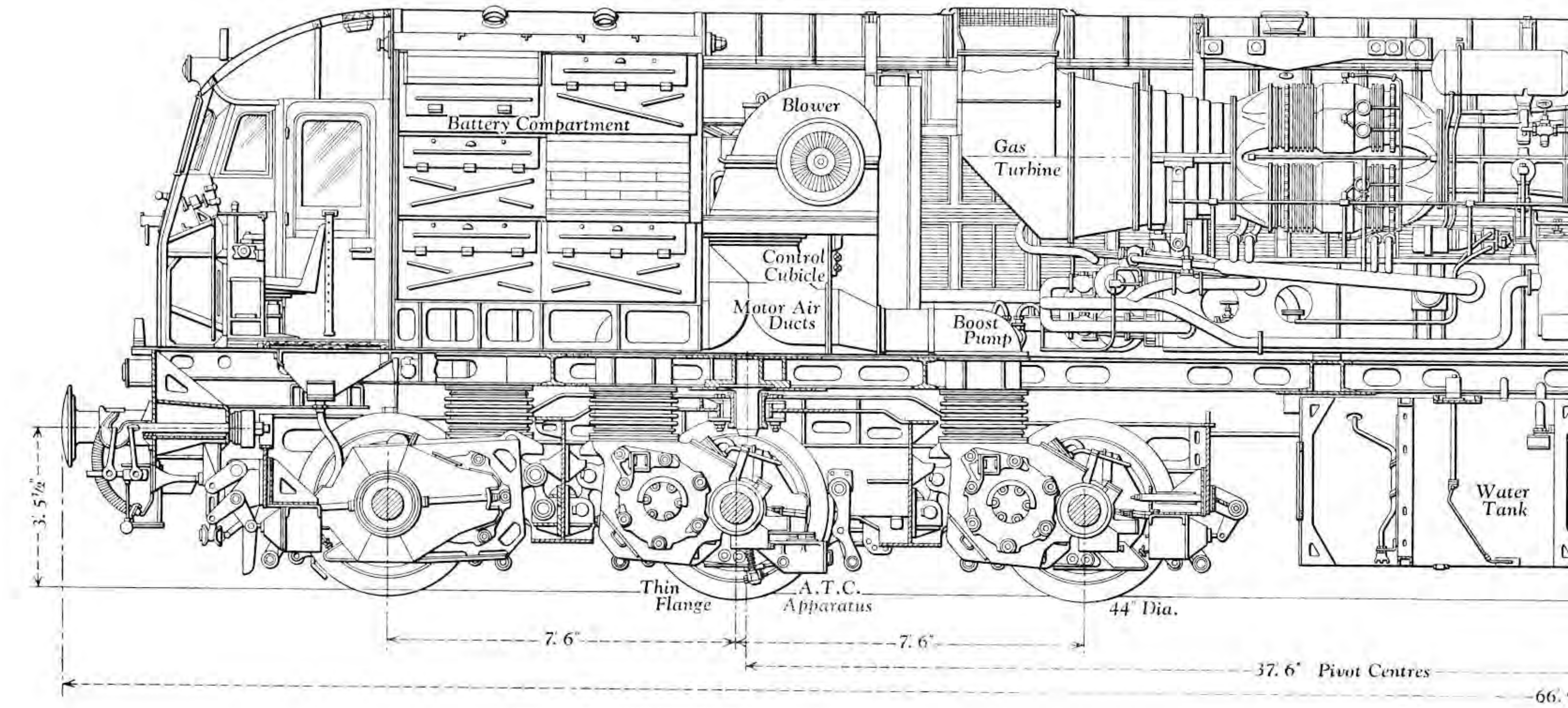


Fig. 23.

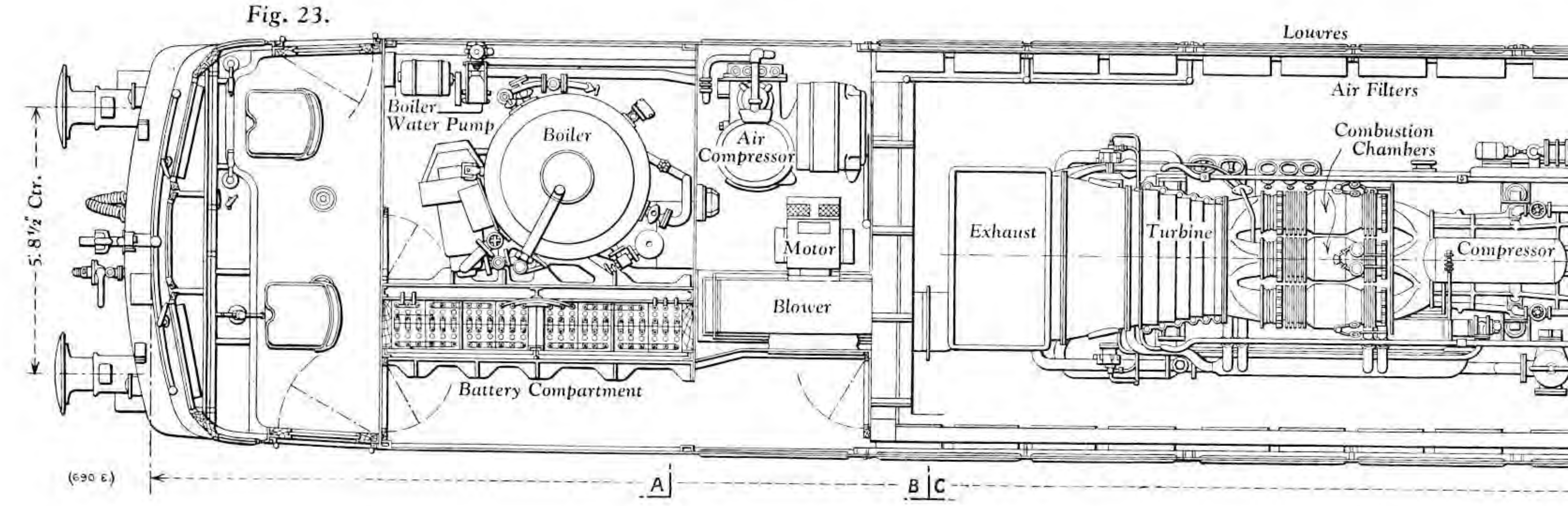


Fig. 24. SECTION AT 'A'

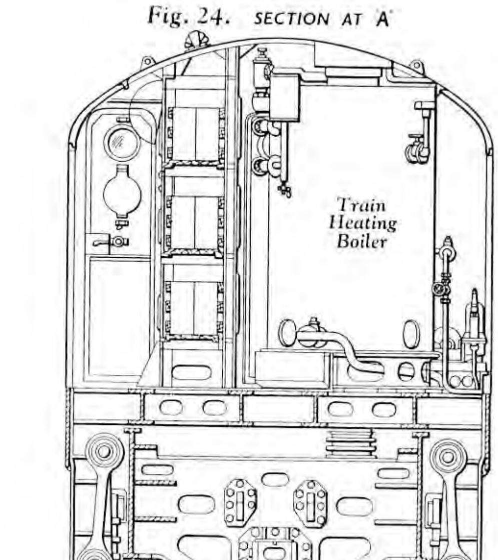


Fig. 25. SECTION AT 'B'

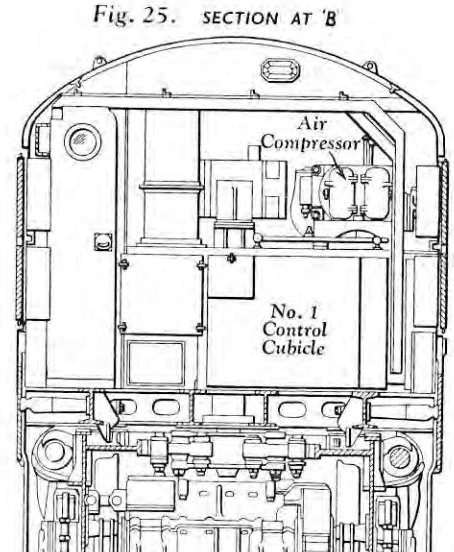
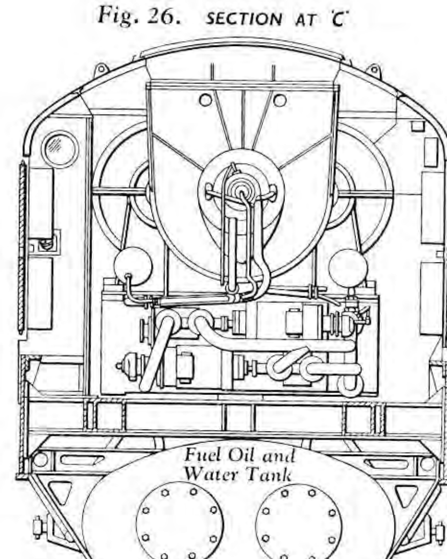


Fig. 26. SECTION AT 'C'



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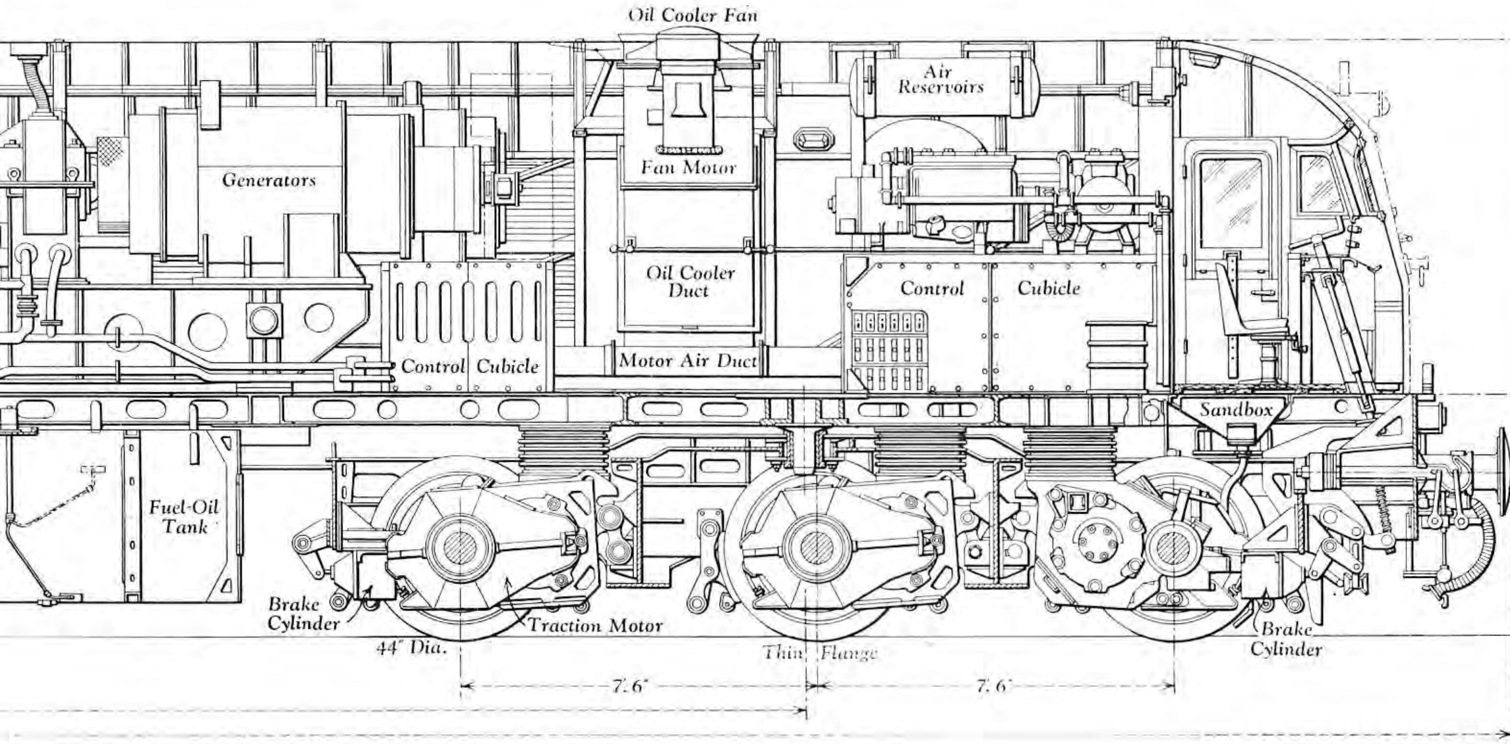
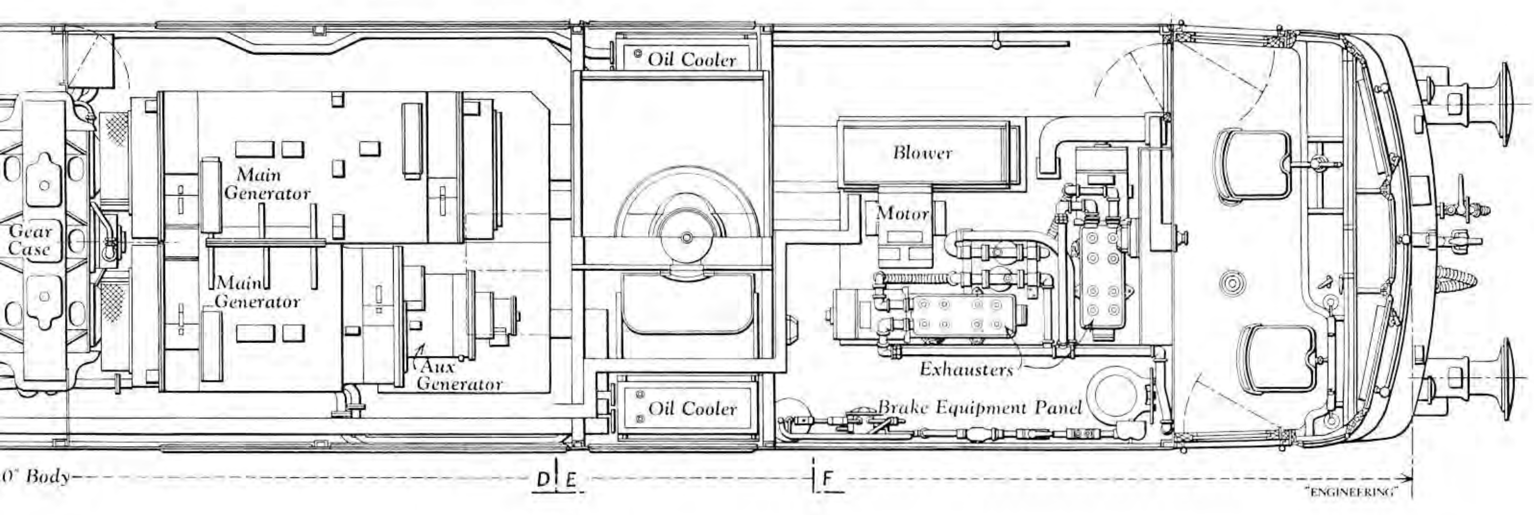




ig. 27. SECTION AT D.

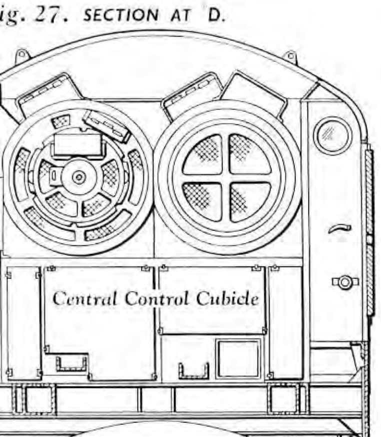


Fig. 28. SECTION AT E.

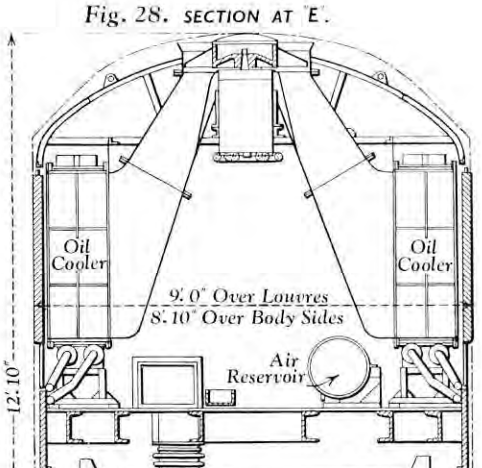
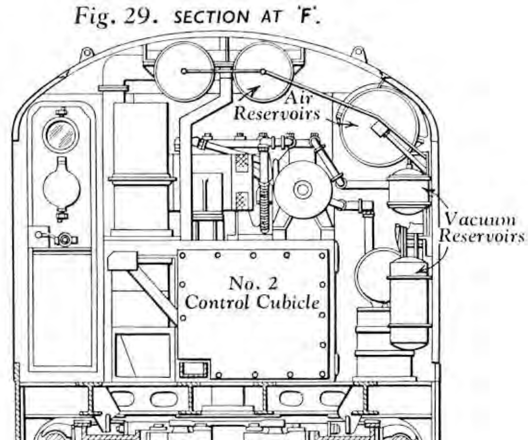


Fig. 29. SECTION AT F.



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is controlled and protected by an electro-pneumatic unit switch, and its field is reversed by an electro-pneumatic drum switch. The auxiliary circuits also are controlled by conventional electric-traction apparatus, but, on the other hand, in the subsidiary control and regulating circuits, new conditions are encountered and special devices have been designed to deal with them. For instance, the principal components of the master controller are low-voltage potentiometers. Their function is to apply to servo devices in the control circuits voltages proportional to the response required by the position in which the driver has placed the controller lever. These servo devices are of the vibrating-contact type and they control field strengths and servo motors to produce the desired result.

The body and underframe are built together as a single unit, almost entirely by welding. The principal members are the two solebars, consisting of continuous plates of deep section, reinforced by top and bottom welded flanges and tied together at each end by the welded headstock structures. The solebars are attached by fitted bolts to the main supporting structures, which are also welded assemblies, at the bogie-centre locations; elsewhere they are cross-braced by a lattice of rolled-steel sections and by the floor plate. At cant-rail height a ribbed curved plate section of the roof forms a rigid boom running on each side from end to end of the body except over the cabs. The body wall sheeting is welded to this boom, to the solebars and to the carlines, except where spaces are left for air filters and louvres. The roof sections between the booms are of aluminium alloy and are removable for most of the length of the body. At each end the driving-cab walls and roof, in the form of a separate welded aluminium-alloy structure, are mounted on the underframe platform.

The bogies, one of which is shown in Fig. 17, on page 193, are welded assemblies constructed from plates, some with welded flanges. The side frames are connected by the headstocks and by two cross-stays, all of welded plate. Each complete bogie frame and each main welded sub-assembly of the body structure were stress-relieved in an annealing furnace.

The body is suspended by swing links from the bogies, as shown in Fig. 19, opposite. There are eight of these links—two on each side of each bogie, outside the bogie frames. Each link end contains a rubber universal joint, without any metallic contact between the elements. One of these joints, or spherical bushes, is shown in Figs. 20 and 21, opposite; they were supplied by Metalastik, Limited, Evington Valley-road, Leicester. The lower joint is, in each case, attached to the lower end of the body support brackets, and pairs of upper joints are attached to longitudinal equalising beams. At the middle of each beam is a rubber universal joint resting in the corresponding bogie support bracket; the joints or flexible bearings in these positions were supplied by Silentbloc, Limited, Victoria-gardens, London, W.11. The resilience of the rubber joints permits the necessary relative angular motion between body and bogies about the vertical and transverse axes, and also the degree of lateral relative movement necessary for good high-speed riding. The restoring forces are mainly those due to gravity, as those arising from deformation of the rubber are relatively small, although they provide a measure of damping against hunting. More effective damping is provided by Girling hydraulic dampers located at four points on each bogie and connected between the body underframe and bogie frames by links with universal rubber joints. These resist lateral displacements and vertical-axis rotation of the bogies in relation to the body with forces which are functions of the rate of movement. Relief valves, however, prevent these resisting forces from exceeding certain predetermined limits.

The longitudinal reactions between the body and bogies, arising from traction and braking forces, are taken through a pivot pin on the body which carries a parallel-motion linkage coupled to the bogie cross-stays and equipped with Silentbloc flexible bearings. This does not interfere with any of the other relative movements between the body and bogies. The use of rubber at the points of relative movement dispenses with the necessity for lubrication and rectification of wear of metallic surfaces; it is only necessary to renew standard rubber-joint units at intervals, which experience indicates are likely to be long. Another feature of the rubber joints is the complete interruption of metallic connection between body and bogies and the consequent isolation of the body from high-frequency vibrations due to track irregularities. Another essential for good riding at high speed is the avoidance of axle transverse play relative to the bogie. The steps taken to reduce this to a minimum are the use of roller-bearing axleboxes with only nominal play on the axles and in the horn guides. The boxes are of the Hoffmann type, with two rows of rollers and one row of balls for end location; they are oil-lubricated. The boxes are very closely guided in the slides, with initial clearances of only 0·010 in. in both horizontal directions, the wearing surfaces being of manganese steel on the boxes and oil-hardened steel on the guides, with grease lubrication. On each axle the close guiding in the transverse direction is applied to one box only, the other having ample transverse clearances; thus the axle is located from one end. At each end the horn guide is of the trunnion type to permit canting of the axle in relation to the bogie. The high degree of flexibility of springing, which is another requirement for high-speed running, is achieved by the use of two springs in series at each axlebox, one above and the other below the box. The arrangement has the additional advantage of eliminating spring-hanger wear.

As indicated earlier, the traction motor is located transversely from the bogie frame by a Silentbloc rubber-bushed link, thereby eliminating the detrimental effect on high-speed riding of the free play of such a relatively heavy mass along the axle within the suspension bearing end-float limits, and also the wear of suspension-bearing thrust faces, which is normally the most serious aspect of motor-bearing maintenance. The torsional resilience in the gear drive between the motor and axle is another contribution to good riding at high speed and to reduced maintenance on track and running gear. The train brake equipment is the vacuum system, but space considerations have led to the use of compressed-air braking on the locomotive. The driver manipulates the vacuum-brake valve to apply the train brake, and a simple automatic valve applies a proportionate air application to the locomotive wheels, unless the driver prevents this interaction by pressing a thumb trigger on the brake handle. When running light in sidings and hauling unbraked trains in territory not equipped with automatic train control, the exhausters need not be run, and the locomotive brakes can be applied directly from an independent air-brake valve. Each wheel is fitted with two clasp brake shoes. Four air-brake cylinders on each bogie operate three brake shoes each. In each driving cab a hand-brake operates on the six shoes on the adjacent one and a half axles.

In addition to firms already mentioned, the following were sub-contractors to the Metropolitan-Vickers Electrical Company: Yorkshire Engine Company, Limited, Meadow Hall Works, Sheffield (who were responsible for the machining and assembly of the bogies and providing some of the bogie components); Taylor Bros. and Company, Limited, Trafford Park Steel Works, Manchester, 17 (wheels and axles); James Booth and Company, Limited, Nechells, Birmingham, 7 (aluminium alloy); and Keith Blackman, Limited, Mill Mead-road, Tottenham, London, N.17 (traction-motor blowers).

LITERATURE.

The Photographic Study of Rapid Events.

By W. D. CHESTERMAN. Clarendon Press, Oxford. [Price 21s. net.]

THE apparent reluctance of scientific investigators to make anything like full use either of still photography, or of its sophisticated offspring the cinematograph, for years after each of these essentially scientific inventions had achieved enormous importance and social influence by commercial development, contrasts curiously with the eagerness of scientists to exploit more recent inventions like electronics or nuclear fission. Even to-day, when the potentialities and diverse applications of technical photography have been abundantly and convincingly demonstrated, a reluctance or neglect to use it persists, even among many who would not dispute for a moment its place in the modern armoury of research. Some of the reasons for this attitude are no doubt obscure and vary with the individuals concerned, but one which must be common to many investigators is the justifiable belief that a good deal of specialised knowledge and experience go to the making of pictures of such quality and character as to embody, in themselves, the results of a first-rate piece of research.

Mr. Chesterman's book goes a long way towards surmounting these particular obstacles to the extending use of photography for the study of rapid events. He is well qualified to write on these subjects by having specialised in this type of work for several years in the Royal Naval Scientific Service, where he enjoyed opportunities of using first-class apparatus and of perfecting new techniques to meet the individual requirements of a wide range of problems. In such circumstances, it is understandable that he has tended, by implication, somewhat to exaggerate the importance of expensive equipment beyond the means of many research workers, some of whom have obtained remarkable results with crude cameras, home-made for a few pounds. Mr. Chesterman's descriptions of commercial cinematograph and film-drum cameras, embracing ranges of taking speeds up to several thousand pictures per second, are none the less particularly clear and instructive. They are valuably supplemented by discussions of picture quality in relation to geometrical and optical considerations, the illumination of the experiment, and the choice of sensitive photographic materials.

Also included in the main part of the book, dealing with techniques, are discussions of optical devices of the Schlieren type, and photography by isolated or repeated spark discharges. For all these methods of studying rapid events the author has presented the theoretical aspects of many elegant techniques with a clarity and confidence possible only to an experimenter who has himself employed many of them successfully. Further proof of this conclusion, were it needed, is to be found in the later chapters of his book where, among examples of the applications of high-speed photography to various lines of research, including zoology, biology and medicine, predominance is given to the physical, engineering and military sciences. Within the limitations of a single volume it has not been possible, of course, to cover more than a part of the whole field of knowledge which contributes to the photography of rapid and ephemeral events. Mr. Chesterman's survey of what may be described as the tool of the photographic time microscope employed in the art of scientific investigation has been the more thorough for his self-imposed limitation of scope, and its value is not impaired by the impression that the author knows a good deal more about the subject than he has so far divulged. Even so, Mr. Chesterman stimulates at the same time as he instructs, and few experimental scientists, more especially engineers and physicists, will be able to look through the remarkable plates reproduced by way of illustrations without feeling the urge to employ in their own work some of the techniques there exemplified.

The Instrumentation of Open-Hearth Furnaces.

By the British Iron and Steel Research Association (Steelmaking Division Open-Hearth Instruments Sub-Committee) with a foreword by Sir Charles Goodeve, F.R.S. George Allen and Unwin Ltd., Ruskin House, 40, Museum-street, London, W.C.1. [Price 30s.]

IN the introduction of new processes and equipment for making or treating steel, or in the perfection of older techniques, this country has always been in the forefront, as such names as Huntsman, Bessemer, Thomas and Gilchrist, Mushet, Talbot and Hadfield testify. During the past 20 years, steelmaking by the open-hearth process has become increasingly scientific and, nowadays, in all modern steelworks, production is controlled very largely by accurate measurement and to as great an extent as possible by automatic regulation. In this field also this country has led the way in some important respects, but, whereas, in the Nineteenth and early Twentieth Centuries, men worked alone or in

THE COLLEGE OF AERONAUTICAL AND AUTOMOBILE ENGINEERING.

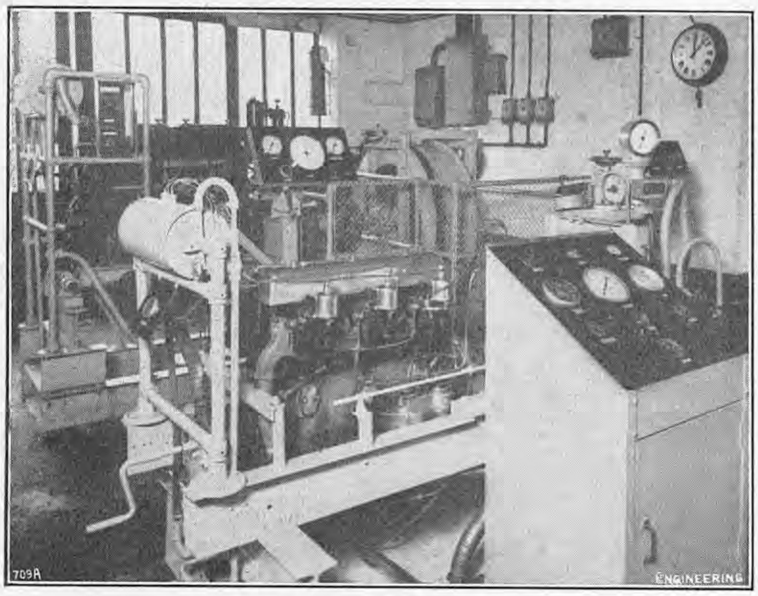


FIG. 1. AUTOMOBILE-ENGINE TEST SHOP.

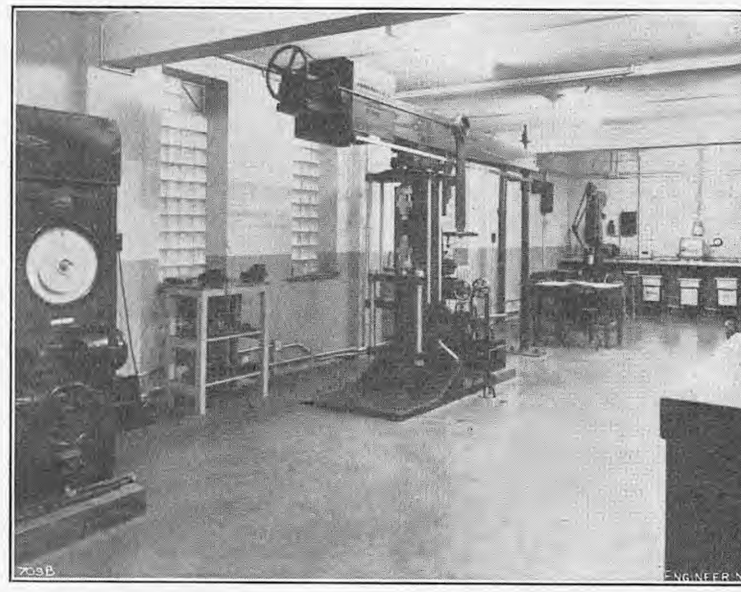


FIG. 2. MATERIALS-TESTING LABORATORY.

small groups, much of the progress made with what has come to be termed the instrumentation of steel open-hearth furnaces is the result of the work of committees, panels and teams, many of which are now operating or working under the ægis of the British Iron and Steel Research Association. The book under review, as is to be expected, is of an authoritative nature, and as Sir Charles Goodeve points out in his foreword, co-operation between the steel-plant manager, the physicist and the instrument manufacturer, has provided this country with an adequate range of instruments suitable for the steel manufacturing processes. As he observes, however, though much remains to be done, a stage has been reached at which a handbook describing the present instruments and their use is much needed. The book is divided into two parts, in the first of which the function of instruments and their basic principles are described including that of automatic-control equipment. In the second part, the instruments most commonly used in British melting shops are briefly described in simple language. These instruments include pressure meters, flow meters, high-temperature pyrometers, single and multipoint recorders and automatic control systems. In common with most publications issued by leading research associations the book is excellently turned out in every way and among its attractive features are the many clear line diagrams and drawings of apparatus and plant.

DE-ASPHALTING TOWER FOR ISLE OF GRAIN OIL REFINERY.—Good progress is being made with the erection of the Anglo-Iranian Oil Company's new oil refinery on the Isle of Grain, Kent. The latest additions to the plant include a 75-ft. high de-asphalting tower which will be used in connection with the manufacture of lubricating oils. The tower weighs 160 tons but was lifted into position complete with all internal fittings in place. Two vertical steel masts were used for the purpose, the associated hoisting tackle being driven by compressed-air motors.

COURSE ON WELDED STRUCTURES.—The Quasi-Arc Company, Limited, Bilston, Staffordshire, have arranged two courses at their works on the design of welded structures, one a series of evening lectures and the other a full-time course lasting a week. The evening lectures, with practical demonstrations, are intended for draughtsmen and designers from the Midlands, and will be held on Tuesdays and Thursdays from February 19 to April 3. The week's course will commence on Monday, May 5, and will include, in addition to lectures, practical tuition in arc welding, visits to local engineering firms, and tours of the Quasi-Arc electrode factory, X-ray and testing laboratories, and manual and automatic arc-welding demonstration centres. It is intended primarily for designers and draughtsmen from outside the Midlands, and accommodation can be arranged by the Quasi-Arc Company. Application forms are available from the Constructional Design Department.

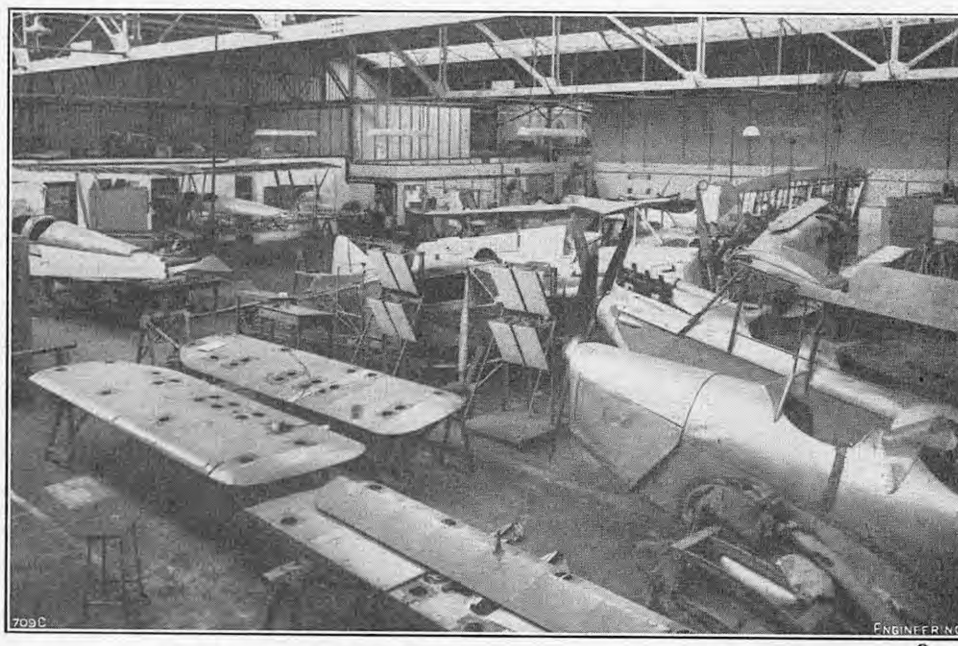


FIG. 3. PART OF THE MAIN HANGAR; REDHILL AERODROME.

THE COLLEGE OF AERONAUTICAL AND AUTOMOBILE ENGINEERING.

THE College of Aeronautical and Automobile Engineering, Sydney-street, Chelsea, London (which also gives training in agricultural engineering), was founded in 1924, and although aeronautics now take pride of place in the title, this department was not opened until 1931, the activities of the College, until then, having been concerned wholly with automobile engineering. It was the original intention of the founders to give those entering the automobile industry a basic training in all facets of automobile engineering, but with a distinct bias towards the practical side, and this principle has been maintained throughout the development of the College. Much the same principles were followed when the aeronautical courses were introduced, but owing to the difference between the curricula, it was only possible to use those shops dealing with basic subjects such as machining, fitting, welding, etc., for both courses, separate workshops being set up for the aeronautical side. As it was impracticable to instal complete aircraft in the buildings, a branch was established, first at Brooklands and later at Redhill aerodrome, where the College now have a hangar, as well as workshops, lecture rooms, etc.

In the course of time, various improvements and additions were made to the teaching facilities and by 1939 the college had built up a comprehensive range of well-equipped workshops. Unfortunately, the College buildings in Sydney-street were severely damaged during an air raid in 1940 and the authorities were forced, as a consequence, to transfer most of their activities to the residential hall at Wimbledon Park. When the time came to rebuild, the opportunity was taken to modify the layout so as to incorporate several improvements found desirable in the light of experience and at the same time to re-equip the workshops with modern machine tools, etc. The work of rehabilitation has now been completed and some of the new shops are illustrated in Figs. 4, 5 and 7, on page 208, Fig. 4 showing that used for giving instruction on in-line and turbo-jet aircraft engines, Fig. 5 part of the machine shop, and Fig. 7 the fitting shop for radial-type aircraft engines. These three shops are located in a new two-storey reinforced-concrete building erected on the site of the original premises, the ground floor being occupied by the machine shop and the fitting shop for radial engines and the upper floor by the other aero-engine shop; part of the upper floor, however, is set aside for lecture rooms. Several different types of radial and in-line engine are available and the instruction given on them includes methods of dismantling and reassembling the main and auxiliary units, visual and dimensional checking of the various components, alignment of connecting rods, truth of crankshafts, etc. Turbo-jet engines are also dealt with at length but instruction in this subject is not confined to the college as, once students reach the required standard, they attend a course at the School of Gas Turbine Technology operated by Power Jets (Research and Development), Limited. This course is designed specifically for the students and deals with propeller gas-turbines as well as pure turbo-jet engines, all aspects of the subject, such as testing, installation and maintenance, being covered.

To ease the task of the instructors, the machine shop is equipped with a number of screw-cutting lathes of exactly the same pattern, an arrangement which permits all students in a class to be employed on the same task simultaneously. Instruction, however, is not confined to the lathe as, although they are not visible in the illustration, the shop contains a variety of other machine tools, such as milling machines, shapers, slotters, etc. It should, perhaps, be mentioned that the instruction given in the machine shop is intended more to give the students an idea as to the capabilities of the various machines rather than make them skilled machinists. Considerable emphasis is placed, therefore, on teaching the broader aspects of the subject such as the cutting speeds and feeds permissible with the different materials and tool steels. Instruction in various measuring instruments is also given, with special reference to limits and fits.

The materials-testing laboratory is also located in the new building. The laboratory is particularly well fitted out, the equipment available including Denison, Avery and Buckton tensile-testing machines, an Izod impact tester, a Vickers hardness tester and various types of extensometer. Some of these can be seen in the photograph of the laboratory reproduced in Fig. 2, opposite. It has been approved by the Aeronautical Inspection Department of the Ministry of Supply, and by the Air Registration Board, for the testing of aeronautical metallic materials and is used extensively for carrying out tests on behalf of outside bodies, thereby adding greatly to the value of the instruction received by the students.

The other departments of the College include separate shops set aside for tuition in automobile-engine testing, transmission assemblies, electrical installations, and fitting-shop practice, to mention but a few. Although they are not housed in the new building, the opportunity was taken during the work of rehabilitation to bring the shops into line with modern practice and they have virtually been re-equipped. The automobile engine-testing shop is illustrated in Fig. 1, opposite. It is provided with two test beds, one of which is fitted with an A.E.C. 7·7-litre oil engine coupled to an air brake, and the other with an Alvis 3-litre petrol engine arranged to drive a hydraulic dynamometer, both installations being provided with instruments for full engine tests. Instruction is not limited to the determination of brake horse-powers and fuel consumptions, as the test beds are also used to demonstrate the effects of such variables as valve and ignition timing, injection pressures, choke diameters, etc. The Alvis engine is a particularly happy choice, as it is fitted with three carburettors and enables instruction to be given, therefore, in the "balancing" of these components. Adjacent to the engine test house is a separate room fitted out for overhauling and adjusting fuel-injection pumps and carburettors, the equipment provided including calibration gear for the former. After overhauling an injection pump, the student is able to test his work by installing the pump on the engine, learning at the same time the correct procedure for timing the pump and priming the fuel system.

The automobile transmission and chassis sections are located in the same building. A number of different car-type chassis have been installed in the chassis section and these are used for checking and correcting, where necessary, the alignment and for giving detailed instruction in the design and adjustment of the different types of brake-operating gear, shock absorbers, steering assemblies, independent front suspensions, etc. The transmission section is, of course, largely complementary to the chassis section and is equipped with representative examples of the various clutches, gearboxes, and final-drive assemblies found on modern vehicles. The College also maintains a separate service station where students who have passed through all the shops, and have reached the requisite standard, are employed in overhauling cars in conditions similar to those found in a modern repair depot. This forms a valuable department of the college, as here the student is taught to use his own judgment in estimating for repairs and assessing whether a component can be repaired or has to be renewed.

At Redhill aerodrome, where the instruction on complete aircraft and aircraft structures is given, students are able to work on a variety of light aircraft, such as the Puss Moth and Tiger Moth, still considered by most to be the best aircraft on which to give instruction in rigging. Other aircraft available include Miles Magisters and Falcons and Percival Proctors and Redwings, some of which can be seen in Fig. 3, opposite, which shows a general view of the hangar. The equipment provided includes woodworking and metal-working machinery and a wide variety of special hand tools. There is also a wind tunnel, a photograph of which is reproduced in Fig. 6, on page 208. It has a working section measuring 5 ft. by 4 ft. and is used for measuring the lift and drag of model aerofoils, the usual range of ancillary equipment, such as manometers, balances, venturi tubes, etc., being installed. The maximum rate of flow is 75 ft. per second, the fan being driven by a 45-h.p. Petters petrol engine, but it is intended to fit a larger engine in the near future. Recently, action was taken to form a flying club, so that students can be taught to handle light aircraft. This should form a most valuable adjunct to the College, as the students will be flying aircraft maintained by themselves, a circumstance likely to add greatly to the care with which the work is carried out.

It should not be inferred from the foregoing that instruction is confined to practical matters. As already mentioned, the curriculum for the automobile course is designed to meet the requirements of the motor industry and students taking the course attend a complete series of lectures on such subjects as workshop technology, engine design, motor-vehicle construction, applied electricity, etc. In the aeronautical course, which is designed to prepare students for Parts I and II of the Associate Fellowship examination of the Royal Aeronautical Society, lectures are given on pure mathematics, applied mathematics, heat engines, theory of machines, strength of materials, etc. Students do not necessarily take the Associate Fellowship examination, as the College issue their own diploma to those successfully completing the course. There are two diplomas, namely, engineering and design, and the course for the latter is arranged for those who wish, ultimately, to qualify for a post in the aircraft industry requiring a higher standard of theoretical knowledge; in general, it is the students who take this course who are prepared for the Associate Fellowship examination. Two classes of diploma are issued also for the automobile course, and the external examinations taken include the National Certificate, Sections A and B of the Associate Membership examination of the Institution of Mechanical Engineers, and part of the preliminary examinations of the Institute of the Motor Industry.

In view of the growing importance of agricultural engineering, the College opened recently the department for giving instruction in this subject. The training of an agricultural engineer is, of course, closely allied to that of an automobile engineer, and part of the course is conducted, therefore, in the automobile and general-engineering shops of the College. Practical instruction on agricultural machinery is given at the College premises at Redhill Aerodrome, where a selection of tractors and other equipment such as reaper-binders, combine harvesters, ploughs, mowers, etc., is maintained. Here, again, the theoretical side is not overlooked, and the course includes a series of lectures on crop husbandry, animal husbandry, soils and manures, etc. A portion of the final training period is spent with manufacturing firms and operators to obtain experience in the manufacture, operation and care of tractors and agricultural implements.

THE ENGINEERING OUTLOOK.

VII.—THE AIRCRAFT INDUSTRY.

THE burden of re-armament has fallen upon no industry more heavily than on that of aircraft production. The Air Estimates for 1951-52 provide for an expenditure of 328·75*l.* millions, which is 105·75*l.* millions more than in 1950-51. In the three years 1950-51 to 1953-54, Royal Air Force expenditure is to average 400*l.* millions a year and will account for more than a third of the total sum allocated to the forces for re-armament. The Secretary of State for Air announced in March that, by 1953-54, the Air Estimates were likely to be the largest single element in the defence budget, adding that there would be a useful addition to the United Kingdom's air strength in 1951, in 1952 "things will begin to happen on a big scale" and, when at its peak in 1953, the output of aircraft will be four times as great as in 1951. By August, 1951, orders exceeding 500*l.* millions had already been placed for aircraft and auxiliary equipment.

Employment figures provide the only indication of the progress made so far with the programme. From Table I, herewith, taken from the *Monthly Digest of Statistics*, it will be seen that the number employed in the manufacture and repair of aircraft increased by 19,300 (or 13 per cent.) to 168,200 between June, 1950, and October, 1951. The increase in the number employed in the manufacture of accessories for motor vehicles and aircraft, from 97,200 to 108,500, was also due largely to increased production for the aircraft industry. This rate of recruitment, however, is far from satisfactory. At the beginning of November, Air Chief Marshal Sir Guy Garrod estimated that the aircraft industry required 150,000 more workers in the following 18 months if the air re-armament programme was to be carried out. Sir Guy's estimate presumably includes recruitment for the manufacture of accessories; if so, it means that about five times as many are required as were recruited in the 16 months to October, 1951. There is, however, some hope that the necessary labour will be found if the rate of recruitment in September, when 5,000 were engaged, is sustained. For some companies, particularly those round London, labour is not a serious problem; but the dispersion of the aircraft industry throughout the country, the result of large-scale sub-contracting as well as tactical necessity, poses considerable problems in many areas. These are incapable of solution unless sufficient housing is provided. Moreover, in some areas two or more "essential" demands are in competition for labour —e.g., the Chorley Ordnance Works, A. V. Roe, Limited, and Leyland Motors, Limited.

TABLE I.—*Great Britain: Numbers Employed in the Manufacture and Repair of Aircraft (Thousands).*

——	Total.	Males.	Females.
1948—June	141·5	120·5	21·0
1949—June	148·0	126·7	21·3
December	149·2	127·2	22·0
1950—June	145·9	124·0	21·9
December	149·6	127·2	22·4
1951—January	153·1	130·0	23·1
February	155·3	131·7	23·6
March	156·6	132·9	23·7
April	157·9	133·9	24·0
May	158·3	134·1	24·2
June	159·1	134·7	24·4
July	160·0	135·5	24·5
August	161·9	137·0	24·9
September	165·2	139·5	25·7
October	168·2	141·7	26·5

Neither labour nor the industry can be considered at fault over the poor rate of recruitment. The Prime Minister, Mr. Churchill, has stated that aircraft production is suffering from "acute indigestion," but this is due very largely to the way in which it has been fed with orders by the Government. As recently as August, 1950, the industry was reducing its labour force. Some companies had only development orders for the Ministry of Supply or, at the best, small production orders for some types of civil aircraft, to help them to keep together a small nucleus of designers and skilled technicians—and even this was not always possible. A few companies only—Gloster Aircraft Company, Limited, de Havilland Aircraft Company, Limited, and Rolls-Royce, Limited—had significant orders, for Meteors, Vampires and engines, respectively. It was not until the need for rearmament became immediate and compelling that substantial orders were placed, and it is little wonder that the industry, with contracted capacity, has found it hard to cope with the flood which has poured upon it since then.

Labour is only one difficulty; it has been by no means easy to find the necessary machine tools or to co-ordinate their delivery with production plans. According to Sir Frank Spriggs, managing director of the Hawker Siddeley Group, his company alone are committed to an expenditure of over 30*l*. millions in machine tools and equipment; it is expected that the total assets (of both the Group and the Government) engaged in Hawker Siddeley's re-armament production will be 70*l*. millions. Orders placed by the Group for machine tools (many in the United States, mainly for milling and grinding machines, lathes and borers) amount to 24*l*. millions, and the remaining 6*l*. millions will be devoted to the construction of factory extensions and further research facilities. Mr. Churchill has promised that aircraft production shall have "first and special emphasis and priority" in tools and raw materials, but, even so, it will be difficult to guarantee deliveries on time. In some cases already, it has not been possible to keep up to schedule. The orders placed abroad, particularly in the United States, are causing some concern; the United States Government have accorded high priority to British requirements, but the machine-tool industry in that country has had difficulty in expanding production sufficiently to meet home orders for re-armament.

Some of the aircraft on order are well-established types such as the Gloster Meteor, the de Havilland Vampire and more recent Venom fighters, the Vickers Supermarine Attacker, and the Hawker Sea Hawk. Some bold decisions have been made, however, about putting into quantity production some new machines which have had less extensive proving, but which, according to the late Secretary of State for Air, represent "a really big advance on present types." The re-equipment of Royal Air Force fighter squadrons with jet aircraft is now practically complete. Fighter Command's day fighter force has already been doubled and is being doubled again. Some squadrons have had their first deliveries of the de Havilland Venom. Mr. W. E. Nixon, chairman of the de Havilland Group, pointed out in May, at the annual general meeting, that it was overseas demand which had made possible the development of the Venom. Contracts from a dozen countries for the Vampire enabled the company to maintain their production at a fairly high level and to undertake the further design and development work which eventually gave them the higher-powered Venom.

So far as bombers are concerned, the first squadron of the English Electric Company's Canberra type, the forerunner of a large light-bomber force, has already been formed. Heavier bomber squadrons are to retain their Avro Lincolns and Washingtons (B.29 Super Fortresses) but they are to be replaced eventually by long-range jet bombers, including the Vickers Valiant, the first British four-jet bomber, and other advanced types at present being developed. Among the advanced fighters in production is the Hawker P1067, ordered for the Royal Air Force "off the drawing board." This machine, the first fighter to be fitted with the Rolls-Royce Avon engine, has been described by Sir Frank Spriggs as "the best fighting aircraft flying anywhere in the world to-day" and by Mr. Arthur Henderson as "the fastest in the world." The long-standing rivalry between the makers of the Hurricane and the Spitfire is continued in the Supermarine Swift, another single-seater fighter fitted with the Avon engine, which is also to go into quantity production for the Royal Air Force. The Supermarine 508, claimed to be the fastest and most powerful naval fighter in the world, made its maiden flight at Boscombe Down on August 31. This fighter has two Avon jet engines, and, unlike the other new fighters about which information has been disclosed recently, does not have swept-back wings. It is unique in incorporating the so-called "butterfly" tail, not hitherto employed on high-performance aircraft. Still more recent developments are the Gloster GA5 and the de Havilland 110, the first to bear the official Air Ministry designation of "multi-purpose fighter."

The primary purpose of these fighter aircraft is understood to be defence against atom bombers, which, in normal circumstances, will fly singly without fighter protection, and at great heights. Interception aircraft would require great climbing power and, for this reason, both the new fighters are twin-engined. The GA5, fitted with two Armstrong-Siddeley Sapphire turbo-jet engines, is the first British Delta-winged fighter. The wings of the de Havilland 110, which has two Avon engines, though sharply swept back, do not quite constitute a "Delta." In spite of accidents and setbacks, it now seems likely that the Delta shape, which gives a strong and rigid structure particularly suitable for very high speeds, will be widely adopted for military aircraft. Three companies have designed research aircraft of this type, namely, A. V. Roe and Company, who have produced three versions of the Avro 707 (one of which has been destroyed in an accident); the Fairey Aviation Company (model F.D.1); and Boulton and Paul, Limited (model P.111).

Developments in bombers are as far-reaching as in fighters. An announcement of substantial production orders was made as soon as the Vickers Valiant, with four Avon engines, made its first flight in May. Sir John Slessor, Chief of the Air Staff, has claimed that these new heavy British bombers, armed with atomic bombs, would have a striking force "enormously superior to anything we knew six years ago." They are expensive aircraft, costing more than a destroyer did in the old days; "we shall never have very many in peace-time," Sir John said, "but what we lack in quantity we shall make up in quality." Another four-jet bomber of considerable promise is the Short SA4, which made its maiden flight in September. Like the Valiant, it has Avon engines. In the sphere of military transports a machine, the GAL60, has been developed by Blackburn and General Aircraft, Limited, which, with a wing span of 162 ft., two-thirds of that of the Brabazon, has carried a 22-ft. caravan—the largest cargo ever carried by a British aircraft. Powered by four Bristol Hercules engines, it can carry a load of 15 tons for 250 miles at a cruising speed of 185 m.p.h.

Among the airframe builders, the most orders seem to have gone to Vickers-Armstrongs Limited—even more than to the Hawker Siddeley Group—but every company has had its share. The Fairey Aviation, Company, have large orders for Fairey 17 anti-submarine aircraft; Percival Aircraft, Limited, for their new basic trainer, the P56; and Boulton Paul Aircraft, Limited, for their Balliol trainer, also being built by Blackburn and General Aircraft, Limited. Orders have not been confined to those companies who designed the aircraft required for the re-armament programme, but have been distributed as widely as possible throughout the industry, to make the best use of available capacity. The Canberra bomber, for example, is being built by Handley Page, Limited, A. V. Roe and Company, Limited, and Short Brothers and Harland, as well as by the English Electric Company. The de Havilland Venom is being built by the Bristol Aeroplane Company, and orders for the Gloster Meteor have been placed with other companies within the Hawker Siddeley Group.

Sub-contracting of parts of aircraft, including sections of wings, fuselage and other major components, is on a very large scale. It is estimated that about 80 manufacturers make equipment which eventually goes into the Meteor. Abundant factory space is available for the construction of airframes, but this is not so in the case of engines. The Select Committee on Estimates, which reported in May, expressed some concern that the production of engines might not remain "in phase" with the production of airframes. The engine required in greatest quantity is the Rolls-Royce Avon, though large orders have also been placed for the Armstrong-Siddeley Sapphire. There are still outstanding orders for the Rolls-Royce Derwent and Nene engines and for the de Havilland Goblin, fitted in the Meteor, Attacker and Vampire fighters, and the de Havilland Ghost engine is required in quantity for the Venom fighter.

The Avon is already in production at several Rolls-Royce factories, and the factory at Glasgow is being changed over from the production of piston-type engines to Avons. A new factory at East Kilbride, for the construction of which contracts valued at 2*l*. millions have been placed, is expected to be in production by the end of 1952. Other companies entrusted with production of the Avon are the Bristol Aeroplane Company, D. Napier and Son, Limited, and the Standard Motor Company. The Standard Company have acquired 500,000 sq. ft. of factory space at Liverpool, to which they are transferring their spares and service facilities to make room for the production of the Avon at Coventry. The Sapphire engine is being made at the Armstrong-Siddeley factory in Coventry, but a new company, Brockworth Engineering, Limited, has been formed by the Hawker-Siddeley Group to undertake its production at Hucclecote, Gloucestershire. Three-quarters of the floor space of the factory of Hawksley Constructions, Limited, a subsidiary of the Group which has been building prefabricated houses, has been taken over. Planning and layout work began in June, and in September Mr. H. Burroughes, a director of the Group, said that the first Sapphire would "soon" come off the production line, provided that the necessary deliveries of machine tools were forthcoming. Major Frank B. Halford, chairman of the de Havilland Engine Company, has stated that production of de Havilland engines has been "increasing, indeed multiplying, against a widespread demand over a period of three or four years preceding the time when full-scale re-armament was decided upon in this country." Since then, the company "have been called on to organise a very much greater expansion and a much accelerated rise in output."

It will be two years before all the new factories, planned or under construction, attain peak production. The provision of new capacity is only one of the problems in the manufacture of jet engines; a major difficulty arises over the supply of turbine blades. The axial compressers of the newer engines require about 1,500 to 2,000 blades per engine, and the total requirements of these blades, which, according to *The Economist*, may prove to be the worst bottleneck in the whole re-armament programme, may easily be a million a month. In the Rolls-Royce engines, these blades are made of light alloys and, in other types, of stainless steel. The complicated aerofoil shapes can be formed to the required degree of accuracy by die-stamping, but, in the case of the light-alloy blades, the life of each set of dies is only about 1,500 to 1,800 blades. With stainless-steel blades, the life of a set of dies may not be more than 300 blades. Several other methods of producing the blades in quantity have been tried, without much success so far, and a high-speed machine tool for machining rough forgings is to be tried out in the spring in the United States. Neither the Ministry of Supply nor the engine manufacturers have expressed much anxiety over the supply of blades, and yet, according to *The Economist*, "probably the only concern with a real prospect of receiving blade deliveries in time is Rolls-Royce, Limited, simply because that company was able to place its orders ahead of the others." The engine manufacturers are not likely to be able to produce more than half the blades they require, and providing factory space for subcontractors is a serious enough problem in itself. A solution to the technical difficulties might be the acceptance of lower tolerances. It is obviously undesirable to accept lower engine performances than necessary, but it seems reasonable to plead, as *The Economist* does, for closer co-operation between the Services, the engine designers and the blade production specialists to see whether standards and quantities have been set too high and whether the aircraft programme can still be realised by technical collaboration at all levels.

On the design side, further progress was made with turbine engines in 1951. Two new types released from the secret list were the Nomad NNm3, made by D. Napier and Son, Limited, and the Olympus of the Bristol Aeroplane Company. The latter has been described by Sir W. G. Verdon Smith as a "large turbo-jet with an extremely low fuel consumption, which is destined to have an important place in both civil and military aviation." The Nomad is the first British composite engine, a combination of a piston engine and a turbine connected to an airscrew. The airscrew, it is clear, is by no means outmoded; British designers have evolved airscrews of new shapes and construction which are capable of transmitting the full power of the latest gas turbines. Messrs. de Havilland Propellers, Limited, have on test an eight-bladed contra-rotating airscrew which will give the same thrust at take-off as the four turbo-jet engines of the Comet. Another innovation in aircraft propulsion in 1951 was the Snarler rocket motor developed by Armstrong-Siddeley Motors, Limited, as an auxiliary to a jet engine; this, it is claimed, can double the power of the fastest jet fighter for short periods at high altitudes.

The re-armament programme and the production of military aircraft for export have inevitably interfered with the output of civilian aircraft. From Table II, herewith, taken from the *Monthly Digest of Statistics*, it appears that, between January and November, 1951, only two aircraft were produced for civil aviation at home. The development of some new types, including the Armstrong-Whitworth Apollo, has had to be slowed down. It will be unfortunate indeed if British manufacturers of civil aircraft are unable, because of production difficulties, to exploit to the full the large market for civil air liners which their lead in jet aircraft has secured for them. The foreign survey group of the United States Civil Aeronautics Board's advisory committee has recently reported that British experience in civil transport with gas turbines "gives them an advantage of three to five years at the present time," and that the impact of the British lead will be felt by the United States international operators during 1952. The price paid for the lead in terms of development expenditure was estimated by the Americans as 140*l*. millions. It was not thought that the United States had lost "an irretrievable amount" in competitive position, provided that urgent steps were taken to proceed with intensive testing of available turbine-engined aircraft in order to obtain design, operating, airway and airport data, and to start the development of advanced types. At present, only two United States companies have jet airliners even at the drawing-board stage. The Lockheed Aircraft Corporation have a design for a 64-passenger type, to have four engines with a total of 12,200 lb. thrust, still not built; and the Boeing Aircraft Company have a design based upon the six-engined B47 bomber.

The British Overseas Airways Corporation are now receiving delivery of the Comet, and the first British jet airliner will be going into regular service on the Commonwealth routes early this year. Route-proving tours by the second prototype on loan to the B.O.A.C. have already established the success of the aircraft, a typical performance of which was the trip to Johannesburg in July in $17\frac{1}{2}$ hours flying time at an average speed of 422 m.p.h. A Series 2 Comet has now been developed, with Avon instead of Ghost engines, and five of these will be delivered to B.O.A.C. as part of their order for 14 Comets. Sir Miles Thomas, the chairman of B.O.A.C., has said that the vision and skill of British engineers in producing the pure jet and turbo-propeller power plants for the Comet and the Bristol 175 will enable the Corporation to operate within a few years two all-British round-the-world routes, one encircling the Northern Hemisphere and the other the Southern. The Bristol 175 (Britannia), 26 of which are on order, is due to fly in the summer. Powered by four Bristol Proteus engines, it is expected to achieve an exceptionally high "revenue index" with a payload of 25,000 lb., which it can carry for 4,000 miles at a mean cruising speed of 360 m.p.h. The smaller Handley Page Hermes V, with Theseus engines, has already had many hours' flying time and can carry a payload of 14,000 lb. for 3,000 miles at 390 m.p.h. The Vickers-Armstrong Viscount, with four Rolls-Royce Dart engines, is even farther advanced; the type 701, on order for British European Airways, is to carry 40 to 48 passengers.

TABLE II.—*United Kingdom: Deliveries of Aircraft.**

—	Total.	For Export.	Total.	For Export.
	Number.		Index of Air-frame Structure Weight.†	
Annual totals:—				
1948	444	311	75‡	50‡
1949	452	418	85‡	75‡
1950	517	478	85‡	55‡
Monthly:—				
1950—October ..	39	35	85	40
November ..	36	35	50	35
December ..	25	24	40	30
1951—January ..	68	67	115	100
February ..	35	35	45	45
March	38	37	75	65
April	45	45	45	45
May	56	56	85	85
June	59	59	95	95
July	32	32	45	45
August ..	30	30	65	65
September ..	41	41	50	50
October ..	46	46	55	55
November ..	49	49	65	65

* The figures exclude aircraft of military type, except those produced for export.

† The monthly average of deliveries (home and export combined) in 1946 is taken as 100; this applies both to the index of total deliveries and to the index of export deliveries.

‡ Monthly average.

TABLE III.—UNITED KINGDOM: EXPORTS OF AIRCRAFT AND PARTS.

—	Number.			Value (1,000*l*.)			
	1948.	1949.	1950.	1948.	1949.	1950.	1951.
Complete aircraft	1,123	1,248	852	14,313	19,947	14,079	—
Engines for aircraft	1,363	1,674	1,708	3,238	4,977	5,245	—
Rubber tyres	16,448	18,874	20,778	183	239	298	—
Other	—	—	—	8,270	9,055	14,654	—
Total	—	—	—	26,004	34,218	34,276	41,599

The development of jet airliners was a joint gamble of the Government and the British aircraft industry and is likely to bring handsome returns, though it is by no means certain that enough will be realised from sales of Comets to cover the development expenditure. The Minister of Supply announced in July, however, that it was hoped to recover the whole or a substantial part of his department's expenditure of 1·5*l*. millions on the development of the airframes.

A gamble which did not come off was the costly experiment with very large aircraft. British European Airways have suggested that it might be possible to use the completed Brabazon profitably on the London and Paris route in the busy season, but even this would involve difficulties. Reports that the Bristol Aeroplane Company have been ordered to stop work on the second Brabazon, with Proteus turbo-propeller engines, have not been confirmed officially, but may not be without foundation. The Britannia already incorporates most of the experience gained from the Brabazons and the labour at present engaged upon the Brabazon II could usefully be employed by the Bristol Company on re-armament work. The first of the three Saunders-Roe Princess flying boats is to start flight trials in the spring, the others following at intervals of six months. Since no profitable commercial use can be found for these aircraft, they are now to be used as troop carriers. Each will be able to convey 200 men non-stop for a distance of 3,500 miles.

In the export field, British makers of aircraft had a record year in 1951; as will be seen from Table III, herewith, taken from the *Trade and Navigation Accounts*, exports, valued at 41·6*l*. millions, were 7·3*l*. higher than in 1950. These exports include a high proportion of military aircraft, but there are now important orders for civil types. Air France, who recently ordered two Comets (Series I) for their associate company operating the Paris-Saigon service, have since placed an order for three more and are considering further orders. Earlier in 1951, Air France had ordered 12 Vickers Viscounts, with Dart engines; these are to be delivered in 1953 and 1954. American airlines are also interested in the Comet. Mr. W. T. Gill, the President of the Society of British Aircraft Constructors, said in September that several American airlines are prepared to buy Comets, but only if they can be supplied by the dates when makers in the United States are prepared to guarantee deliveries of piston-engined types. Whether or not British manufacturers will be able to tap this large potential market will depend upon the priority in men and materials which the Government are prepared to grant to production of the Comet. Other civil aircraft for which there are important overseas orders include the Percival Prince twin-engined feeder liner. The Government of Tanganyika have ordered two for aerial survey work; the Shell Petroleum Company have ordered several, equipped to carry 8 to 10 passengers, for oilfield communications; and Brazilian airlines, some for feeder lines in the State of Maranhao, in Northern Brazil. Bristol freighters are in demand for commercial flying as well as military purposes. These are now in service with B.O.A.C. and British European Airways, and an order for six, valued at 500,000*l*., has been placed recently by Silver City Airways. As a military aircraft, it is operated by the Royal Air Force, the Royal Australian and the Royal New Zealand Air Forces, and recently a number have been ordered by the Royal Canadian Air Force.

Just as important from the revenue point of view are the royalties received from the manufacture under licence of British aircraft and engines overseas. In the United States, the Glenn L. Martin Company are building the Canberra B.2 bomber, which is replacing the American B.45 jet bomber. Pratt and Whitney Aircraft, Incorporated, are building the Tay turbo-jet engine, which is being fitted to the Grumman Panther, the North American F.93A Sabre and the Lockheed F94C. The same company are building the Nene turbo-jet engine, fitted to another version of the Panther. The Bristol Olympus is also being built in the United States, as well as several Armstrong-Siddeley engines, including the Sapphire, Mamba and Double Mamba. In Canada, the Avon engine is already being produced, and it was announced recently that the production of the Nene engines is to be put in hand at Montreal, where Canadair, Limited, are building Sabre fighters for the Royal Canadian Air Force at the rate of 20 a month. Vampire fighters are being constructed in Australia, France, Italy and Switzerland, Meteors in Belgium and the Netherlands, and the Canberra bomber (together with Avon engines) in Australia, as well as in the United States. Nene engines are being built in Australia and in France, where the Rolls-Royce Tay is being fitted to fighters of French manufacture. Ghost engines are being made in Italy, Sweden and Switzerland, and Derwent engines in Argentina for installation in the Argentinian Pulque fighters. Apart from licensing, some income is being obtained from the use of British patents overseas, but this is not very considerable. After protracted negotiations, an agreement has been reached with the United States Government covering the use of more than 200 British gas-turbine patents over the next 20 years. The sum of 1·43*l*. millions is to be paid in full settlement of all claims.

The production of aircraft for re-armament in the United States has been lagging behind schedule. At the end of 1951, it was at the rate of only 6,000 aircraft a year, compared with a peak of 96,318 during the war. The eventual aim is to produce 10,000 aircraft and 196,000 jet engines a year, which, according to the Munitions Board, will cost the Government 40,000 million dollars a year. The capital outlay needed to expand capacity is estimated at 4,000 million dollars. Floor space for the manufacture of aircraft has already doubled, but, as in the United Kingdom, there have been difficulties over the supply of machine tools and labour. Unless, in fact, larger cuts than at present are made in the production of cars, refrigerators and washing machines, it is doubtful whether the planned production can be achieved. On the other side of the Iron Curtain, high priority is also being given to the production of aircraft. William Green and Derek Wood, in a booklet on *Russia's Jets and other Aircraft*, state that the Soviet aircraft industry is the largest in the world; the annual output of aircraft of all types is estimated at 8,000 to 9,000. Moreover, the quality of the Soviet aircraft, and the capability of their designers should not be underestimated. Much assistance has been obtained from German equipment, research and technicians.

There can be no question about the quality and performance of British aircraft, both civil and military, which are second to none in the world and, in many cases, are much in advance of contemporary foreign types. There are, unfortunately, still many difficulties to be overcome before they can be produced in sufficient quantity to give Britain security in the air or to capture the export markets for civil airliners. Given full assistance from the Government, however, the industry may be expected to fulfil with credit its arduous dual role.

THE IRONFOUNDRY INDUSTRY.*

SOME confusion of thought exists among the public regarding the title of "The British Iron and Steel Federation" as it is thought that this body represents all the iron interests, including the foundries making cast-iron products. This is not the case, as the Council of Ironfoundry Associations is an entirely separate body with no affiliations whatsoever to the British Iron and Steel Federation. The "Iron" referred to in that title does not include the cast-iron industry; only iron for steelmaking.

A number of statements have appeared in the Press regarding the failure of the steel industry to reach its target of 16 million tons in 1951. In practically every instance, the iron foundries have been blamed for this failure, on the ground that they used more than their fair share of raw materials (pig iron and scrap). The British Broadcasting Corporation, on January 25, broadcast a statement from the British Iron and Steel Federation, when a similar charge was repeated, together with a suggestion that it would be reasonable to limit iron-foundry output to the 1950 level of 3½ million tons (the output for 1951 is expected to be at the annual rate of 3¾ million tons). The Council of Ironfoundry Associations replied to this statement on January 26, pointing out that, in 1951, ironfounders' stocks were reduced by 180,000 tons of pig iron, and foundries were now working on a hand-to-mouth basis. The iron foundries denied the right of another industry, i.e., the British Iron and Steel Federation, to define, or attempt to define, the rate of their expansion, and so interfere with their responsibility to industry and the general public.

During 1951, the import of scrap into this country for steelmaking fell by 1,340,000 tons, compared with the previous year. If this figure is compared with the extra amount of both pig iron and scrap used by the iron foundries during that year (237,000 tons), it is seen that the failure of the steel industry to reach its target is principally due to the shortage of foreign scrap, and not, as alleged, to the increase in the amount of iron used by the foundry industry, which amounts to only one-sixth of the decline in imported scrap. Statements in the Press have failed to draw attention to this position; nor has any reference been made to the large reduction in the iron foundries' stocks of pig iron (180,000 tons)—a considerable figure when set against the estimated output of 3¾ million tons.

The most objectionable feature of the attack on the iron industry from the national point of view has been the suggestion that (because sheet steel is much lighter than iron castings) it was much more wasteful in the use of pig iron and scrap than the steel industry. The instances quoted include baths, rainwater pipes, gutters and manhole covers. For example: in the case of rainwater and soil pipes and gutters, of which 103,000 tons were made in 1950, there is at present a prohibition on galvanising owing to the world shortage of zinc. As regards enamelling, we know of no available capacity in this country for processing 25 million pieces of these goods, a large proportion of which are 6 ft. in length. Pressed-steel baths were produced in this country in the early post-war years, but production was discontinued some two years ago because public demand proved that the cast-iron bath is far more satisfactory both for the home and export markets; over 125,000 cast-iron porcelain-enamelled baths were exported in 1951, approximately 25 per cent. of the total production. Any attempt to substitute sheet steel would certainly endanger goodwill in the export markets.

Apart altogether from these technical reasons, we are convinced that an attempt to substitute steel sheet for iron castings on any scale—and, to be effective, it would have to be on a large scale—would cause acute dislocation in both the sheet-fabricating industry and iron-foundry industry, to say nothing of the engineering problems which would have to be solved first. Moreover, the Chancellor of the Exchequer has made it clear that the use of steel in this country is to be drastically restricted; in view of this decision, it is difficult to see how these suggestions for substitution could be carried into effect.

Our case rests mainly on the fact that the small expansion which has taken place in the last two or three years is due mainly to increased demand for cast-iron products for the housing programme, railways, machine tools, textile machinery, the motor industry, and agricultural implements. Ingot moulds for the steel industry take over 9 per cent. of the total output. It is no exaggeration to say that, taking into consideration the difference in our size compared with the steel industry, the service we are rendering to industry generally is equally important. By scientific research and exact control, the ironfounder can make a cast iron to-day almost three times as strong as the material produced 25 years ago. At the same time, the actual amount of iron used in the various products has been considerably reduced as a result of improved design and production technique. As an example, 20 lb. of metal has been saved on the weight of a cast-iron bath.

It has been stated that most countries use less of iron castings in proportion to steel sheet than we do, and this fact is being used against the iron foundries to prove that their expansion is against this trend, and, consequently, is made at the expense of the steel industry. In the case of Europe, building standards generally are much lower than in this country. The bigger ratio of iron to steel used in this country as compared with America is influenced by a number of varying conditions, one of which is the difference in manufacturing techniques. America, because of mass demand, can afford the initial high cost of dies for steel stampings and forgings, from which they produce in great quantity. In Britain, where the number of such products required is much smaller, it is more economical and practical to produce iron castings.

The above statement was accompanied by a table showing the amount and distribution of the output of the iron foundries. This table, slightly abridged, is reproduced herewith.

PRODUCTION AND CONSUMPTION OF GREY IRON AND MALLEABLE IRON CASTINGS, 1948–1951.

Year.	1948.		1949.		1950.		1951 (nine months).	
Total of Production, Tons.	3,283,901		3,388,121		3,486,892		2,782,977	
Malleable Cast Iron Only, Tons.	125,119		120,447		129,511		106,229	
	Tons.	Per Cent. of Total.	Tons.	Per Cent. of Total.	Tons.	Per Cent. of Total.	Tons.	Per Cent. of Total.
Main fields of consumption:—								
Building and municipal (pipes, gutters, manhole covers, baths, sanitary goods)	206,205	6·28	236,275	6·97	255,671	7·33	192,137	6·90
Cooking and heating apparatus, including radiators ..	207,843	6·32	207,591	6·12	227,829	6·53	184,036	6·61
Other domestic appliances ..	15,573	0·47	12,801	0·37	15,322	0·44	12,465	0·44
Pipes and fittings for gas, water, sewage, etc. ..	491,714	14·97	545,253	16·09	572,197	13·54	439,813	15·70
Coal-mining, quarry, clay and cement plant ..	63,473	1·93	61,962	1·82	56,204	1·61	45,167	1·62
Gas production ..	33,227	1·01	34,284	1·01	34,587	0·99	25,779	0·92
Electricity generation and distribution ..	98,015	2·98	100,387	2·96	95,060	2·72	80,911	2·90
Motor-car and cycle industry ..	214,523	6·53	215,748	6·36	269,726	7·73	217,348	7·84
Railway equipment ..	316,405	9·63	321,799	9·49	277,645	7·96	244,297	8·77
Shipbuilding and docks ..	120,925	3·68	115,053	3·39	102,878	2·95	80,472	2·92
Prime movers (turbines, engines) for land use, and transmission machinery	92,852	2·82	102,439	3·02	115,540	3·31	96,221	3·09
Boiler-house plant for industry, etc. ..	72,880	2·21	74,687	2·20	72,911	2·09	55,709	2·00
Agriculture and food-processing ..	194,805	5·93	178,033	5·25	198,342	5·69	160,918	5·78
Machine tools ..	175,575	5·34	179,813	5·37	180,257	5·16	148,916	5·35
Textile machinery ..	157,890	4·80	146,845	4·33	134,165	3·87	107,535	3·89
Valves, pumps and compressors ..	46,391	1·41	60,623	1·78	70,731	2·02	59,511	2·13
Chemical plant ..	24,502	0·74	26,865	0·79	27,367	0·78	19,730	0·70
Ingot moulds for steel and non-ferrous metal manufacture ..	302,580	9·21	318,339	9·39	321,647	9·22	251,050	9·02
Iron and steel works plant, and rolls for mills ..	88,097	2·68	135,092	3·98	131,584	3·77	100,039	3·59
Cranes and conveyors, transport, etc. ..	32,587	0·99	34,465	1·01	36,302	1·04	27,653	0·99
Printing and paper machinery ..	22,074	0·67	23,151	0·68	29,006	0·86	23,398	0·84
Balance (general engineering and jobbing castings) ..	259,304	7·89	256,616	7·86	261,928	7·51	204,862	7·36
Steel output ..	14,877,000 tons		15,553,000 tons		16,293,000 tons		12 months ending 31.12.51 15,638,000 tons	
Total labour engaged in ironfounding (operatives, clerical and management) at end of year; and output per head, tons	149,981 = 21·898 tons per man-year		146,211 = 23·172 tons per man-year		150,329 = 23·195 tons per man-year		151,919	

* Statement issued by the Council of Ironfoundry Associations. Abridged.

INSTRUCTIONAL FILMS FOR RAILWAY STAFF.

A SERIES of instructional 16-mm. films for demonstrating to the permanent-way staff of British Railways the best methods of carrying out track-maintenance work with the modern equipment at their disposal is being produced for the Railway Executive by the Films Section of the British Transport Commission. It is intended to show the films to railway engineering staff throughout the country during the comin year, and, to cater for out-lying districts, 60-seat travelling cinema coaches, equipped with generators, will be used. Technical instructors will supervise the performance and answer questions.

The first five films to be completed were shown recently to the technical Press. Two of the films, "The Hallade Track Recorder" and "A Mechanical Rail Creep Adjuster," were made by World Wide Pictures, in association with British Transport Films, the other three being made entirely by the latter organisation. "The Hallade Track Recorder" is intended to explain to lengthmen and gangers the operation of the Hallade track-recording instrument, which provides a continuous record of the vertical, sideways and fore-and-aft accelerations of a train during a journey, and thus reveals bad stretches of track requiring maintenance. "A Mechanical Rail Creep Adjuster" shows in detail how to adjust a section of line, in which some of the expansion gaps have closed up and others have opened out, by a horizontal screw-jack mechanism, known as the creep adjuster, which can be attached to the rail at a joint and which can pull or push up to ¼ mile of track. Two of the remaining three films dealt with day-to-day track maintenance on plain line, and on switches and crossings, for both bull-headed and flat-bottomed track. The last film showed how track buckling could be caused by rail creep, by seized fish-plates, or by lack of ballast or bad sleeper packing, and demonstrated the measures to be taken to prevent its occurrence.

It is intended to produce instructional films for other sections of the railway staff, and such subjects as locomotive fuel efficiency, the use of Pallets and fork-lift trucks for loading, and signal maintenance are under consideration. The films, which are excellently produced and may be expected to stimulate the interest of the men who see them in their work, are also available to approved bodies as, for example, technical schools. Further particulars may be obtained from the Public Relations Officer, Railway Executive, 222, Marylebone-road, London, N.W.1.

DIESEL RAILCARS IN NORWAY.

DIESEL RAILCARS ON NORWEGIAN STATE RAILWAYS.

THE Diesel railcar train set illustrated above is one of four, each consisting of two driving cars with a "trailing car" between them, which are used by the Norwegian State Railways on the Oslo-Bergen and Oslo-Trondhjem routes. They were ordered in 1939 from Strömmens Vaerksted A/S, Oslo, but the first driving car was not completed until 1945. Meanwhile, the oil engines, due to prolonged storage, had deteriorated, and as there was also a difficulty in obtaining spare parts, an order was placed with Messrs. Davey, Paxman and Company, Limited, Colchester, for six of their 12 RPHL engines, of which four were to be fitted in two trains, one fitted into a spare bogie and the fourth held in stock. This is the first application of this type of engine to railcars—a duty to which it is well suited on account of its compact size. The cylinders, with a bore of 7 in. and a piston stroke of 7¾ in., are arranged in a 60-deg. V, and the engine develops 500 brake horse-power at 1,250 r.p.m. on the B.S. 12-hour rating.

The total weight of each train in running order, but without passengers, is 113½ tons, comprising 42½ tons for each driving car and 28¼ tons for the trailing car. Seats are provided for 155 passengers. The distance between Oslo and Bergen is 306 miles, and between Oslo and Trondhjem 345 miles. The journeys take about 8 or 9 hours by day, compared with about 12 hours for a sleeping-car train hauled by a steam locomotive. Diesel railcars are particularly suitable for this class of traffic, where a high-speed service is desired between large towns, the line running between sparsely-populated mountainous country where the traffic density is not high enough to warrant electrification.

The Paxman engine is mounted on the four-wheeled bogie, and the drive is through a hydraulic torque converter of the Voith T 45 MZ type. The converter is also carried on the bogie, on three trunnions, and it consists of four converter stages. The construction of Voith units of this type was described in ENGINEERING, vol. 171, page 720 (1951). Power is transmitted from the engine through a Layrub shaft and step-up gearing to the primary elements of the converters, and from the secondary, or output, elements, through a final-drive shaft and Hardy-Spicer propeller shafts to the leading and trailing axles. The fluid circuits are filled by a pump driven from the input shaft, the converters being engaged successively to suit the speed of the railcar. At speeds up to 60 km. per hour both the trailing and leading axles are driven by two of the converters, thus obtaining the maximum tractive effort for starting and low speeds, but when that speed is reached a governor-controlled valve automatically empties the two converters and fills the third one, which drives the leading axle only at speeds up to 90 km. per hour. From 90 to 120 km. per hour—a range seldom used, owing to the severe curves and gradients of the lines—the fourth stage of the converter comes into operation.

The engines are mounted on fabricated steel cradles, which are suspended on three trunnions in spherical housings, by which means the crankcases are insulated from possible frame flexure of the bogies. The converter is contained within the bogie frames, but the engine projects above the bogie through an aperture in the coach floor, over which is mounted a housing constructed of removable light-alloy panels. Engine inspection and maintenance may thus be carried out *in situ*; it is possible to remove the cylinder heads, and to dismantle the piston and connecting-rod assemblies, which are taken out of the engine by passing them through the crankcase doors, without removing the engine from the bogie or lifting the car. The loss of about 20 sq. ft. of floor space is therefore compensated by ready accessibility; nevertheless, in the event of a major overhaul of the power equipment, the car body can be lifted and a defective bogie replaced by maintenance staff in under four hours.

Each engine is controlled by electro-mechanical means, comprising a small motor which drives a worm-wheel geared to a quadrant and linkage to the standard Paxman hydraulic servo-governor. There are five power notches on the driver's controller, giving speeds of 900, 1,000, 1,100, 1,200 and 1,250 r.p.m., and the idling speed is set at 500 r.p.m. The driver's station is at the leading end of the power car, his seat being immediately in front of the engine housing. Driver's controls include the usual power controller with reverser, brake valve, sander, horn and light switches.

The speed and cooling-water temperature of both engines are indicated at each driving position. Electrical services in the train operate on 110-volt direct-current, supplied by batteries which are charged by a 7·5-kW generator driven from the primary side of the torque converter and mounted on the bogie. Each engine is started by a C.A.V. motor, wound for 110 volts and controlled by a relay switch. A motor-driven lubricating-oil priming pump is carried on the engine cradle and serves to feed lubricant to the engine bearings before motoring. On the first two bogies this pump also circulates oil through a radiator and back to the sump, after engine starting, the changeover from the priming to the cooling circuit being made by a magnetic valve. Later, bogies will be fitted with a water/oil heat exchanger in the main oil-pressure feed piping and the long external cooling circuit will be eliminated; this modification will then permit all four sections of the radiator to be used at maximum efficiency for water cooling.

This is effected by a radiator mounted below the car body between the bogies, and comprising four panels through which air is drawn by fans. Temperature control is obtained by a clutch in the fan drive and by shutters actuated by compressed air under thermostatic control. The fans are driven by a cardan shaft from the torque converter. Water is circulated by a centrifugal pump mounted on the cradle and V-belt driven from the free end of the engine crankshaft. The pump takes its supply from an expansion tank in the driver's compartment. On delivery from the engine outlet manifolds, the coolant is fed to the torque-converter coolers; thence to a thermostatic by-pass valve, and so back to the expansion tank at temperatures up to 65 deg. C., or to the radiator at higher temperatures.

The initial installation of the Paxman engines was undertaken by Messrs. Strömmens Vaerksted A/S. in their works at Strömmen, near Oslo, and subsequent modification and the erection of the remaining engines in their bogies have been undertaken by the Norwegian State Railways in their maintenance shops at Lodalen, Oslo. Here there is a modern well-equipped building which accommodates four complete three-car trains on adjacent tracks, and also provides workshop, office and living accommodation for the staff. The tracks are raised above floor-level and provided with illuminated inspection pits, and the shops have adequate head-room and lifting capacity.

NOISE IN PRIVATE CARS.*

By J. R. BRISTOW, B.Sc., Ph.D., A.M.I.Mech.E.

THE generally accepted definition of noise is that it is any unwanted sound; and in this paper it is proposed to use the term noisiness to cover the whole of the subjective impression of noisiness due to noise-level and annoyance, as experienced by driver or passengers in a car travelling on the road. The noisiness of a vehicle is, of course, purely subjective, for not only does it depend on the ear response of the "observer" and his psychological state at the time, but, also, on his preference; those who can afford to will pay heavily for comfort, including quietness. The sports car enthusiast, on the other hand, is most happy when he can hear plenty of wind and exhaust noises.

Noisiness being purely subjective, its evaluation subjectively would seem, at first sight, the correct line of approach. However, this has several disadvantages, namely: a large number of observers are required to obtain a consensus of opinion; only comparison between vehicles run at virtually the same time under identical conditions is possible as, unless the noisiness between vehicles is very dissimilar, any appreciable time interval makes subjective comparison quite impossible; a subjective estimate cannot be expressed in explicit terms, so that comparison of various cars over periods of months, or years, is out of the question; and if a thorough comparison of several cars over a speed range is carried out, with a number of observers, the time necessary becomes quite prohibitive.

It may be thought that these difficulties can be overcome by recording the noise and reproducing it aurally to a panel of observers. However, loud-speaker response and room acoustics make the realistic reproduction of vehicle noise exceedingly difficult. At first sight, in view of the undoubted pleasure given by wireless transmissions and the playing of recorded music, this apparently is not so, but, in actual fact, the fidelity generally of recordings, wireless transmissions and reproduction leave much to be desired. Indeed, lack of fidelity of acoustic reproduction is most marked just where, for the reproduction of vehicle noise, fidelity is most needed, namely, at low frequencies, the most intense part of vehicle noise being generally in and around the 50 cycles per second region, whereas for speech and music the mid-frequency regions are of greater importance. From a practical viewpoint it is necessary to turn to objective measurements and face the attendant difficulties of interpreting such measurements in terms of subjective impressions.

There are two physical quantities associated with noise which can be objectively determined, namely, energy, or some quantity directly related to it, and frequency; and any noise will be physically and objectively defined if the energy-spectrum is known. It is, therefore, almost axiomatic that overall noise-level, that is, the summation of noise energy over the whole frequency range, as determined by simple noisemeters, can give but very limited information, since it takes no account of how the energy is distributed with frequency; moreover, ear response is not only very non-linear with reference to frequency, but also follows a logarithmic law with reference to loudness, it being a general physiological law—within certain limits—that sensation is a logarithmic function of the stimulus. It is, of course, because of this latter ear characteristic that noise-levels are compared in decibels. The decibel is a particularly suitable unit for this work since it corresponds to the minimum change in noise intensity perceptible by most people in the middle frequency range. It is not practically possible, therefore, in an instrument—except in very limited circumstances—to correct effectively, for ear response, the summation giving overall noise-level. Although certain noisemeters contain one or more weighting networks to correspond with the Fletcher-Munson curves for ear response at one or more loudness levels, it must be remembered that these curves are for single pure tones, and make no allowance for variation of annoyance with frequency, or for the masking effects of the lower frequency ranges over the mid-frequency and upper-frequency ranges. Indeed, the employment of weighting networks is generally more misleading than helpful. It is, in fact, common experience that the noise-level in a vehicle cannot be expressed satisfactorily by the single magnitude overall noise-level.

If then it is necessary to determine the noise energy-spectrum, thoughts turn to sharply-tuned analysers of the heterodyne or degenerative feed-back type which will, in theory, allow the energy-spectrum to be determined most accurately; indeed, for analysing noise of a well-defined energy-spectrum which mainly consists of a series of sharp and related frequencies, such as gear noise, such analysers are of great value. However, the noise in vehicles on the road is found to be so heterogeneous and wildly fluctuating that a sharply-

* Paper presented at a meeting of the Automobile Division of the Institution of Mechanical Engineers, held in London on Tuesday, February 12, 1952. Abridged.

tuned analyser is quite useless, indicating a continuous and very violently fluctuating spectrum, except perhaps for some indication of two or three discrete frequencies in the 50-200 cycles per second region. It is for this reason also that waveforms are not very useful as they show only signs of two or three definite frequencies in the low-frequency regions. A compromise, therefore, is needed between instruments giving overall noise-level and sharply tuned analysers, and this is found in instruments that measure noise-level in bands. Several types of instrument are available which split up the aural spectrum in various ways, the commonest method being into octave-bands. Measurements with such equipment do not define the energy-spectrum of a noise absolutely, but give a mean or " smoothed " spectrum which is, in fact, an advantage when the noise is continuously fluctuating as in a vehicle on the road.

The energy-spectrum of a noise, or, as it may be termed, the noise-spectrum, having been determined, the problem of its subjective interpretation must not be under estimated. Subjectively, sound has associated with it the qualities of loudness, pitch, quality, and annoyance. Loudness depends on the physical quantity sound-pressure, or intensity, measured in decibels, but it is also a function of pitch and quality. Pitch depends on the frequency, but also, to a minor extent, on the loudness and quality. Quality, in turn, depends mainly on the frequency spectrum and phase relationships of the components ; in fact, on the wave shape, and to some extent on the loudness. Annoyance depends on the three characteristics mentioned and also on the occasion and meaning of the sound and on the psychological and physiological state of the subject. Other things being equal, a noise is more annoying if it contains a particular fequency, or set of frequencies, which is outstanding, or if it is impulsive. In general, a uniform, wide-band noise is less annoying than a more complex-patterned impulsive noise of the same loudness ; also, among bands adjusted to be equal in loudness, those bands composed of low frequencies are slightly less annoying, and those of high frequencies are definitely more annoying, than the standard band. Other characteristics like the duration and impulsiveness of the sound are taken to be included in the term quality. Also, the ear is not equally sensitive to all frequencies at all loudness levels and one sound can have a masking effect on another. In general, sounds are more effective in masking other sounds of higher frequency than those of frequencies below them, and, moreover, the effectiveness depends much more on the spectrum of the masking sound than on its loudness.

The equipment used by the Motor Industry Research Association to analyse noise in vehicles is an objective noise-meter, designed for use with octave filters. Essentially it is an amplifier fed from a moving-coil microphone, the output of which is indicated on a meter calibrated directly in decibels above the " threshold of hearing " (0 decibel = 10^{-16} watts per square centimetre). The filters consist of two sets of eight octave filters staggered relatively to each other by half an octave which, when plugged into the noise-meter, allow the noise-level in each octave to be determined in turn, the octaves being 37·5 to 75 cycles per second, 50 to 100 cycles per second, etc. The mid-frequency range of the filters is from 56·25 to 9,600 cycles per second, and curves of noise-spectra are obtained by joining, with straight lines, points which represent the noisemeter readings obtained for each octave-band plotted at the mid-frequency of the band. Values of overall noise-level given were taken with the amplifier " flat " ; that is, not weighted in any way for ear response. This equipment can be used directly in a vehicle but the carrying out of detailed analyses on the road of the type described hereafter is both lengthy and tedious. Hence present practice is to record the noise with a portable magnetic-tape recorder constructed by the Motor Industry Research Association for this type of work, and analyse it subsequently in the laboratory by purely electrical means, without resort to acoustic reproduction. This technique reduces actual road work to a minimum.

When using any electronic equipment on the road, two sources of spurious signal have generally to be guarded against, namely, microphonic signals, generated in the valves themselves by road shock, and electrical pick-up of energy radiated by the ignition system. Fortunately, these two sources of interference are readily overcome, since complete suppression of them is by no means necessary. Reduction of the spurious signal to give a resultant output equivalent to a noise-level small compared with that to be investigated is all that is necessary. Microphonics are sufficiently reduced by placing the equipment on a thick mat of sponge rubber, and suspending the microphone itself on a weak spring system so that its natural period of vibration is some 5 cycles per second, or lower. Ordinary resistance-type suppressors in plug leads are sufficient to reduce ignition interference.

(*To be continued.*)

THE "STAFFA" 3-TON MOBILE CRANE.

CHAMBERLAIN INDUSTRIES, LIMITED, LONDON.

THE "STAFFA" 3-TON MOBILE CRANE.

SINCE the end of the war, the activities of Chamberlain Industries, Limited, Staffa Works, London, E.10, have included the repair and reconditioning of mobile cranes of both British and American manufacture. During the course of this work, it became apparent that one particular crane of American manufacture was becoming extremely popular with many different classes of operator largely on account of its robustness and simple mechanical design. The demand for this model, therefore, increased steadily, but, owing to the necessity for restricting dollar expenditure, the supply was inadequate. As a consequence, Chamberlain Industries, Limited, decided to manufacture a similar type of crane, but with a considerably enhanced performance and after much experimental work produced the mobile crane illustrated on this page.

Known as the " Staffa," the new crane is capable of lifting a maximum load of two tons, using the normal lifting gear, but by fitting special tackle to a bracket, located at approximately two-thirds of the length of the jib, loads up to a maximum of three tons can be lifted. It is completely mobile, and, as will be seen from the illustration, has two wheels set wide apart at the front and two additional wheels set at a narrower track at the rear, an arrangement that gives good manœuvring qualities but does not impair stability. Care has been taken to keep the design as simple as possible, with the object of reducing maintenance to a minimum and to ensure that when such work has to be done it is of a simple nature. The chassis is of all-welded steel construction and is fitted with a substantial front bumper plate to give protection to the tyres and wheels and to act as a buffer when pushing other vehicles, etc. Power is supplied by a Newage-Austin four-cylinder overhead-valve industrial-type engine having a bore and stroke of 2·578 in. and 3·5 in., respectively, and developing 15 brake horse-power at 1,800 r.p.m. Cooling is effected by means of an engine-driven fan and radiator assembly working in conjunction with a centrifugal-type pump, the engine temperature being maintained within close limits by a thermostat. The equipment supplied with the engine includes a fuel pump, air cleaner and electric starter motor.

The drive is transmitted to the front wheels, the rear wheels being used for steering in accordance with usual practice for cranes of this type. The transmission assembly comprises a single dry-plate clutch and a four-speed and reverse Synchromesh gearbox arranged to drive the front axle through an open propeller shaft fitted with needle-roller bearing universal joints. A double-reduction final-drive unit is employed, the secondary reduction gear incorporating a differential. Mechanically-operated brakes of the internal-expanding type are fitted to the front wheels and the operating linkage is designed so that they may be applied by a pedal or hand lever. The two steering wheels are mounted on a trunnion and are turned by a worm meshing with a segment of a worm wheel, the design being such that the wheels can be moved through an angle of 150 deg., thereby giving an exceptionally small turning circle. Twin wheels are fitted at each side of the driving axle and all wheels are provided with 27 in. by 6 in. pneumatic tyres.

The jib is of lattice construction and, as will be seen from the illustration, is supported by two triangular side frames suitably braced by cross-members. The supporting frames are of all-welded construction, but the jib is largely riveted. One of the main features of the design is the method employed for raising and lowering the jib, a hydraulic ram being employed for this purpose. The base of the ram cylinder is connected to the main frame of the crane and the top of the ram to the inner end of the jib, pivoted joints being used to permit movement of the jib relatively to the rest of the structure. Oil under pressure is supplied by an engine-driven vane-type hydraulic pump and is led to the cylinder through flexible pipes, the control valves and non-return valves being designed so that the jib is retained in position in the event of the loss of oil pressure due to a burst pipe.

The hoisting gear consists of two sheaves arranged in

"KUE-KEN" BALANCED-JAW CRUSHER.

SIR W. G. ARMSTRONG WHITWORTH AND COMPANY (IRONFOUNDERS), LIMITED, GATESHEAD-ON-TYNE.

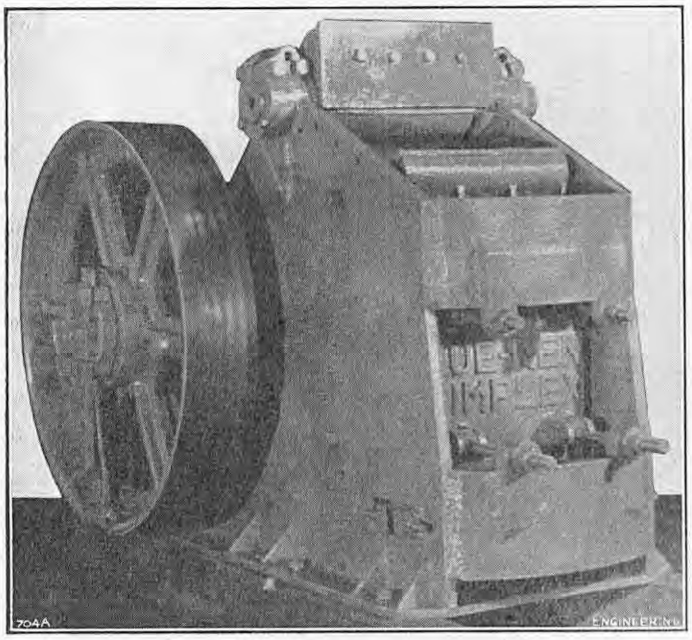
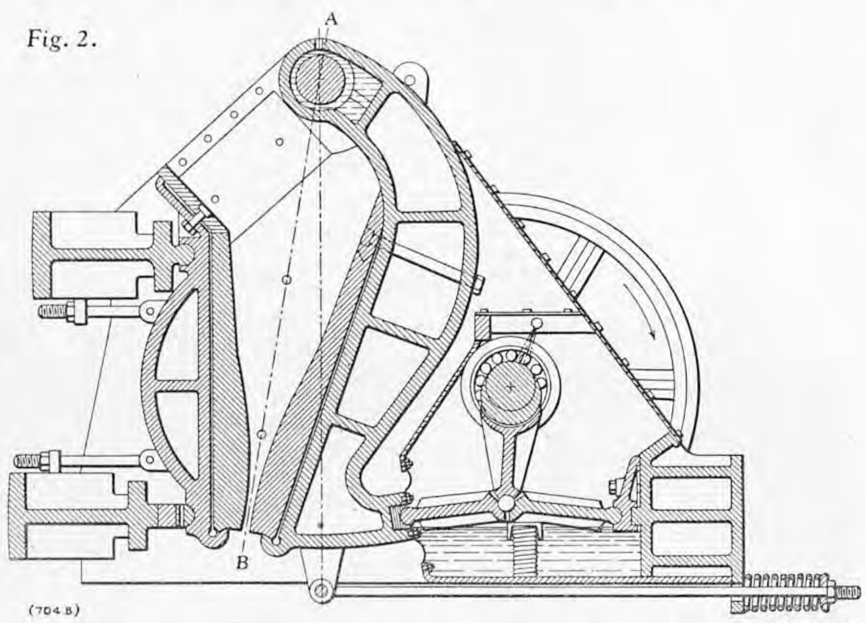


Fig. 1.

Fig. 2.



the jib and a grooved winding drum, the drum being designed to accommodate 65 ft. of $\frac{5}{8}$-in. diameter rope. The drum is driven through a fan-cooled worm-reduction unit, the driving power being transmitted from the free end of the engine crankshaft first to a marine-type forward and reverse gearbox by means of an open propeller shaft and then by a further propeller shaft and chain drive to the input side of the worm-reduction unit. The forward and reverse gearbox is situated at the rear of the chassis and it incorporates an automatic brake to give accurate control of all hoisting operations.

In view of the fact that equipments of this type are used frequently in areas where maintenance facilities are scarce, every effort has been made to keep the design as simple as practicable. Furthermore, unit-construction is used throughout so that if any major part requires replacement, a complete sub-assembly can be supplied for fitting to the chassis, etc., jig-drilled locating holes ensuring accurate alignment of the new parts. The crane is well fitted out, the standard equipment including a car-type driver's seat, electric lighting, driving mirror, etc., and a spot light fitted to the jib in such a manner that the load is illuminated regardless of the angle of working.

BALANCED-JAW ROCK CRUSHER.

SOME months ago, Sir W. G. Armstrong Whitworth and Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne, acquired the sole rights to manufacture in this country the American Straub range of Kue-Ken jaw crushers, which are suitable for all classes of rocks and minerals. The significant feature of these machines, one of which is illustrated in Fig. 1, above, is the arrangement of the jaws, which are designed to crush the rock by direct pressure alone, avoiding rubbing and abrasion, and therefore reducing wear and minimising the power required. As Fig. 2 shows, the fixed jaw and the swinging jaw are symmetrical about a line A B passing through the hinge pin of the swinging jaw, and thus the motion of one towards the other is sensibly square to the line A B. The makers contrast this design with those of the double-toggle Blake crusher and the single-toggle overhead-eccentric crusher: with these the rock is moved up and down while being crushed, thus wasting power and causing unnecessary wear, whereas in the Kue-Ken crusher the power is used efficiently, wear is reduced to a minimum, and the capacity of the machine is stated to be enhanced.

The general construction of the machine is obvious from Fig. 2. The swing jaw, fitted with bronze bearings, is carried on a hinge pin which is clamped at both ends in the side frames. Lubrication at this point is provided by a large oil-bath surrounding the pin, which is provided with oil seals. The machine frame consists of steel side plates welded to transverse steel castings, and after fabrication it is stress-relieved and shot-blasted. The jaw plates, which are available in various designs to suit different operating conditions, are made of manganese steel. In order to retain the designed geometry of the toggle mechanism in spite of wear, the bolts holding the fixed jaw to the front cross members can be loosened and the bottom of the jaw swung towards the movable jaw, after which spacer bars can be inserted to reduce the jaw setting, or bars can be removed to increase the setting.

The toggle seats and plates, made of heat-treated alloy steel, are machined and polished on their working faces. Play in the mechanism is taken up by a spring below the toggle and another which pulls horizontally on the lower end of the swinging jaw. The upper end of the pitman bears on the lower side only of the eccentric shaft, thus eliminating the bearing caps, bolts and shims which are usually employed and thereby saving weight. The makers state that the pitman is about one-tenth of the weight of normal crusher pitmans, permitting a long-stroke eccentric and flatter toggles so as to give greater leverage combined with low pressures on the shaft and pitman bearings. Thus, with flood lubrication of the working parts, these features permit cool running at 350 to 425 crushing strokes per minute.

The driving mechanism is enclosed by the frame side plates, a bottom plate, a removable cover plate, and an oil-resistant flexible diaphragm which joins the swinging jaw to the main oil bath. A comparatively light flywheel pulley is sufficient; it can be coupled directly to a motor or engine running at about 1,200 r.p.m. To protect the crusher against "tramp iron" or a severe overload, the pulley is coupled to the shaft through an overload device. The eccentric shaft is carried in large self-aligning roller bearings; it presses down on the toggles, whereas in the Blake crusher the toggles are arranged to be pulled up. Lubrication is by means of a pump, driven from one end of the crusher shaft, which draws oil from the main oil bath through a strainer, passing it through a filter of the quick-cleaning type, provided with a by-pass valve. A control valve regulates the pressure, which is indicated on a gauge. A pressure switch automatically stops the crusher motor or engine if the oil pressure falls below a minimum value, or if the overload device on the pulley is brought into action for any reason.

The Kue-Ken crusher is made in a wide range of sizes, with feed openings from 12 in. by $2\frac{3}{4}$ in. to 42 in. by 27 in. and the capacity from 4 to 200 tons per hour. If an electric motor is used, the horse-power required is from $7\frac{1}{2}$/10 to 50/60, but with a petrol or Diesel engine 15 to 20 per cent. more power rating is necessary. Moreover, such engines are subject to losses due to altitude.

WOMEN'S ENGINEERING SOCIETY.—The meeting of the London branch of the Women's Engineering Society, previously announced as taking place to-day, will now be held on Tuesday next, February 19, at 35, Grosvenor-place, S.W.1, and will commence at 7 p.m. Miss A. S. Lockhart will speak about the early days of the Society and Miss D. Pile about its post-war future.

LECTURES ON LIQUID FUELS.

A COURSE of eight evening lectures on "Liquid Fuels, their Properties and Utilisation," will be delivered by Mr. G. F. J. Murray, B.Sc., A.M.I.C.E., in the Department of Applied Chemistry of the Northampton Polytechnic, London, E.C.1, at 7 p.m., on Tuesdays, commencing on February 26. The second lecture will be held on March 4, after which the lectures will be held on March 25, April 1, 22 and 29, and May 13 and 20. The course is intended to provide a survey of present-day knowledge and the standpoint of the user of liquid fuels will be stressed throughout.

The subjects to be dealt with in the first lecture will include the origin, properties, characteristics and grades of fuel oil and typical analytical specifications, methods of analysis and such matters as viscosity-temperature relationships. The second lecture will deal in a similar manner with liquid fuels other than fuel oil. The third lecture will be concerned with the layout of liquid fuel-burning systems, storage, pumping and piping arrangements, types of atomisers and burners and considerations affecting the choice of a type of burner. In the fourth lecture, the applications of liquid fuels and their use in central-heating installations and large steam-raising plant will be described, and the influence of the quality of the fuel oil upon its applicability for a particular purpose will be considered. The fifth lecture will deal with liquid-fuel usage in metallurgical furnaces for melting and for heat-treatment, and for kilns and drying processes. The use of fuel oil in Scotch and water-tube marine boilers will be considered in the sixth lecture, as well as such questions as smoke, fuel consumption and additives to fuel oils. Some recent work on high- and low-temperature corrosion and fire-side deposits on oil-fired plant will be discussed in the seventh lecture, which will also deal with the question of ash in fuel oil and its importance as related to the availability of land and marine boiler plant. The eighth and last lecture, on May 20, will be devoted to such matters as oil applied to gas production, heavy oils in carburetted water-gas manufacture, and the limitations in their use, and the manufacture of gas from oil by thermal and catalytic cracking processes and their fields of application.

The fee for the course is 1*l*., but a student who has already enrolled in another course at the Polytechnic may also attend the present course for an additional fee of 15*s*.

ECONOMY IN HOSPITAL ENGINEERING SERVICES.—The Ministry of Health have issued to hospital engineers, management boards and committees, a memorandum setting out the type of record of boiler-plant performance which should be kept in order to ensure that fuel is being used in the most economical manner, and the instruments that are necessary to furnish the recorded measurements. Certain records are required to be sent regularly to the Regional Hospital Boards and to the Engineering Department of the Ministry of Health, starting from April 1. Copies of the memorandum may be obtained from Room 8, Ministry of Health, Savile-row, London, W.1.

CONSTRUCTION OF DRAKELOW POWER STATION.

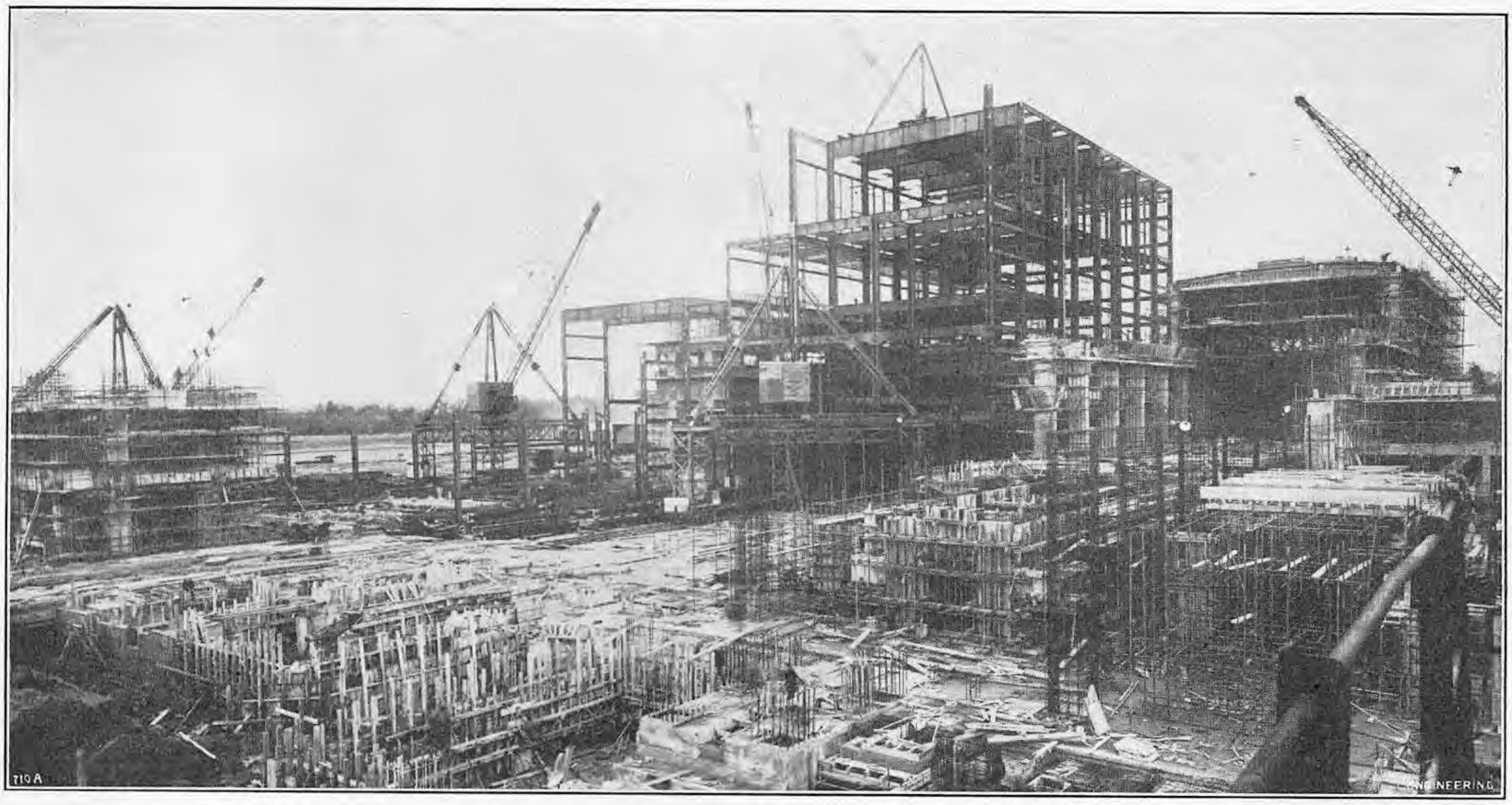


FIG. 1. GENERAL VIEW OF CONSTRUCTIONAL WORK ON DECEMBER 4, 1951.

THE 240-MW DRAKELOW-"A" POWER STATION OF THE BRITISH ELECTRICITY AUTHORITY.

THE Drakelow-"A" power station of the British Electricity Authority, which is now in course of construction, is situated about 2 miles to the south-west of Burton-on-Trent on a site bounded by the River Trent and the Leicester-Burton railway. It is designed to accommodate four steam generators and four 60-MW turbo-alternators arranged on the unit system and will be followed by a "B" station on the same site. A control room and office block will be built between the two stations with a central workshop behind.

Site clearance was begun early in June, 1950, by Sir Robert McAlpine and Sons (Midlands), Limited, Leicester, and the foundations for the main buildings were started in October of the same year. As a result of a survey, it had already been decided to excavate to an average depth of 6 ft., thus providing material for forming the embankment of the railway sidings and enabling the depth of the main foundations to be reduced. Owing to the special plant used it was possible to carry out this work very rapidly. In fact, no less than 300,000 cub. yd. of earth were removed and levelling effected in less than eight weeks. The foundations have been carried down to good marl, which is capable of sustaining loads of from 3 to 4 tons per sq. ft.

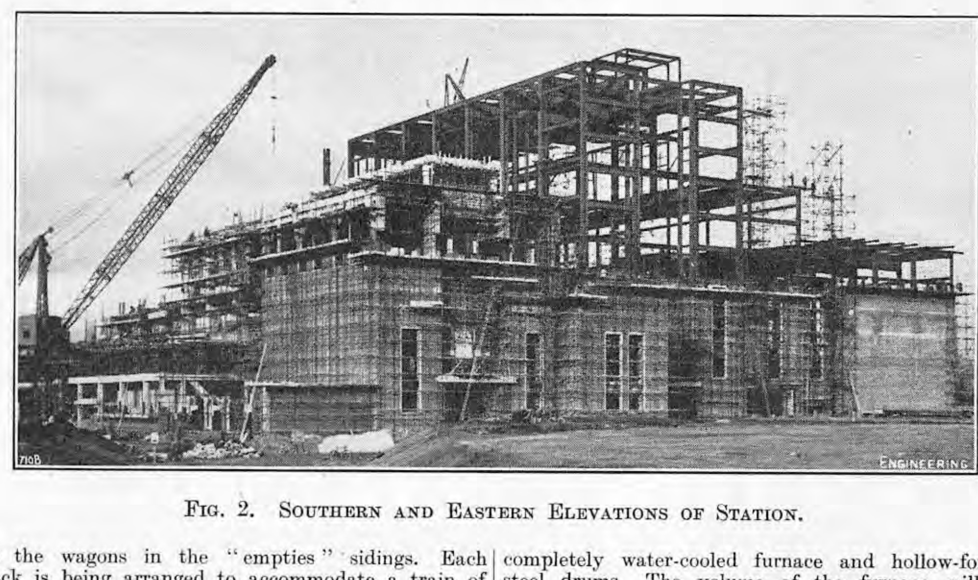


FIG. 2. SOUTHERN AND EASTERN ELEVATIONS OF STATION.

The turbine house, heater bay and circulating-water pump annexe are being constructed entirely in reinforced concrete, the aggregate of which is being obtained from sand and gravel workings at the south-west corner of the site. The pits thus formed will subsequently be filled with ash slurry. The boiler house and its subsidiary bays are, however, steel structures, certain sections of which will support the air heaters, economisers and other plant. The cladding of the building consists of Early English Blockley brickwork. The stage at present reached in the work will be clear from Figs. 1 to 3. There will be two chimneys, each 360 ft. high, with an internal diameter at the top of 18 ft. 6 in. They will consist of Accrington "Nori" bricks laid in hydrolised lime mortar with Prodorite acid-resisting joints $4\frac{1}{2}$ in. deep and they are being built on reinforced-concrete stools which are also lined internally. The separate 132-kV switching station is shown in course of construction in Fig. 4.

The coal consumed in the station will be rail-borne and will be brought into "fulls" sidings from the Leicester-Burton line. These sidings will form a triangle with the corresponding "empties" sidings. It will therefore be possible for a locomotive to draw the train into the "fulls" sidings, reverse and pick up the wagons in the "empties" sidings. Each track is being arranged to accommodate a train of 60 wagons and as 12 tracks to both sidings will ultimately be laid it will be possible to handle 6,000 tons of coal per day. Seven miles of track are already in position and are to be floodlighted.

The coal-handling plant, for which the main contractors are Mitchell Engineering Company, Limited, Peterborough, will consist of four tipplers each of which will be capable of handling a 24-ton railway wagon. Coal will be taken thence through a system of bucket elevators and belt conveyors either to the boiler-house bunkers or to a store, and will be reclaimed from the latter by a transporter with a span of 188 ft. The capacity of each tippler and its associated conveyors will be 120 tons per hour, while the capacity of the belt to the store will be 240 tons per hour. Facilities for dealing with road-borne coal will also be provided and extra storage capacity will be obtainable by bulldozing an area under the cantilever portion of the transporter.

From the boiler-house bunkers the coal will be fed to Lopulco L.M.16 mills, of which there will be four to each steam-raising unit, and thence to pulverising burners of the tilting type of which there will be one at each corner of the combustion chambers. This arrangement will enable tangential firing to be employed and thus high turbulence to be set up in the furnace. The boilers, which are being constructed by International Combustion, Limited, 19, Woburn-place, London, W.C.1, will be of the radiant-heat type with a completely water-cooled furnace and hollow-forged steel drums. The volume of the furnace will be 34,900 cub. ft. and the heating surface, including the water walls, 14,410 sq. ft. Each boiler will be designed to supply 515,000 lb. of steam per hour at the maximum continuous rating at a pressure of 1,550 lb. per square inch and a temperature of 1,060 deg. F. at the superheater outlet. Oil-fuel lighting equipment is being provided by the Wallsend Slipway and Engineering Company, Limited, Wallsend. The superheaters, which will be of the welded type, are being manufactured by the Superheater Company, Limited, Haymarket, London, S.W.1, and are designed to maintain the final temperature within $\pm$ 10 deg. F. by means of the tilting burners over a minimum load range of 80 to 100 per cent. of the maximum continuous rating. The total superheater surface will be 34,950 sq. ft. The economisers, which are being constructed by Senior Economisers, Limited, 11, Southampton-row, London, W.C.1, are to be of the Heenan all-welded steaming type and will have a heating surface of 39,168 sq. ft. They will be supplied with feed water at a temperature of 430 deg. F. Two air heaters are also being provided on each boiler by Messrs. James Howden (Land), Limited, Glasgow, the total heating surface of which will be 124,000 sq. ft. Draught will be provided in each boiler by two 60-in. forced-draught and two 73-in. induced-draught fans, which are being manufactured by Messrs. Davidson and Company, Limited, Belfast. All these fans will be driven by variable-speed motors supplied by Messrs. Laurence,

DRAKELOW POWER STATION.

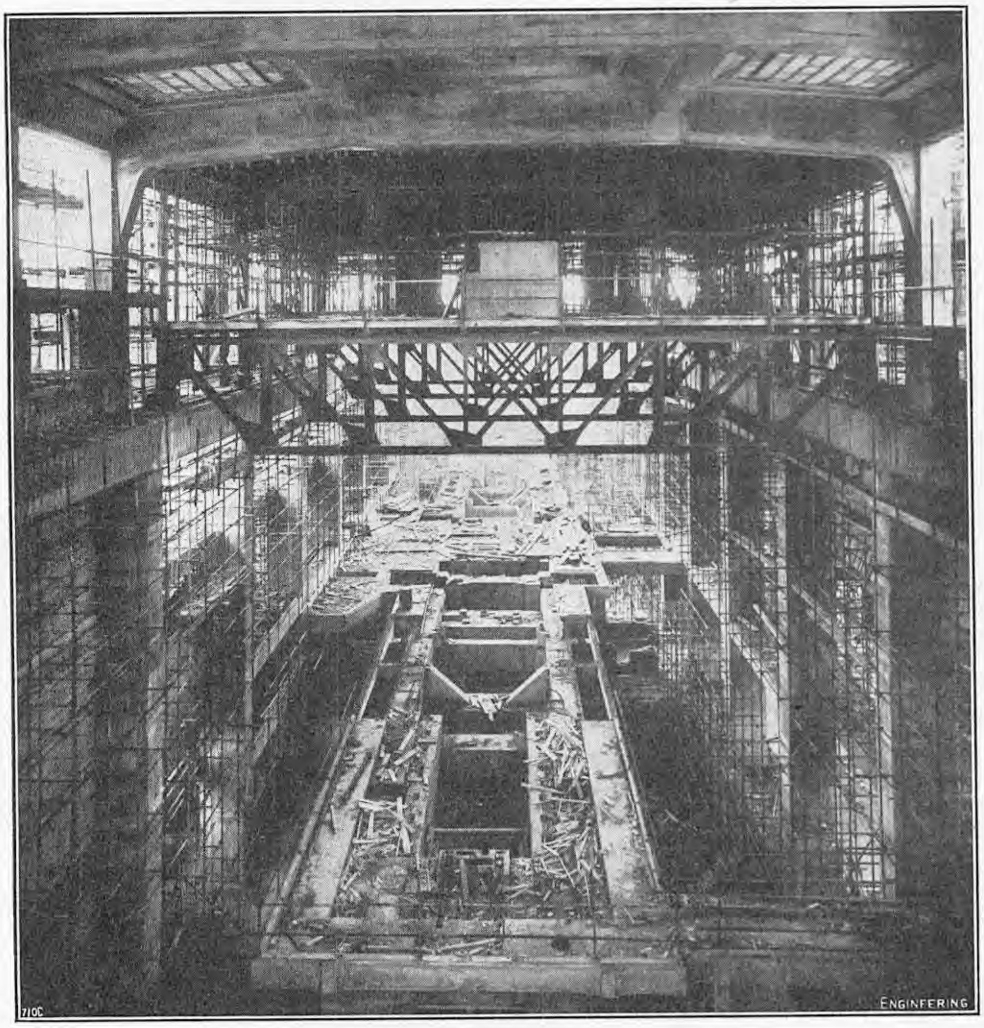


FIG. 3. TURBINE HOUSE UNDER CONSTRUCTION.

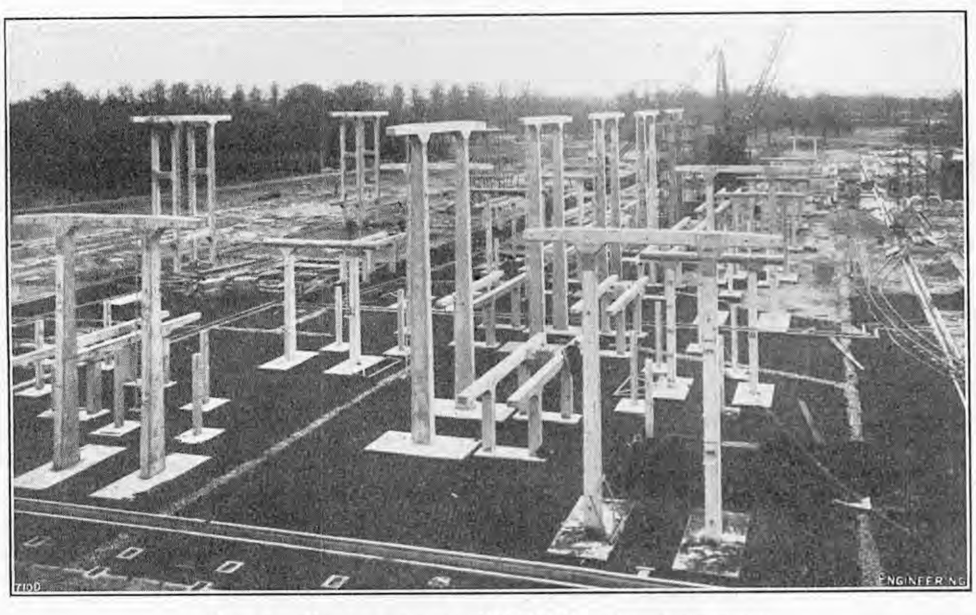


FIG. 4. FRAMEWORK OF 132-KV SWITCHING STATION.

Scott and Electromotors, Limited, Norwich. The automatic control equipment is being manufactured by Bailey Meters and Controls, Limited, Purley-way, Croydon. The boiler guarantees are based on the use of coal with a calorific value of 10,200 B.Th.U. per pound and containing 30 per cent. volatile matter, 25 per cent. ash and 4·0 per cent. hydrogen. When burning this fuel at the maximum continuous rating and with a moisture content of 14 per cent., a combustion heat efficiency of 87·8 per cent., and an overall efficiency of 85·1 per cent. are anticipated.

Grit will be extracted from the flue gases by electrostatic precipitators constructed by the Sturtevant Engineering Company, Limited. The ashes will be handled by plant manufactured by International Combustion, Limited. It will consist of gravity sluices between the boiler house and a pump house in which three pumps with a capacity of 3,300 gallons per minute will be installed. These pumps will elevate the slurry to a gantry on which troughs will be mounted, running to the disposal area on the low-lying ground in the loop of the river.

The first four turbo-alternators, which are being constructed by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, will each have an output of 60 MW when supplied with steam at a pressure of 1,500 lb. per square inch and a temperature of 1,050 deg. F. They are being designed to generate three-phase current at 11·8 kV and 50 cycles when running at 3,000 r.p.m. and it is anticipated that the steam and heat consumption will be 7·939 lb. and 8,808 B.Th.U. per kilowatt-hour, respectively. To obtain the most from the heat drop available, the turbines are being designed with three stages of expansion, comprising a short high-pressure cylinder, an intermediate-pressure cylinder and a double-flow low-pressure cylinder. The alternator will be hydrogen-cooled, the two coolers being arranged longitudinally in the upper part of the casing. The gas will be drawn through the machine and coolers by fans mounted one at each end of the rotor. Excitation will be derived from a separate machine which will be driven by a 400-h.p. 3·3-kV squirrel-cage motor. There will also be one stand-by exciter for the whole station. Supplies for the auxiliaries of the unit will be obtained from a 6-MVA 11·8/3·3-kV transformer, the primary of which will be directly connected to the alternator terminals.

The turbines will exhaust into twin shell condensers, which are being constructed by Messrs. Worthington-Simpson, Limited, Newark, and each of which will have a cooling surface of 55,000 sq. ft. and will be capable of dealing with 354,000 lb. of steam per hour. The circulating-water system has been designed so that the 31,800 gallons per minute required by each unit can be supplied either from the river or from cooling towers. In the former case, water will be drawn from the river through four Brackett screens by four vertical centrifugal pumps, manufactured by Messrs. Drysdale and Company, Limited, Yoker, Glasgow. Each of these pumps will have an output of 2,000,000 gallons per hour, and they will be situated in a pump house on the river bank upstream of the station and will deliver water through culverts into ponds. As the total of 8,000,000 gallons per hour, required will not be available when the flow is small, one cooling tower is at present being erected by Mitchell Construction Company, Limited. This will be capable of cooling 3,800,000 gallons of water from a temperature of 93 deg. to 76 deg. F., with an atmospheric dry-bulb temperature of 60 deg. F. and an atmospheric humidity of 80 deg. F.

The feed water will be heated in two low-pressure heaters, one of which will be a de-aerator, and will be delivered to four high-pressure heaters by two electrically-operated feed pumps, to be supplied by Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, S.4, with a capacity of 650,000 lb. per hour against a head of 1,965 lb. per square inch. Make-up water will be obtained from two artesian wells which are being sunk by Messrs. C. Isler and Company, Bear-lane, Southwark-street, London, S.E., through the sandstone and bunter beds to a depth of some 700 ft. and will, it is expected, yield from 280,000 to 320,000 gallons per day. Water from these wells will be pumped to water-softening plant with which two reservoirs with a capacity of about 1,500,000 gallons will be associated. It will be treated in three sets of triple-effect evaporators, manufactured by Messrs. Aiton and Company, Limited, Derby, each of which will have a capacity of 25,000 lb. per hour; and then pumped into treated water tanks. The high-pressure steam and feed pipes are also being provided by Messrs. Aiton, and will be made of F.C.B.(T) steel obtained from Messrs. Thomas Firth and John Brown, Limited, Sheffield.

Each main alternator will be connected to a 72-MVA English Electric transformer, which will be wound in delta on the primary and in star on the secondary side and in which the voltage will be stepped up to 132 kV. Switching and synchronisation will be effected at this voltage, the equipment for this purpose being installed in an outdoor double 'bus-bar substation, which will initially contain accommodation for two generators, two transformers and four feeder circuit-breakers, as well as a 'bus-bar coupler. These circuit-breakers, which will be of air-blast type, and are being manufactured by Messrs. A. Reyrolle and Company, Limited, Hebburn, Co. Durham, will be controlled from the main control room in the power station.

Supplies for the station auxiliaries will be obtained from two 10-MVA 132/3·3-kV station transformers, the low-tension output of which will be controlled by Reyrolle air-break switchgear with a rupturing capacity of 150 MVA. In addition, certain supplies will be given at 415 volts through switchgear with a rupturing capacity of 25 MVA. All the auxiliaries pertaining to one unit will be connected to separate 3·3-kV and 415-volt switchboards. Stand-by and starting supplies at the same voltages are obtainable from station auxiliary boards, of which there will be one for each pair of turbo-alternators and boilers. The unit and station 3·3-kV boards will be controlled from the main control room. The 3·3-kV system will be resistance-earthed and the 415-volt system solidly earthed.

Direct-current supplies will be obtained from two 800-ampere-hour batteries, which will be charged through two 20-kW mercury rectifiers or, in emergency, from the stand-by exciter.

The engineering work connected with the station is being supervised by the staff of the Generation Construction Department of the Midlands Division, British Electricity Authority, under the control of Mr. F. W. Lawton.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

THE LATE SIR ANDREW LEWIS.—The death is announced of Sir Andrew Jopp Williams Lewis, D.L., LL.D., a former Lord Provost of Aberdeen and senior partner in the shipbuilding and engineering firm of John Lewis & Sons, Ltd. Sir Andrew, who died on February 9, was born on April 18, 1875, had considerable interests in the fishing industry and had been President of the Aberdeen Steam Fishing Vessel Owners' Association and of the British Trawler Federation. He was also one of the Aberdeen Harbour Commissioners, a director of the National Bank of Scotland, and of the Millom & Askam Hematite Iron Co., and held other directorships in industry and industrial insurance.

THE STEEL INDUSTRY.—Scrap collection, retarded for a week or two by snow and ice, was resumed on normal lines last week. The curtailment of deliveries had interfered with operations at melting shops, and steel supplies to users were affected. Little improvement in the general position is looked for until the promised American steel is circulating freely. Meanwhile, observers are watching closely the changing trend in overseas markets, particularly in respect to Japanese competition and the flagging interest of United States buyers in European steel. These, they consider, will herald a closer equality between supply and demand in the future.

SHORT-TIME WORKING.—On account of material shortages, the Motherwell works of Hurst Nelson & Co., Ltd., wagon builders, went on to a four-day week from February 4. British National Electrics, Ltd., Newarthill, have been compelled to take a similar step.

EXTENSIONS TO DALMARNOCK POWER STATION.—The British Electricity Authority have received permission to carry through an extension of Dalmarnock generating station, Glasgow, comprising two 60,000-kW turbo-alternator sets and six boiler units, each of an evaporating capacity of 200,000 lb. of steam an hour.

SCOTTISH BUILDING CENTRE.—The number of visitors to the Scottish Building Centre, Glasgow, last year was about 20,000, and 9,000 technical inquiries were handled, it was reported last week at the annual meeting of the Centre.

CLEVELAND AND THE NORTHERN COUNTIES.

RIVER TEES CONSERVANCY COMMISSION.—Revenue from tolls and dues to the River Tees Conservancy Commission during December, 1951, was 25,655*l*., the highest December figure ever recorded. It represents an increase of 1,051*l*. over the figure for December, 1950, and one of 2,658*l*. over that for the previous month. Commenting on these and other figures presented at a meeting of the Commission, held at Middlesbrough last week, Alderman B. O. Davies, who presided, said that, in his opinion, they could look forward with more hope for trade improvement on the North-East Coast than the position a few months ago had justified.

NORTH EASTERN TRADING ESTATE.—Speaking on February 5, at the opening of a communal canteen on the East Middlesbrough Estate, Alderman A. Ross, a director of the North Eastern Trading Estates, Ltd., said that, since 1947, the light industries founded by his company had provided employment for 7,043 men and women in the Tees-side district and that the factories on their 30 different estates in the North-Eastern area now employed a total of 43,179 persons. The East Middlesbrough Estate employs 1,788 men and women.

WEAR AND TEES POLLUTION-PREVENTION WORK.—A recommendation that an analytical laboratory to combat river pollution be established in the Darlington headquarters of the Wear and Tees River Board has been approved by the Board. Speaking at Darlington Town Hall on February 1, the chairman of the Board, Mr. C. U. Peat, stated that pollution was an evil of long standing which had reduced the lower reaches of the Wear and Tees virtually to sewers, wholly unfit for the health, recreation and enjoyment of the large population living on the banks of the rivers or near them.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL ALLOCATIONS.—Mr. W. F. Fletcher, regional controller at Sheffield of the Ministry of Supply, has told the Sheffield branch of the Purchasing Officers' Association that his department would be willing to discuss their problems arising from the allocation scheme for steel. He asked them to give the scheme a chance and to report their difficulties to him. District steel users had described the allocation as " quite inadequate." The estimates, he said, had been based mainly on what steel had been received and consumed in 1950, and the amount used against allocations when steel had last been rationed. He pointed out that the latest supply figures were between 15 and 16 million tons for next year, and that this did not include any material from the United States.

STEEL FOR HAND-TOOL INDUSTRY.—The fear that Sheffield's hand-tool industry, which makes at least 70 per cent. of the industry's estimated national production of 24,000,000 hand tools every year, would have to sacrifice some of its valuable export trade if steel allocations remained at about 50 per cent. of requirements, has been partly dispelled by a decision that a steel allocation will be made against each Government contract, if necessary. The contention was that a firm having a large amount of Government work might find the whole of the allocation absorbed, leaving nothing to spare for export and home needs. The value of the export trade in hand tools is estimated at 11,000,000*l*. a year.

SMALL CUTLERY FIRMS.—It is urged by Mr. Harold Slack, secretary of the National Cutlers' Union, that there are too many small firms in the Sheffield cutlery trades. The Working Party reported in 1947 that the industry had more than 500 individual firms each employing fewer than five persons. The number is now estimated to be over 600. Many of the newcomers, he asserted, have taken over semi-derelict workshops in areas of Sheffield scheduled for clearance. The industry would be stronger if there were fewer such firms. He urged the need for an effective training scheme for young employees in the industry.

MORE MEN FOR THE MINES.—More men and boys are taking up work at Yorkshire collieries than for many years past. A net gain of 1,131 in man-power was recorded in the North-East Division in the first three weeks of the present year, but there are still over 3,000 vacancies, including 2,484 for men and 588 for boys.

THE MIDLANDS.

PROPOSED CONCENTRATION OF INDUSTRY AT SMETHWICK.—The development plan for the county borough of Smethwick aims to concentrate industry in the north and east parts of the town. The majority of Smethwick's factories, including most of the engineering works and foundries, are in the scheduled area, and the plan provides for the removal there of all such factories at present elsewhere in the town. The plan is a long-term one, extending over 20 years, and affects about 100 firms altogether. It has already met with considerable opposition. At least one of the factories affected has, within the last two years, carried out extensions for which planning permission had been granted. It has been pointed out by objectors to the plan that the area scheduled for industry is at present congested, and that, if new factories are to be brought into it, there will be no room for extensions of existing ones. The amount of land available in the borough for building of any kind is negligible, for Smethwick is entirely surrounded by other towns, and cannot extend. Some of the local manufacturers whose premises are affected by the plan have suggested that the proposals will cause them to leave the district. About 70 firms are to make a joint protest to the Minister of Housing and Local Government.

STEEL DISTRIBUTION.—Now that the iron and steel distribution scheme is in operation, it is possible to see something of its first effects on Midland industry. The motor-vehicle manufacturers have been the first to experience difficulties, and in the Coventry area some fairly substantial dismissals of labour have taken place. For the present, however, the matter seems to be one of transfer from one factory to another, for there are many vacancies for skilled labour in Coventry. On the whole, Coventry should be less affected than many other parts of the Midlands, for its factories are suitable for defence work. There may well be some redundancies, however, while re-tooling is in progress. The reduction in motor-vehicle output may affect other parts of the Midlands more than at first appears. Coventry draws large supplies of components from Birmingham and the Black Country, and not all this manufacturing capacity is likely to be absorbed in defence work. In several of the steel-using industries in the Midlands there is a certain optimism, and a hope that steel allocations in the second period, which begins in April, will be better. The cycle trade has already been told by the Ministry of Supply that it is hoped to increase its allocation in the next period.

SHROPSHIRE SCRAP COLLECTION.—Taking advantage of the slack period for farm work, the Shropshire branch of the National Farmers' Union has organised a scrap collection in the Wellington, Shifnal and Newport districts. The campaign, which lasted a fortnight, produced 315 tons of scrap metals of various kinds, which have been sold to local merchants.

NEW MOTOR CAR.—Sir John Black, deputy chairman and managing director of the Standard Motor Co., Ltd., Coventry, has announced that, if research now being carried out by Harry Ferguson Ltd. on a new popular type of motor car is successful, the vehicle will be produced entirely by the Standard Company.

FOUR ASHES CHEMICAL WORKS.—It is stated by Mr. S. J. L. Robinson, the chairman of Midland Tar Distillers Ltd., that their new plant at Four Ashes, near Wolverhampton, will be completed towards the end of 1952. The Four Ashes works will be used for the special treatment of tar oils, and about 30 acres of land are being developed for this purpose. When the new plant is in operation the company's other works will concentrate on straight tar distillation.

THE LATE MR. T. A. M. ROBERTS.—The death of Mr. Thomas Alec Maxwell Roberts, sales director of Imperial Chemical Industries Ltd., Metals Division, we note with regret, occurred on February 3. Mr. Roberts, who was 51 years of age, was chairman of the Brass and Copper Tube Association and the Extruded Brass and Copper Alloys Association. He was also a member of the Advisory Committee of the High Conductivity Copper Association, and of the Executive Committee of the Rolled Brass and Copper Association.

SOUTH-WEST ENGLAND AND SOUTH WALES.

EXCHANGE OF COAL FOR STEEL.—News has been received on the Welsh steam coal market during the past week that negotiations were proceeding for a coal-for-steel exchange scheme with Luxembourg. Under this plan, it is proposed that Britain should supply about 40,000 tons of coal in return for steel, about 12,000 tons of the coal being in Welsh qualities. Similar proposals are being discussed with France. The South Wales programme of coal exports, for the current quarter, includes the provision of 80,000 tons for France, but it is hinted that this quantity may be doubled if a satisfactory agreement is reached regarding steel. These are the latest steps in a trend that has been obvious on the coal market for some while past. Under this, such supplies as are available for shipment abroad are being largely reserved for the countries able to offer in return materials urgently needed by the home industries.

TRAFFIC OF SOUTH WALES PORTS.—The total traffic handled at the South Wales ports of Cardiff, Swansea, Newport, Barry, Port Talbot, Penarth Harbour and Briton Ferry in the first four weeks of the current year was 1,743,544 tons, which was a gain of 396,634 tons on the corresponding period of 1951. Furthermore, it was the second highest figure reached in the past ten years, the best being in the four weeks ended October 18, 1951. Imports were up by 165,629 tons at 737,122 tons and exports by 231,005 tons at 1,006,422 tons. Swansea handled nearly half of the past month's total trade owing to the rapidly expanding oil traffic at the port. Iron ore imports for the group of docks were up from 106,881 tons to 153,565 tons and those of other ores from 23,399 tons to 36,969 tons. Tin-plate shipments abroad were just 100 tons down at 17,113 tons.

CLOSING OF THE PORT TALBOT BAR MILL.—The Port Talbot bar mill of the Steel Company of Wales, which started in 1902, is to close on June 30 next. The weekly production of rails and sleepers has averaged 3,000 tons a week. The company state that the continued operation of the old works would involve substantial capital expenditure in the near future and the obvious alternative was to concentrate all available steel supplies, to maintain the highest possible output of the hot strip mill. About 480 men will be displaced, many being absorbed into other departments of the steelworks.

BAN ON SATURDAY SHIFT IN COALFIELD.—A development in the Welsh coalfield during the past week which has caused a good deal of misgiving to exporters has been the ban placed on the Saturday morning voluntary shift by the miners engaged at the Parc and Dare Colliery in the Rhondda Valley, who have called upon every other colliery in the coalfield to follow their example. The ban is a protest against the new arrangements in the health services announced recently by Mr. Butler, the Chancellor of the Exchequer. The action of the colliery, which took a lead in the introduction of the Saturday shift four years ago, has been condemned as unconstitutional and a circular has been issued by the South Wales area of the National Union of Mineworkers calling upon the men to remain loyal to the national agreement.

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.—*Mersey and North Wales Centre:* Monday, February 18, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Characteristics and Control of Rectifier-Motor Variable-Speed Drives," by Mr. P. Bingley. *Measurements Section:* Tuesday, February 19, 5.30 p.m., Victoria-embankment, W.C.2. (i) "Automatic Compensation of Zero-Drift Errors in Direct-Coupled Feedback Systems," by Mr. F. A. Summerlin. (ii) "High-Gain D.C. Amplifiers," by Mr. K. Kandiah and Mr. D. E. Brown. (iii) "Design of Practical D.C. Amplifier Based on Second-Harmonic Type of Magnetic Modulator," by Mr. S. W. Noble and Mr. P. J. Baxandall. *North Midland Centre:* Wednesday, February 20, 7.30 p.m., Yorkshire Electricity Board, Ferensway, Hull. "Electrical Control of Dangerous Machinery and Processes," Part II, by Mr. W. Fordham Copper. *Utilization Section:* Thursday, February 21, 5.30 p.m., Victoria-embankment, W.C.2. "Inherent Current, Voltage and Speed Control in Dynamo-Electric Machinery," by Mr. J. C. Macfarlane and others. *Education Discussion Circle:* Friday, February 22, 6 p.m., Victoria-embankment, W.C.2. Discussion on "Engineering Graduation Theses at University of Cape Town," opened by Professor B. L. Goodlet.

ILLUMINATING ENGINEERING SOCIETY.—*Sheffield Centre:* Monday, February 18, 6.30 p.m., University, Sheffield. "Electric Lighting: A Contractor's Viewpoint," by Mr. J. Ashmore.

INSTITUTE OF PACKAGING.—*Midland Area:* Monday, February 18, 6.30 p.m., Imperial Hotel, Birmingham. "Packaging for the Services," by Mr. P. A. Andrew.

INSTITUTION OF MECHANICAL ENGINEERS.—*Yorkshire Branch:* Monday, February 18, 7 p.m., Technical College, Bradford. "Measurement and Interpretation of Machinery Noise, Especially Oil Engines," by Mr. C. H. Bradbury. Wednesday, February 20, 7.30 p.m., Station Hotel, Hull. "Excavators and Grabs," by Mr. P. D. Priestman. *Western Branch:* Wednesday, February 20, 7 p.m., College of Technology, Unity-street, Bristol. "High-Altitude Flights with Free Balloons," by Professor C. F. Powell. *Southern Branch:* Wednesday, February 20, 7 p.m., Municipal College, Bournemouth. Discussion on "Britain, Liquid Fuels, and Engineers," opened by Engineer Captain H. Moy. *Midland Branch:* Thursday, February 21, 6.30 p.m., Birmingham and Midland Institute, Paradise-street, Birmingham. Joint Meeting with other Institutions. Thomas Hawksley Lecture on "Some Fuel and Power Projects," by Dr. H. Roxbee Cox. *North-Western Branch:* Thursday, February 21, 6.45 p.m., Engineers' Club, Manchester. (i) "Size Effect in Fatigue of Plain and Notched Steel Specimens Loaded Under Reversed Direct Stress," by Mr. C. E. Phillips and Dr. R. B. Heywood. (ii) "Fatigue Tests on Aluminium-Alloy and Mild-Steel Sheet," by Mr. C. E. Phillips and Mr. A. J. Fenner. *Institution Internal-Combustion Engine Group:* Friday, February 22, 4 p.m. and 5.30 p.m., Storey's gate, St. James's Park, S.W.1. (i) "Utilisation of Anti-Knock Quality in Automobile Engines," by Mr. J. D. Davis. (ii) "Developments in 'Knock' Research," by Mr. D. Downs and Mr. R. W. Wheeler. (iii) "Significance of Laboratory Octane Numbers in Relation to Road Anti-Knock Performance," by Mr. H. J. Eatwell and Mr. J. G. Withers.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, February 18, 7 p.m., School of Art, Derby. "Ball and Roller Bearing Manufacture," by Mr. P. A. Champion. *North-Eastern Section:* Monday, February 18, 7 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting and Film Evening. *Manchester Section:* Monday, February 18, 7.15 p.m., College of Technology, Manchester. "Relation of Toolroom to Production," by Mr. H. W. Townsend. *Birmingham Section:* Wednesday, February 20, 7 p.m., James Watt Memorial Institute, Birmingham. "Craftsmanship Applied to Processing of American Brassfoundry Work," by Mr. F. E. Rattlidge. *Liverpool Section:* Wednesday, February 20, 7.15 p.m., Exchange Hotel, Liverpool. Discussion on "Economic Use of Materials." *Edinburgh Section:* Wednesday, February 20, 7.30 p.m., North British Station Hotel, Edinburgh. "Denny-Brown Ship Stabiliser," by Mr. J. W. Sinclair. *Coventry Section:* Thursday, February 21, 7 p.m., Geisha Café, Coventry. "Rolling Bearings," by Mr. R. K. Allan.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Monday, February 18, 7.30 p.m., University Building, St. George's-square, Sheffield. "Metal-Working Laboratories of British Iron and Steel Research Association," by Mr. W. C. F. Hessenberg.

ROYAL INSTITUTION.—Tuesday, February 19, 5.15 p.m., 21, Albemarle-street, W.1. "Physical Methods of Meteorology.—IV. Global Meteorology," by Mr. P. A. Sheppard. Thursday, February 21, 5.15 p.m. "Interference and Diffraction as General Wave Properties.—I. Object-Image Relationship in Optical Instruments," by Sir Lawrence Bragg, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 19, 5.30 p.m., Great George-street, S.W.1. "Festival of Britain, 1951: The South Bank Exhibition Buildings," by Mr. R. Freeman, Mr. R. T. James and Mr. H. Casson. *Midlands Association:* Wednesday, February 20, 7 p.m., Loughborough College, Loughborough. "Developments in Railway Bridge Design," by Mr. F. Turton. *Yorkshire Association:* Wednesday, February 20, 7 p.m., University, Leeds. Joint Meeting with INSTITUTION OF STRUCTURAL ENGINEERS (*Yorkshire Branch*). "Prestressed-Concrete Bridge, Skelton Grange Power Station," by Mr. J. N. Garden.

INSTITUTE OF FUEL.—Tuesday, February 19, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Investigation of Whole-House Heating," by Mr. F. C. Lant and Dr. J. C. Weston. *Midland Section:* Tuesday, February 19, 6 p.m., James Watt Memorial Institute, Birmingham. "Measurement of Transient Temperatures," by Mr. D. K. Mackenzie and Miss R. Milne. *North-Western Section:* Wednesday, February 20, 7.30 p.m., Grosvenor Hotel, Chester. "Thermal Factors in Furnace Design," by Professor R. J. Sarjant and Mr. W. Hulse. *Yorkshire Section:* Wednesday, February 20, 6.30 p.m., University, Sheffield. "Gas Producers," by Dr. F. J. Dent.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, February 19, 6.30 p.m., 2, Savoy-hill, W.C.2. "Scope and Application of Metal Rectifiers," by Mr. Donald Ashby.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch:* Tuesday, February 19, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Completed Abertillery Bridge," by Mr. Mr. W. A. Evans.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, February 19, 7 p.m., 4, Hamilton-place, W.1. "Glider Design," by Mr. K. G. Wilkinson. Thursday, February 21, 7.30 p.m., Electricity Showrooms, Hull. "Power Steering for Aircraft," by Mr. K. G. Hancock and Mr. P. Person.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* Tuesday, February 19, 7.30 p.m., Royal Victoria Station Hotel, Sheffield. "Enterprise in Engineering," by Air Commodore F. R. Banks. *Institution:* Friday, February 22, 6.30 p.m., 39, Victoria-street, S.W.1. "Anglo-American Productivity Reports," by Mr. R. G. Hooker.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, February 19, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Modern Body Design and Construction," by Mr. J. McIndoe. *Institute:* Thursday, February 21, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Chassis-Frame Construction and Repair," by Mr. C. F. Cunningham.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 20, 3 p.m. to 7 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. Discussion on "Meteorology and the Operation of Jet Aircraft."

ROYAL SOCIETY OF ARTS.—Wednesday, February 20, 5.15 p.m., John Adam-street, W.C.2. "Modern Developments in Soil Science," by Sir William Ogg.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, February 20, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Developments in Vacuum-Brake Equipment," by Mr. G. C. Marsh.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Liverpool Branch:* Wednesday, February 20, 6.30 p.m., Radiant House, Bold-street, Liverpool. "Centrifugal Pumps and Heating Systems," by Mr. G. R. Radcliff. *Manchester Branch:* Friday, February 22, 6.30 p.m., Engineers' Club, Manchester. "Full-Scale Heating Research," by Dr. J. C. Weston.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, February 20, 6.30 p.m., School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Search Radar for Civil Aircraft," by Mr. P. L. Stride.

INSTITUTE OF BRITISH FOUNDRYMEN.—*North-East Scottish Section:* Wednesday, February 20, 7.30 p.m., Imperial Hotel, Arbroath. "Defects in Castings," by Mr. J. L. Francis. *West Wales Section:* Friday, February 22, 7 p.m., Technical College, Llanelly. "Engineering of Castings," by Mr. G. Jones.

INSTITUTION OF ENGINEERING INSPECTION.—*North-Western Branch:* Wednesday, February 20, 7.30 p.m., Engineers' Club, Manchester. "Non-Destructive Testing of Materials," by Mr. J. F. Hinsley.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, February 21, 2.30 p.m., Caxton Hall, S.W.1. Discussion on "Operating Problems."

INCORPORATED PLANT ENGINEERS.—*Liverpool Branch:* Thursday, February 21, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Refrigeration," by Mr. W. F. Ball.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 22, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Aluminium Alloys as Shipbuilding Materials," by Dr. E. C. B. Corlett.

PERSONAL.

MR. A. P. WICKENS, M.I.Mech.E., deputy chief engineer, Fighting Vehicles Design Establishment, Chertsey, Surrey, has been made chief engineer, Armament Design, Ministry of Supply. This post was formerly held by MR. S. S. C. MITCHELL, C.B., O.B.E., M.I.Mech.E., who, as stated on page 591 of our issue of November 9, 1951, has been appointed Controller of Guided Weapons and Electronics.

The Admiralty have announced the promotions of Captains (E) C. LITTLEWOOD, O.B.E., L. E. REBBECK, A.D.C., and I. G. MACLEAN, O.B.E., R.N., to Rear Admiral (E).

MR. J. L. TURNER, B.Sc., who is a vice-president of the Institution of Works Managers, has been appointed technical adviser to Leadbeater & Scott, Ltd., steel and tool manufacturers, National Steel Works, Penistone-road, Sheffield, 6.

MR. R. H. BRACKENBURY has relinquished his position on the board of directors of Acrow (Engineers) Ltd., as from January 28.

MR. F. C. LYNAM, F.R.Ae.S., technical director of the Airscrew Co. and Jicwood Ltd., Weybridge, Surrey, has been appointed general manager of the company. Mr. Lynam joined the board in 1946.

MR. W. S. ATKINS, B.Sc., M.I.C.E., M.Inst.W., has been awarded the Sir William J. Larke Medal of the Institute of Welding, 2, Buckingham Palace-gardens, London, S.W.1, for his paper, "Continuous Welded Structures—Abbey Works, Port Talbot." Papers highly commended were those of MR. J. LATIMER, on "Automatic Welding," and MR. A. R. MOSS, on "The Welding of Cast Iron." The Sir W. J. Larke Medal is the highest award of the Institute.

MR. L. B. SMITH has been appointed manager of the Building Division of Chamberlain Industries Ltd., Staffa Works, Leyton, London, E.10. He joined the staff of the company in 1934.

DR. S. HARPER, B.Sc., who has been working at the Institute for the Study of Metals, Chicago, after receiving a Fellowship from the Union Carbide and Carbon Corporation, has returned to this country to take up a post as investigator in the general metallurgy section of the British Non-Ferrous Metals Research Association, Euston-street, London, N.W.1.

The chairman of the Metropolitan Branch Committee of the Engineers' Guild Ltd., Abbey House, 2, Victoria-street, London, S.W.1, for 1951-52 is MR. J. T. WILLIAMS, B.Sc., A.M.I.C.E., the vice chairman is MR. R. F. PEARSON, A.C.G.I., B.Sc., D.I.C., A.M.I.C.E., and the honorary secretary MR. R. W. H. COUZENS, M.A., A.M.I.C.E., M.I.E.E.

MR. RAYMOND HAYNES, assistant lecturer in metallurgy, University of Leeds, has been awarded the Ph.D. degree of the University of Sheffield.

MR. R. DEAN ROBERTS, formerly with the Ford Motor Co. Ltd., Dagenham, has been appointed director of personnel for the David Brown Group of Companies.

MR. T. E. WHITESIDE has been appointed secretary of the British Cast Iron Research Association, Alvechurch, Birmingham. He will relieve the director, DR. J. G. PEARCE, O.B.E., who has also acted as secretary of the Association for many years.

MR. F. O. JONES has relinquished his position as assistant lecturer at the University College of Swansea and joined the staff of the A.E.I. Research Laboratory, at Aldermaston, Reading, Berkshire, as a research metallurgist.

NUCLEONIC AND RADIOLOGICAL DEVELOPMENTS LTD., have removed to 22, Marshgate-lane, London, E.15 (Telephone: MARyland 4577. Telegrams: Enarde Telex London).

A new northern regional office of the general rubber-goods division of the DUNLOP RUBBER CO., LTD., has been opened at Buckton Chambers, 57, Meadow-road, Leeds, 11, and MR. P. A. BRIDGE, manager of the hose and belting sales at Cambridge-street, Manchester, has been appointed regional manager. The office at Park-lane, Liverpool, is now closed.

AN INTERNATIONAL COUNCIL FOR ELECTRODEPOSITION has been formed by the INSTITUTE OF METAL FINISHING in co-operation with the AMERICAN ELECTROPLATERS' SOCIETY, with the object of co-ordinating their activities where international action may be necessary or desirable. The headquarters of the Council, for the present, are at 27, Islington High-street, London, N.1. The President of the Institute of Metal Finishing, MR. H. SILMAN is the chairman of the Council and the honorary secretary of the Institute, DR. S. WERNICK is honorary corresponding secretary of the Council.

BRITISH INSULATED CALLENDER'S CABLES LTD. announce that the telephone number of their Cardiff branch will be changed, with effect from 1.30 p.m. to-morrow, Saturday, February 16, to Cardiff 24716-7.

The London office of the NORDBERG MANUFACTURING CO., makers of crushing and grinding machinery, is being moved during the present month from Brook House, Park-lane, to 19, Curzon-street, W.1.

THE COLLEGE OF AERONAUTICAL AND AUTOMOBILE ENGINEERING.

(*For Description, see Page* 196.)

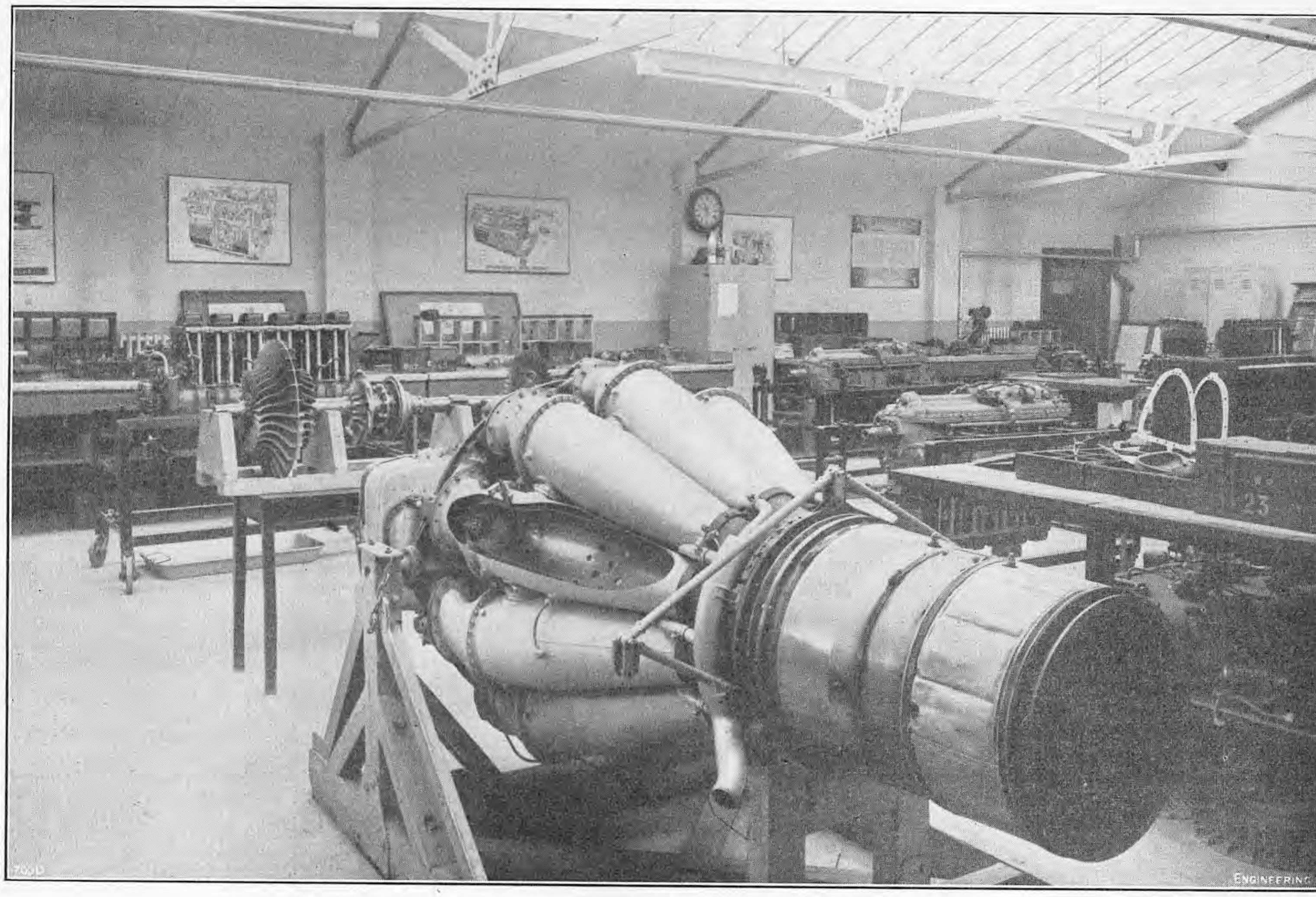


FIG. 4. AERO-ENGINE INSTRUCTION SHOP; IN-LINE AND TURBO-JET ENGINES.

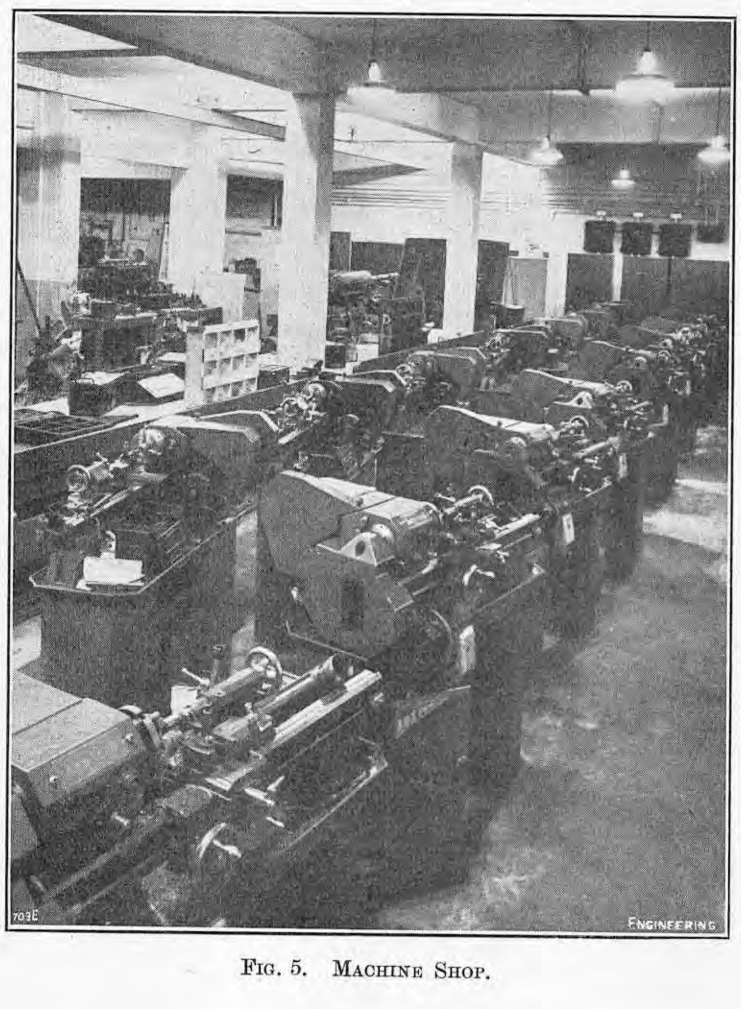


FIG. 5. MACHINE SHOP.

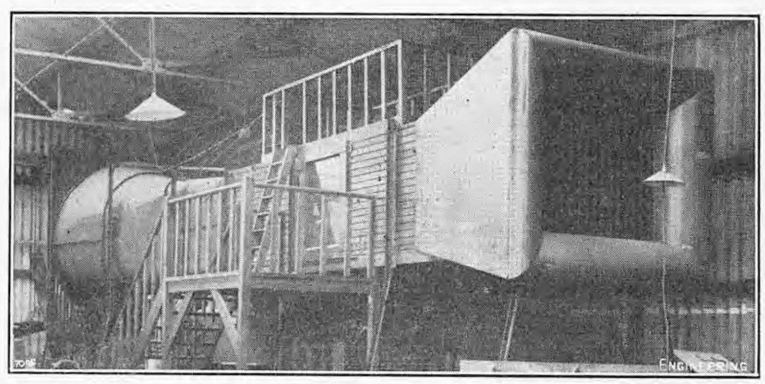


FIG. 6. WIND TUNNEL AT REDHILL AERODROME.

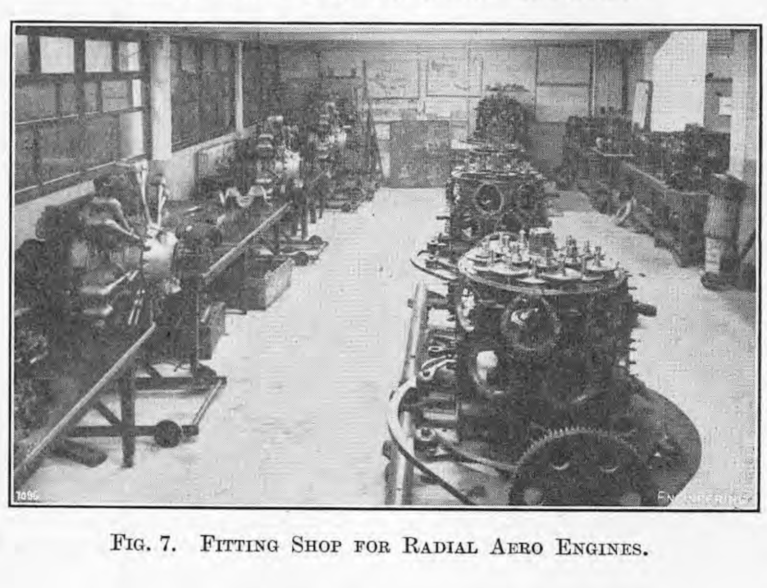


FIG. 7. FITTING SHOP FOR RADIAL AERO ENGINES.

ENGINEERING

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ENGINEERING

FRIDAY, FEBRUARY 15, 1952.

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STEEL AND INDUSTRY.

READERS of the newspapers of this country—which means all but a negligible percentage of the population—cannot have failed to notice how frequently, in the past few months, there have been reports that factories have been obliged to work short time, and, in many cases, to dismiss some of their employees, because of a lack of steel. Week by week in our "Notes from the Industrial Centres," we have recorded such instances ; and those that we have mentioned have been by no means all that our various correspondents have brought to our notice. Industrial users of steel in its many forms were beginning to feel some anxiety about the supplies long before the official list of allocations was published, and even before the possibility of such controls was discussed in Parliament ; but it is doubtful whether the full significance of the pending reductions in supplies was appreciated at all generally before the blow actually fell, in spite of warnings from knowledgeable executives in the steel industry that the shortage of scrap must inevitably affect output in the very near future. To some extent, perhaps, the steel industry itself should be held responsible, in that its spokesmen did not sufficiently stress, while the output was mounting steadily in the years immediately after the war, that this seemingly buoyant development was, in fact, something abnormal ; but those in the industry may be pardoned if they did not, at that time, preach a caution that would have seemed somewhat illogical when, concurrently, they were announcing repeated increases in steel-producing and working capacity.

Even if they had done so, it is doubtful in the extreme whether the general public would have taken any notice. The average man is not inclined by nature or training to take the wide views of the economist. Unless he is personally engaged in steel production, the output of ingots or castings means nothing to him. He thinks only in terms of consumer goods, and of his own ability or inability to buy them and pay for them ; and, more often than not, not even so far as that, for he expects, as a matter of course, that the goods shall be available all the time so that he may buy them just as soon as his personal finances permit. He is now learning something about economics at first hand ; but so complicated has become the structure of trade since two wars have encouraged Governments to take control of it that the real why and wherefore of the handicaps and restrictions that are afflicting him are still beyond his comprehension.

There is some justification for the failure of the man in the street to understand the position, for it is not easy to see at a glance where the annual output of steel actually goes. The total production in 1950 was 16,293,000 tons and in 1951, 15,638,000 tons. Shipbuilding, obviously, is a heavy consumer ; the demand of the heavy engineering industries is also a major item, though a less obvious one to the ordinary public ; the needs of the re-armament programme are considerable, though much of that consumption is going in directions which are not likely to be the subject of published statistics. When every allowance is made for these large demands, however, they do not add up to anything like 15,000,000 and more tons per annum, and it becomes evident that the growth in steel consumption is the result of a host of relatively small increases, none of which would be expected individually to have much effect on the level of supplies.

Some insight into the distribution of steel is afforded by the figures given in the *Monthly Statistical Bulletin*, issued by the British Iron and Steel Federation, though these figures relate only to the output as various forms of steel and not, in most cases, to the eventual uses to which the steel is put. The issue of the *Bulletin* for December, 1951, for instance, shows the deliveries of non-alloy steel under 17 headings, comprising ingots, etc., and 16 forms of finished steel. The deliveries of alloy steel are added, making 18 categories in all. The figures are given for the complete years 1948, 1949 and 1950, and for the first eleven months of 1951 ; and, for comparison, for the first eleven months of 1950 as well as for that complete year. In a majority of the 18 categories there are considerable increases in the consumption, the total (including alloy steel) rising from an average of 256,700 tons a week in 1948 to 275,900 tons in 1949, 290,800 in 1950, and 298,400 in the first eleven months of 1951.

The wide spread of the increased consumption can be inferred from the categories which show the greatest increases. Plates of ⅛ in. thickness and over (which, of course, covers the shipbuilding industry) increased from 36,100 tons a week in 1948 to 40,000 tons in 1950 and 40,900 tons in 1951 ; and "other heavy rolled products" were in about the same proportion. Deliveries of sheets, however, rose from 26,300 tons a week in 1948 to 33,600 tons in 1951 ; tubes, pipes and fittings from 15,100 tons in 1948 to 21,800 tons in 1951 ; mild wire from 10,100 tons to 12,100 tons in the corresponding periods ; and hard wire from 2,900 tons to 3,700 tons. Alloy steel deliveries, which were 9,100 tons a week in 1948, jumped to 10,400 tons in 1949, 10,600 tons in 1950, and averaged 12,200 tons in the first eleven months of 1951. These are the categories from which scores of small industries draw their supplies ; some directly, but the majority through factors. It must be remembered, too, that the whole economic tendency of the past halfcentury or more, as transport facilities have improved, has been for both the final users and the factors to hold smaller stocks than formerly and to rely on being able to draw promptly, as the occasion might arise, from the source next above them. Heavy taxation and consequent financial stringency have probably accelerated this trend, by depriving both users and factors of the means to accumulate the capital necessary to maintain bigger stocks.

The Iron and Steel Distribution Order, No. 2006 of 1951, which came into force on February 4, 1952, is not one of the easier publications to understand, when perusal of it is continued beyond the first paragraph. That paragraph, introducing "Part I—Acquisition and Disposal," is clear enough, stating with the most uncompromising bluntness that "No person shall acquire or dispose of or agree to acquire or dispose of any iron or steel being of a type and class mentioned in the First Schedule to this Order: except in accordance with the provisions of this Order." The Schedule referred to lists three types of material—alloy iron, alloy steel and non-alloy steel—and 18 classes, not identical with those of the *Monthly Statistical Bulletin* of the British Iron and Steel Federation, but covering the available output with almost equal completeness. There are exceptions to the general control, however; the Fifth Schedule, dealing with "Material which may be acquired, used, etc., for any purpose," exempts high-speed steel, and "sheet guaranteed by the makers to be sheet having specified electrical properties." The restricted categories of steel and iron are also exempted when dealt with in small quantities (in no case exceeding 1 ton) and this is the subject of the Third Schedule. The Fourth Schedule specifies uses (mainly the manufacture of advertising novelties) which are now prohibited.

Apart from the relatively unimportant prohibitions listed in the Fourth Schedule, the sum total of which cannot affect the disposal of any considerable part of the steel industry's annual output, "the bearings of this" Order, as Mr. Bunsby might have remarked, "lays in the application on it," and it is in this respect that the Ministry of Supply appear to have acted, in some cases, rather short-sightedly. An example was disclosed, during the present week, by the British Waterworks Association at a protest meeting of their members, when it was stated that the allocation of steel for the purposes of water-supply undertakings, during the first three months' operation of the Order, was precisely nil, except for housing schemes. The effect of this embargo on the construction, extension and repair of water mains was illustrated by a number of instances in which, it was alleged, the provision of necessary supplies to industrial establishments, many of evident national importance, would be seriously retarded. In one case, it was stated, in which a mere 2 tons of steel was urgently needed to repair a burst main, an allocation had been refused. In another, fears were expressed that the progress of work in connection with the water supply to a new electricity generating station might be seriously jeopardised.

It is inevitable, in the detailed application of any intentionally comprehensive control, that there will be inequalities of treatment, possibly leading to individual hardships, if only because no official or group of officials can be expected to have at their fingers' ends all the knowledge necessary to evaluate every claim for special consideration. The best that can be hoped for, in such circumstances, is that the officials concerned will preserve open minds and may be given the necessary authority to make essential adjustments without too great an elaboration of red tape; and that the claimants for special consideration should restrain any tendency to exaggerate the amount and urgency of their needs. That there is not enough steel is self-evident; but any control which retards essential work is, *ipso facto*, bad, and should be revised promptly.

POWER DEVELOPMENTS IN ONTARIO.

In the 45 years since its inception, the Hydro-Electric Power Commission of Ontario has grown from a small organisation, purchasing power from two commercial companies, to "one of the leading public utilities of the world." The first generating station, with an installed capacity of 2,160 kW, was purchased in 1914, and in the same year the Commission built a 640-kW station. In 1950, the dependable peak capacity of the Southern Ontario system, which serves the triangular peninsula lying between Lakes Huron, Erie and Ontario and forms the most populous part of the Province, was 2,181,000 kW. The corresponding figure for the Thunder Bay system, covering a smaller area of the north-western shore of Lake Superior, was 232,600 kW. The Northern Ontario Properties, which are not a system in the same sense as the other two, cover a group of systems serving the district to the north and west of Lake Nipissing; of these the dependable peak capacity at the end of 1950 was 316,700 kW. The grand total of these three figures, 2,730,300 kW, includes resources from which power is purchased.

The load on, and resources of, the whole organisation have, with few minor exceptions, grown steadily with each year of operation but, as recorded in the latest report,* progress in the year 1950 surpassed anything previously achieved. In that period, plant in four hydro-electric stations and five thermal stations went into operation representing a total additional capacity of 467,350 kW. During the year, the Commission operated 64 hydro-electric stations and seven thermal stations which together delivered 12,378,521,053 kWh of energy, but even this was not sufficient to meet the demand and 5,880,079,157 kWh were purchased, making a grand total of 18,258,600,210 kWh. The purchased power is mainly obtained from the neighbouring Province of Quebec, but supplies are also obtained from various power companies and from customers having stand-by Diesel and steam plants.

In his introduction to the report, the Chairman of the Commission attributes the "sudden upsurge in the steadily mounting demands for power" to the war in Korea, but it is clear that every type of service is progressing rapidly; supplies to municipalities increased by 16·8 per cent. in 1950 over the previous year and the peak load in the rural areas increased by 22·3 per cent. Even with its new plant and purchased power the Commission was not able to meet all demands in full and it was necessary to curtail supplies to some industrial consumers normally receiving power directly from the Commission. Some assistance was afforded by various municipalities who continued to use daylight-saving time until November 26. The primary peak demand on the Southern Ontario System, which serves the main industrial areas in the Province, was 2,360,864 kW in December, an increase of 18·8 per cent. over the corresponding figure for 1949; it is estimated, however, that if it had been possible to meet the unrestricted demand on the earlier year, the actual increase in customer requirements in 1950 would have been 12·4 per cent., instead of the 18·8 per cent. represented by the actual peak load.

The new hydro-electric plant which became available in 1950 is situated in the Des Joachims and Chenaux stations of the Southern Ontario system; the George W. Rayner station in north-eastern Ontario; and the Pine Portage station serving the Thunder Bay system. In point of capacity, the Des Joachims station is much the most important of these. It is situated on the Ottawa River and contains eight 62,000-brake horse-power Francis-type turbines, operating under a 130-ft. head, and connected to 50,000-kVA alternators generating at 13·8 kV. Seven of these machines went into operation during 1950, and the eighth in February, 1951. The main dam, on the Ottawa River, is a concrete structure 2,400 ft. long and with a maximum height of 180 ft, the power house being situated at the foot of this dam. On the north side of the main river, there is an ancient river channel leading to McConnell Lake, this channel joining the main river at a point below the main dam. At the upper end of the ancient river channel, the McConnell Dam has been built. This is a concrete structure 1,600 ft. long and with a maximum height of 130 ft. The dam is provided with six sluice gates 40-ft. wide. During periods of high river flow, excess water is passed through this dam and flows into the Ottawa River through the McConnell Lake.

The Chenaux Station is also situated on the Ottawa River, about 60 miles downstream from the Des Joachims station. It has a total installed capacity of 120,000 kW in eight units. Two of these were in operation towards the end of 1950, and it is indicated in the report that the remaining six would be in service by September, 1951. Including these six units, there were at the end of 1950, plants of a total capacity of 1,368,000 kW authorised or under construction to serve the Southern Ontario System. The largest of these new plants is the Sir Adam Beck-Niagara Station No. 2 on the Niagara River, which is expected to be in service in 1954; it will have a total capacity of 450,000 kW. The building of this station has been made possible by the coming into operation of the Niagara Diversion Treaty negotiated between Canada and the United States. The treaty came into force on October 10, 1950. In addition to hydro-electric plant serving the Southern Ontario System, five "emergency fuel-electric generating stations" came into operation in 1950; these presumably are stand-by stations available at times of water shortage. Two further steam stations are under construction. One of these, the J. Clark Keith Station, in Windsor, will have a total capacity of 198,000 kW in three units, the last of which is expected to be in operation in November of this year. The other, the Richard L. Hearn Station in Toronto, is designed for an ultimate capacity of 400,000 kW. It will contain four units, but two of these will have a capacity of 88,000 kW at 25 cycles on installation; later they will be converted to a capacity of 100,000 kW at 60 cycles.

This matter of frequency conversion constitutes an important part of the work of the engineering staff of the Commission. A periodicity of 60 has been adopted as a standard and a large area in southern Ontario, now supplied at 25 cycles, is being changed over. By the end of 1950, 343,020 frequency-sensitive pieces of electrical equipment, owned by 86,000 consumers, had been converted. One of the difficulties experienced in carrying out the frequency-standardisation programme has been the increase in the load on the 25-cycle system. To deal with the situation, part of the 25-cycle transmission system is being duplicated by constructing 60-cycle lines and stations which will ultimately be incorporated in a standard 60-cycle system. New customers will be connected to this duplicate supply and it will also be available to customers and municipalities that can undertake the change-over of their own plants.

The extensive increase in power-station capacity of the Commission's systems has naturally been accompanied by transmission-line and sub-station developments. During 1950, eight new transformer stations, having a total capacity of 259,800 kVA, were completed and seven existing stations were increased in capacity by a total of 512,000 kVA.

* *Forty-third Annual Report of the Hydro-Electric Power Commission of Ontario for the Year ended December 31st, 1950.* Printed and Published by Baptist Johnston, Toronto.

NOTES.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

IT is announced that the Council of the Institution of Electrical Engineers have awarded the Faraday Medal for 1952 to Professor Ernest Orlando Lawrence for his distinguished work in the field of nuclear physics. Professor Lawrence is Director of the Radiation Laboratory in the University of California and his early researches were concerned with photo-electric effects. In 1930, he became interested in the possibilities of using the method of resonance acceleration to obtain positive ions of very high energies and this led him to build the first cyclotron, which he used to study the transmutation of elements and artificial radioactivity. During the last war he was a member of the team of British and American scientists who were concerned with the development of fissile materials. In the course of this work he invented the "Calutron" mass separator for effecting the large-scale separation of uranium isotopes. Professor Lawrence is a Nobel Prizeman and has been the recipient of the Hughes Medal of the Royal Society and the Duddell Medal of the Physical Society. It is also announced that the honorary membership of the Institution has been conferred upon Sir Arthur Fleming for his distinguished work in electrical engineering, in particular in the fields of technical education; and upon Sir Edward Appleton for his distinguished work in the field of pure and applied physics and his researches into the characteristics of the ionosphere and the part they play in determining the mode of propagation of radio waves. Sir Arthur Fleming has been connected with the Metropolitan-Vickers Electrical Company for over 50 years and was instrumental in founding its Research Department, where a great deal of important work has been carried out, including the development of a technique for high-vacuum high-voltage equipment and demountable thermionic valves. He has also played a leading part in emphasising the complementary needs of scientific research in industrial problems and the technical training of personnel. Sir Arthur was president of the Institution in 1938-39 and was awarded the Faraday Medal in 1941. Sir Edward Appleton was Wheatstone Professor of Physics in the University of London from 1924 until 1936. During the three following years he was Jacksonian Professor of Natural Philosophy at Cambridge and, in 1939, became Secretary of the Department of Scientific and Industrial Research. He has been Vice-Chancellor of the University of Edinburgh since 1949. Sir Edward's researches into the propagation of radio waves, particularly their reflection and refraction, have been of fundamental importance in the development of radio-location and his name has been given to an ionospheric layer. He was awarded the Nobel Prize in 1947 and has also been the recipient of the Hughes Medal of the Royal Society, the Ewing Medal of the Institution of Civil Engineers and the Faraday Medal.

PROPOSED REGISTRATION OF CLERKS OF WORKS.

We have received a letter from Mr. F. H. Peck, A.R.San.I., the honorary secretary of the Joint Committee for the Proposed Registration of Clerks of Works Act. The text of it is as follows. "The question of a Clerks of Works Registration Act was taken up earnestly some years ago and, as a result, a Joint Committee comprising members representing several important clerks of works associations throughout the country was formed to promote legislation that would lead to the registration of all clerks of works, the prohibition of the use of the title "clerk of works" by persons not so registered, and the establishment of a body to secure proper standards of professional qualifications for clerks of works. The necessity for such legislation would, at first sight, be apparent to all persons engaged in architecture, building or engineering, that is to protect the qualified clerk of works, but the Joint Committee have as their main object the desire to protect the building industry and all those concerned by ensuring that qualified persons only are engaged in superintending, on behalf of the clients or their agents, the progress of the works. We often hear the term "jerry building" used, but can there be jerry building if there are clerks of works supervising the works? There must be an answer to this. The Joint Committee consider that the qualified clerk of works is as important to the building industry as other professional persons or operatives and that, in the interests of all the professions concerned, the building industry and the client, who is so often the public, the occupation of clerk of works must be fully recognised as a profession and that the name or title should be safeguarded. To this end, therefore, the Committee have prepared the various clauses to be incorporated in the proposed Registration Bill, and are now approaching the drafting stage." The chairman of the committee is Mr. G. W. Harris, and the honorary treasurer is Mr. A. Barratt. Mr. Peck's address is 23, Anthony-road, Welling, Kent.

BRANCKER MEMORIAL LECTURE.

The tenth Brancker Memorial Lecture was given before a meeting of the Institute of Transport in London on Monday, February 11, by Air Chief Marshal Sir Frederick Bowhill, G.B.E., K.C.B., C.M.G., D.S.O. He had chosen for his subject "The Flying Boat and its Place in Aviation," because, he explained, the present trend towards eliminating the flying boat appeared to him to be throwing away a valuable asset. The long-distance aeroplane, he thought, must become larger in order to pay its way. The principal points that had been raised against the flying boat were, firstly, that it was less economical to operate than the land-plane, and, secondly, that since other nations had abandoned the civil flying boat, the British Government would have to bear the full cost of marine bases abroad used by British flying boats. Sir Frederick referred to an appendix to the paper in which he quoted references to show that the very large flying boat, owing to its lower structure weight as compared with the equivalent land-plane, would not be uneconomical in operation, and its performance would not compare unfavourably with the land plane. Passengers had shown a preference for the flying boat. He did not believe that the maintenance costs were greater than those of a large land plane, with complicated landing gear and heavy tyre-servicing costs. It was the indirect subsidy of airfield facilities, paid by the taxpayers, that made the land-plane economic from an operator's point of view. From an analysis of the relative costs of flying-boat bases and land aerodromes, he concluded that the cost of the flying-boat base was lower. Land did not have to be purchased for the actual flying-boat base, and there were no heavy runways to be constructed; against this, some dredging might be required for the water base, but the cost might sometimes be largely offset by reclamation of land. For both aerodromes and water bases, land had to be purchased for the construction of maintenance and administration buildings, handling areas, etc., and in the case of the flying-boat base, there was the additional cost of a slipway and a means for beaching big boats. He thought, however, that the slipway would only rarely be required; easily-constructed and transportable floating docks should be provided for loading and servicing. The cost of control, approach and radar aids was common to aerodromes and to water bases. A primary factor favouring the water base, however, was the noise nuisance, which was becoming a serious problem in built-up areas in the vicinity of land aerodromes, and would become still worse with the advent of jets, and more frequent aircraft movements. In the event of war, the country should be able to draw on the strength of its merchant air fleet for vital transport. For this reason alone, a proportion of the transport aircraft should be flying-boats, which did not depend for their operation on runways or landing strips.

EMPIRE MINING AND METALLURGICAL CONGRESS.

The fifth Empire Mining and Metallurgical Congress is to be held in Australia and New Zealand from April 12 to May 23, 1953. It is being convened by the Empire Council of Mining and Metallurgical Institutions, of which the London members are the Institute of Metals, the Institute of Petroleum, the Institution of Mining Engineers, the Institution of Mining and Metallurgy, and the Iron and Steel Institute. The first Congress of this kind was held at the Wembley Exhibition in 1924; the second was in Canada in 1927, the third in South Africa in 1930, and the fourth—which was to have been held in Australia in 1933, but was cancelled owing to the economic conditions prevailing at that time—in Great Britain in 1949. The chief object of the Congress is to afford an opportunity for mining engineers, metallurgists, scientists, engineers and others concerned with the mining and metallurgical industries to meet and discuss technical progress and problems, including the development of the mineral resources of the British Commonwealth. The main session of the forthcoming Congress will be held in Melbourne on Monday and Tuesday, April 20 and 21, but it will be preceded by a week's tour of Tasmania. After the main session, the delegates will tour various industries in Victoria, then meet at Canberra, and finally go on three tours in New South Wales, South Australia, and, if desired, Queensland or Western Australia. Some delegates will later visit New Zealand, inspecting coal and mineral fields in the South Island, attending a conference at Dunedin, and visiting hydro-electric plants, etc., in the North Island. The technical papers to be presented at the Congress will deal with Australian mineral deposits and practices under the following headings: geology of Australian ore deposits, mining methods, milling methods, extraction metallurgy (ferrous and non-ferrous), coal, and miscellaneous and general. Inquiries regarding the Congress, which is open to anyone interested, irrespective of nationality, should be addressed to the Secretary, Fifth Empire Mining and Metallurgical Congress, Osborne House, 399, Little Collins-street, Melbourne, Victoria, Australia.

TRAINING OF MERCANTILE-MARINE ENGINEER OFFICERS.

As a result of consultations between the Ministry of Transport and the organisations representing shipowners, engineer officers and other interested parties, approval has been given by the Ministry to a new scheme for training engineer officers for the Merchant Navy. The scheme embraces a two-year Ordinary National Diploma course in mechanical engineering at an approved technical college, with additional practical training during vacations, followed by a period of 18 months' service as an apprentice engineer at sea and a year's special training in a shipyard, marine-engine works or other suitable engineering works. Candidates wishing to take advantage of the scheme, however, must be 16 years old and must have received full-time education up to the age of 16; furthermore, they have to show proficiency in mathematics and physics. Candidates who have only received a full-time education up to the age of 15 may be accepted provided this has been followed by at least a year's part-time study at an approved technical college qualifying for admission to the first year of the Ordinary National Diploma course. The new scheme will be regarded as an alternative to the standard period of four years' training in an approved engineering works required under the Ministry's regulations for the examinations for certificates of competency. According to the Ministry of Transport, a number of shipping companies have already adopted the scheme and their names can be ascertained from any office of the Shipping Federation. It is not made clear, however, what arrangements have been made for shipyards and engineering works to accept candidates during vacations from technical college and for their one-year practical training.

SYMPOSIUM ON MINERAL DRESSING.

The Council of the Institution of Mining and Metallurgy are organising a "Symposium on Recent Advances in the Field of Mineral Dressing," to be held at the Imperial College of Science and Technology (Royal School of Mines), Prince Consort-road, South Kensington, London, S.W.7, on Tuesday, Wednesday and Thursday, September 23, 24 and 25, 1952. We understand that upwards of 30 short papers are being prepared to form the basis for the discussion. The papers will be broadly grouped into three classes dealing, respectively, with fundamental concepts and experimental methods, advances in practice at selected plants, and advances in plant design and machine manufacture. A provisional list of the papers is now available and such titles as: "The Mathematics of Crushing and Grinding," by Mr. F. C. Bond; "The Determination of the Efficiency of Grinding Mills," by Mr. W. F. Carey; "Principles of Sub-Sieve Particle-Size Measurement," by Dr. H. Heywood; "Recent Developments in Gravity Concentration," by Mr. F. B. Michell; and "Movement of Fine Particles in a Hydraulic Cyclone," by Mr. D. F. Kelsall, suggest the scope of the symposium. Contributions are to be received from Australia, Canada, South Africa, Holland, Sweden, the United States, and elsewhere. Visits to works and research laboratories are being arranged for a few days following the technical sessions, particularly for the benefit of visitors from overseas. The symposium is open to all interested persons, whether or not they are members of the Institution. A charge of about 2*l.* (about 1*l.* for members of the Institution) will be made to cover attendance at the meeting, a set of advance proofs of the papers and a copy of the final volume of the proceedings. All communications should be sent to the secretary of the Institution, Salisbury House, Finsbury Circus, London, E.C.2.

COMMONWEALTH SCIENTIFIC CONFERENCE.

All the self-governing Commonwealth countries will be represented at the Commonwealth Scientific Conference which is to be held in Canberra and Melbourne under the chairmanship of Dr. Clunies Ross, Chairman of the Australian Commonwealth Scientific and Industrial Research Organisation. The Conference will be opened in Canberra by the Prime Minister of Australia on February 18. Sir Ben Lockspeiser, K.C.B., F.R.S., Secretary of the Department of Scientific and Industrial Research, is leading the United Kingdom delegation, the other members of which are Sir William Slater, K.B.E., Secretary of the Agricultural Research Council, Dr. F. H. K. Green, representing the Medical Research Council, and Dr. Alexander King, Head of the Intelligence Division of the Department of Scientific and Industrial Research. Colonial research will be represented by Dr. G. A. C. Herklots of the Colonial Office. Observers representing the United States Government will also attend the Conference. The main object of the conference is to promote collaboration in research throughout the British Commonwealth. Facilities for spreading information and arranging meetings between scientists will be reviewed. A number of subjects have been suggested as possible topics for collaboration, among which may be mentioned the utilisation of seaweed, research on metal casting, sulphur production, the utilisation of low-grade ores and wastes, soil mechanics, and the utilisation of solar energy by physical or biological means. Relations with internal research organisations and with members of the Organisation for European Economic Co-operation will also be discussed.

MECHANICAL PROPERTIES OF PLASTICS.—A whole-day discussion on "The Mechanical Properties of Plastics" has been arranged jointly by the Chemical Engineering Group and the Plastics and Polymer Group of the Society of Chemical Industry. It will take place at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, on Friday, March 7, and not on February 29, as previously arranged. The morning session will be held from 10 a.m. to 12.45 p.m., and the afternoon session from 2 p.m. to 4.30 p.m. A dinner has been arranged for the evening. Further information may be obtained from the secretary of the Plastics Group, Mr. C. E. Hollis, Research Department, Distillers Co., Ltd., Great Burgh, Epsom, Surrey.

AGRICULTURAL TRACTORS IN TURKEY.—Speaking at a luncheon to mark the dispatch of the 5,000th Ferguson tractor to Turkey, Mr. H. C. Berens, chairman of the British Overseas Engineering and Construction Corporation, Limited, the distributors of Ferguson tractors in Turkey, referred to the progress made recently in the mechanisation of Turkish agriculture. The farsightedness of the Turkish Government in making available low-interest long-term loans to farmers, he thought, was largely responsible for the six-fold increase in farm mechanisation which had occurred during 1951. In 1950 only 916 tractors had been imported by Turkey from the United Kingdom, but in 1951 the total rose to 6,322.

LETTERS TO THE EDITOR.

THE ENGINEERING OUTLOOK.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the article on page 131, in your issue of February 1, dealing with the outlook in heavy electrical plant, I think that, inadvertently, you have not done justice to the achievement of the makers of water-tube boilers in meeting the requirements of the British Electricity Authority.

While your article purports to deal with the position during 1951, the specific reference to the fulfilment of the delivery programme for that year is based on the achievement of the first eight months only. On January 3, several weeks before your article was published, it was announced that, for the calendar year, no less than 46 out of 57 boilers had, in fact, been brought into service, representing approximately 80 per cent. of the programme planned at the beginning of the year. A further nine boilers were completed, but could not be brought into commission for causes outside the control of the boiler contractors. This is an achievement which, in present circumstances, deserves the highest credit.

I should also like to correct the statement that the B.E.A. have undertaken to buy up any large Diesel sets not required for export or by home industrial users. The Authority have not given any such undertaking, but they have invited tenders for 100,000 kW of Diesel generating plant which they are arranging to install in a number of their smaller power stations.

Yours faithfully,
ERNEST LONG,
Secretary.

British Electricity Authority,
Great Portland-street,
London, W.1.

PATENT LAW REFORM.

TO THE EDITOR OF ENGINEERING.

SIR,—To-day our real wealth is our inventive genius and our capacity for honest hard work; but present conditions tend more than ever before to stifle inventive enterprise. It is now almost impossible for the average invention to be developed to a substantial stage within the nine months to twelve months of provisional patent protection. An extension of this time-limit is a pressing need. Moreover, income tax abatements should include patent fees, on conditions similar to those governing the allowance for life insurance. Unless something is done, the nation that allowed the inventor of the cinematograph (for example) to die in absolute poverty may find that men with ideas of "brain-wave" quality seek other climes in which to develop them.

Yours faithfully,
G. P. GERME.

London, S.W.16.
February 1, 1952.

EDUCATION FOR MANAGEMENT.—Lectures on "Education for Management in the United States and England" will be delivered to the civil and mechanical engineering department at Woolwich Polytechnic, Thomas-street, Woolwich S.E.18, on Wednesday, February 27, commencing at 7 p.m. The lecturers will be Sir Thomas Hutton, general manager of the United Kingdom section of the Anglo-American Council of Productivity, and Mr. J. Wilson, M.I.Mech.E., Principal of the College of Technology, Birmingham. Numbered seats may be reserved on application to the head of the department at the Polytechnic.

CONFERENCE ON HUMAN RELATIONS IN INDUSTRY.—As announced in this week's "Labour Notes," a conference to discuss human relations in industry is being arranged by the Ministry of Labour and National Service. It will take place at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Tuesday, Wednesday and Thursday, March 18, 19 and 20. Applications to attend should be addressed to the director of public relations, Ministry of Labour and National Service, 8, St. James's-square, London, S.W.1.

THE NATIONAL RESEARCH DEVELOPMENT CORPORATION.

THE report of the National Research Development Corporation for the year ended June 30, 1951, (which was published by H.M. Stationery Office this week at the price of 9*d.* net) states that that body is progressively linking up its own work with such Government Departments as the Department of Scientific and Industrial Research, as well as with the universities and the industrial research associations. As a result, it is increasingly becoming aware of the fact that a new device or process has been originated and is thus in a position to take steps to ensure its development in the public interest. "Inventions which might be regarded as trivial are [thus] fitted into a more embracing pattern of inventive subject matter by collation of all the communications made to the Corporation in a given field." Actually, 897 patents and patent applications have been acquired. In addition, a number of licences and agreements have been completed or assigned to the Corporation.

Besides the routine exploitation of a large number of inventions, a smaller number require continuous supervision to be exercised over them at high level, owing to technical or commercial features of intrinsic importance or complexity in their constitution. In the technical field, this may arise from an initial breaking of fresh ground in an unexpected direction, or the need for the provision of substantial expenditure on development. For instance, some 80 inventions relating to electronic digital computers have been or are being vested in the Corporation, thus ensuring that adequate patent cover is available to inventors in this field.

Among the other activities of the Corporation, attention has been paid to the difficulty experienced by potential users in obtaining certain types of specialised equipment from United Kingdom industry and to the lack of availability of facilities for prototype design, manufacture and testing prior to the production stage. These problems have been examined in detail and, following discussions with industrial organisations, Government departments, research councils and learned societies, an arrangement has been reached with the British Scientific Instruments Research Association and the Scientific Instrument Manufacturers' Association for the study of individual proposals, so that their value can be assessed and recommendations made for the development and exploitation of them. It is not, however, considered to be part of the normal functions of the Corporation to provide working capital for private inventors, although every endeavour is made to put applicants for such assistance in touch with likely entrepreneurs or possible users. In fact, the Corporation's interpretation of their responsibility to the private inventor is to pay "for the development work necessary to give practical embodiment to immature, but fertile, ideas of a sufficient public importance." This can, in their opinion, be best achieved by demonstrating a fully-engineered prototype to a firm engaged in the industry concerned and thereby proving that the invention is a sound one."

Of the 1,317 inventions communicated during the year under review, 752 came from Government Departments, 442 from private sources, 81 from the universities and 13 from industrial research associations. As regards the future, it is pointed out that the Development of Inventions Act, 1948, requires the Corporation to act in the public interest and to collaborate rather than to compete with existing industries. Experience shows that the work which is being done represents a long-term investment in British inventiveness rather than providing support for inventions which will have a spectacular career in the near future. For this reason, it is expected that expenditure will be low in the earlier years of the Corporation's existence, but will increase as the number of inventions with which it is concerned accumulates and as each invention it sponsors approaches a degree of maturity where heavier expenditure upon it would be justified by an increasing measure of certainty as to its prospects. In many cases, too, the functions of the Corporation are likely to be mainly advisory.

FLUIDS FOR HYDRAULIC POWER TRANSMISSION.*

By A. E. BINGHAM, M.I.Mech.E.

THE principles and history of hydraulics have been dealt with in many publications, but in many text-books only water is considered as the hydraulic medium, whereas, in modern equipment, water is seldom used and has been mainly replaced by the lighter types of mineral oil. Although mineral oils have many advantages, in some circumstances their use is accompanied by a fire risk; this has been made more evident in aircraft, in die-casting and in press moulding of certain plastic materials which are inflammable or where there is an amount of inflammable material in the vicinity. When the plant is operating normally, there is no risk; it is only in the event of a failure, not necessarily due to the hydraulic system, that the danger arises. The risk need not be over-emphasised, but it is mentioned because it started many special research investigations which have led to improvement in both equipment and fluids.

The development of aircraft has led to demands for greater temperature ranges, and the solution of this problem should also be of benefit to land and marine applications, thus enabling hydraulic plant to be used in circumstances which might have been considered impossible several years ago. The requirements of an ideal fluid for aircraft are compared with those of land and marine equipment in Table I, herewith.

TABLE I.—REQUIREMENTS OF AN IDEAL HYDRAULIC FLUID.

Item.	Aircraft.	Land.	Marine.
1	Reasonable density; i.e., not greater than 1 gm. per cub. cm.	Unimportant.	Moderate importance.
2	High viscosity index; i.e., low rate of change of viscosity with temperature.	Important.	Important.
3	Large working range of temperature; e.g., + 80 deg. C. to — 70 deg. C. (176 deg. F. to — 94 deg. F.) with viscosity not less than 4 centistokes at 70 deg. C.	Important, but temperature range not so wide, say, + 70 deg. C. to — 40 deg. C. (158 deg. F. to — 40 deg. F.).	Important range, say, + 70 deg. C. to — 30 deg. C. (158 deg. F. to — 22 deg. F.).
4	Good lubricity over the usual working range.	Same.	Same.
5	Good "shelf life"; i.e., should not segregate or otherwise deteriorate during long storage.	Same.	Same.
6	Not harmful to hands of operators, nor toxic if sprayed.	Same.	Same.
7	Flash point above 100 deg. C. (212 deg. F.) and preferably non-inflammable. Spontaneous ignition temperature should be high.	Same.	Same.
8	Should not foam in a reasonably designed system.	Same.	Same.
9	Either natural or synthetic rubber should not be severely attacked by the fluid; neither should metal parts be corroded.	Same.	Same.
10	Should be "pumpable" up to at least 4,000 lb. per sq. in.; i.e., it should not suffer from shear breakdown.	Same, but occasionally even higher pressures required.	Same.
11	The properties should not change if vented to atmosphere at 70 deg. C. (158 deg. F.), even at low atmospheric pressures, say, 5 lb. per sq. in. abs.	Same, but altitude condition only applies rarely and then not so severe.	Same, but not altitude condition.
12	The fluid should be in good supply and available all over the world.	Availability need only be local.	Same as aircraft.
13	The price should be reasonable.	Same, but, except for very special applications, price much lower.	Same as land.

mine; but the S.I.T. is much more difficult to determine and is greatly influenced by circumstances. The specific properties of fluids and also some points regarding glands and seals are set out below. The mechanical arrangements and design of the latter have been covered very extensivly by M. White and D. F. Denny* and also by T. E. Beacham and F. H. Towler,† and so it is only necessary to deal here with the physical properties of the gland and seal materials. The need for further development and research on fluids and sealing materials is very real.

The choice of a hydraulic fluid may be greatly influenced by the available material for glands, seals, piston rings, valve seats, etc., and, generally, some synthetic rubbers are suitable for use with petroleum-base fluids and natural rubber for vegetable-base (castor) fluids. In each case, the "rubber" must be suitably compounded, cured, dimensioned, and finished to suit the particular application. The fluid and the seals must be considered together and, if a suitable sealing material cannot be found for a fluid, the fluid cannot be used, no matter how good its properties. This fact must not be overlooked or dismissed lightly; in fact, it is holding up the development of more than one suggested non-inflammable fluid at this moment.

Seals cause more anxiety in a hydraulic system than any other item, and their design and choice of material should be left to the expert. At the present stage of development, both natural and synthetic rubbers have an extreme temperature range of — 60 deg. C. to + 70 deg. C. (— 76 deg. F. to 158 deg. F.) for normal design of hydraulic systems, provided that the housing is properly designed as well as the seal. Often the seal is blamed instead of faulty design and workmanship of the metal parts; also leaks with dyed fluid are more readily detected than those with almost colourless fluid. Leaks with D.T.D.585 are easily seen because of the rich red dye.

The fluids under consideration are classed as "aircraft hydraulic fluids," and they are blended or compounded so that they can operate the hydraulic services over a wide range of temperatures. Present-day requirments are such that an aircraft must be able to operate on the same fluid at any point on the Earth's surface and up to the maximum ceiling. It is not practical to specify one fluid for operation at the Equator and another for operation above the Arctic Circle.

For commercial plants, in which there are no extreme conditions to be met, a number of petroleum-base oils are available, each reputable company having brands with definite viscosity ranges. These oils are carefully chosen and refined, and may have additives to inhibit oxidation, reduce foaming and augment anti-wear properties. It is not possible to give a full list, but from the seal aspect a gland which will withstand D.T.D.44D will be suitable for most commercial petroleum-base oils in ordinary circumstances. With the heavier oils at high temperature, shrinkage of the gland must be guarded against, and so both oil and gland suppliers should be consulted. The liaison between the plant manufacturer, oil supplier, and rubber and/or leather technologist is essential where high efficiency, with reasonable maintenance, is required. Specification reference numbers are shown in Table II, herewith and Table III shows details of fluids which have no official specification.

No fluid has all the properties listed in this table, but, except for the fire hazard, D.T.D.585 approaches quite closely to the above requirements for aircraft, as do certain well-known mineral oils of somewhat higher viscosity and more limited temperature range for land and marine application. The "non-inflammable" fluids which are available at the moment fall short on a number of points in all three applications, and, except for the water-base fluids, they do not all pass the various inflammability tests.

In aircraft, the question of sacrificing a number of good points for the sake of non-inflammability is not easy to answer. In land and marine applications, the water-glycol fluids would meet the temperature range, and the economic considerations would not be insurmountable; but the pressure would have to be limited to 2,000 to 2,500 lb. per square inch, according to the design of the pump bearings. Table I shows, in general terms, that one ideal fluid could cover all three classes, and therefore the concentrated research now proceeding in many parts of the world will probably help all hydraulic engineers, whether they be aeronautical, land, or marine.

In the meantime, those responsible for design, installation and maintenance should take particular care to see that possible spray leakage, e.g., from a split pipe, should not project itself on to a hot spot, especially where there are naked flames or where the hot spot may be above the spontaneous ignition temperature (S.I.T.) of the fluid. The flash point is important where naked flames are concerned and is easy to deter-

TABLE II.—*Hydraulic Oil Specifications.*

British Specification.	American Specification.	Royal Air Force Stores Reference Number.	Inter-Services Designation.	Notes.
D.T.D.44D	AN-O-6a (X) Amendment 4	34B/43	OM-13	Almost obsolete as hydraulic fluid; used as a turbine oil. Mineral base.
DTD585	MIL-O5606 (late AN-O-366)	34B/159	OM-15	In very extensive use. Mineral base.
	2-3 6D Amendment 1	34B/119	OM-3	For "Exactor" controls. Mineral base.
D.T.D.388	AC.3586.C Grade A	34B/83	OF-30	Castor base for oleo legs.
D.T.D.391				Castor base, almost obsolete; now replaced by Lockheed No. 22.
D.T.D.641	AC.3586.C Grade C Light	34B/182	OF-5	Castor base, not in extensive use; superseded by Lockheed No. 22.
D.T.D. 900/4081		34B/207	OF-4	Formerly Lockheed No. 22. Castor base. Good low-temperature properties and replaced D.T.D.391, D.T.D.388, and D.T.D.641.

TABLE III.—*Fluids which have no Official Specification.*

Name.	Type.	Notes.
"Hydrolube" U.4	Water-glycol base.	Non-inflammable; has been used experimentally in the United States. Has certain limitations.
EEL.6	Water-glycol base.	Non-inflammable; in experimental stage. Produced by Esso European Laboratories of the Esso Petroleum Company. May be used in trial installations in near future.
"Skydrol" ..	Phosphate-ester base.	Low inflammability. Developed by Douglas Monsanto in the United States. Specific gravity = 1·08.
"R.P.M." fluid ..	Halogenated.	Non-inflammable. Developed by California Research Station and marketed by Standard Oil Company in the United States. Specific gravity = 1·51.

The fluids are divided into various types depending on their basic ingredients: (*a*) Mineral—petroleum base; (*b*) Vegetable—castor base; (*c*) Water—water-glycol base; (*d*) Synthetic—ester base. Silicones; (*e*) Halogen—halogenated petroleum.

The type of fluid generally determines the material required for the seals and packings. Type (*a*) requires synthetic rubber; type (*b*) requires natural rubber; type (*c*) requires synthetic rubber, but slight modification may be necessary compared with type (*a*), and types (*d*) and (*e*) require very special compounding of synthetic rubber. Except in very few instances, the fluid cannot be changed in any system without changing all the glands and packings. Generally, the effect of using the wrong material is to cause excessive swelling and ultimately the complete failure of the material. Occasionally, the effect is excessive shrinkage, which leads to hardening and ultimate failure by cracking.

The identification of the available fluids is helped to a certain extent by colouring with dyes, but in other cases the recognition is more difficult. In most cases, a reasonably quick check can be made by measuring the density and viscosity. Mineral-base fluids can be isolated from castor-base by shaking in a test tube with alcohol. If they mix, the fluid has a castor base; if they separate out quickly it has a mineral base.

The following notes may help: D.T.D.391 is dyed

* Paper presented at a meeting of the Institution of Mechanical Engineers, held in London on December 14, 1951. Abridged.

* "The Sealing Mechanism of Flexible Packings." Min. of Supply Sc. and Tech. Memorandum No. 3/47 (1947).

† "Hydraulic Seals." *Proc. I. Mech. E.*, vol. 160, page 532 (1949).

FLUIDS FOR HYDRAULIC POWER TRANSMISSION.

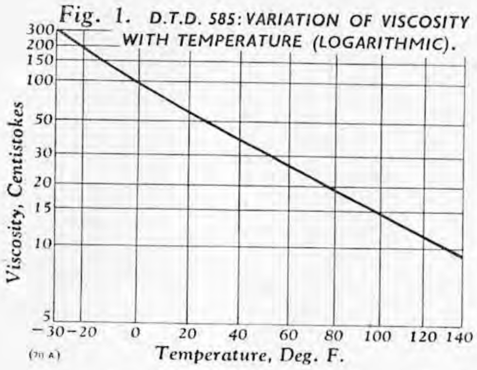


Fig. 1. D.T.D. 585: VARIATION OF VISCOSITY WITH TEMPERATURE (LOGARITHMIC).

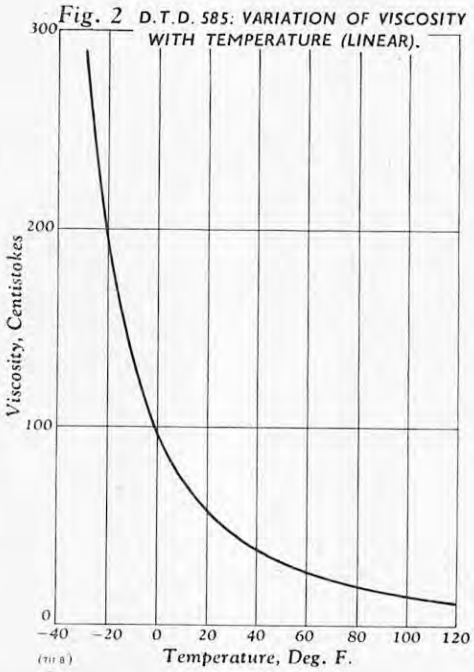


Fig. 2 D.T.D. 585: VARIATION OF VISCOSITY WITH TEMPERATURE (LINEAR).

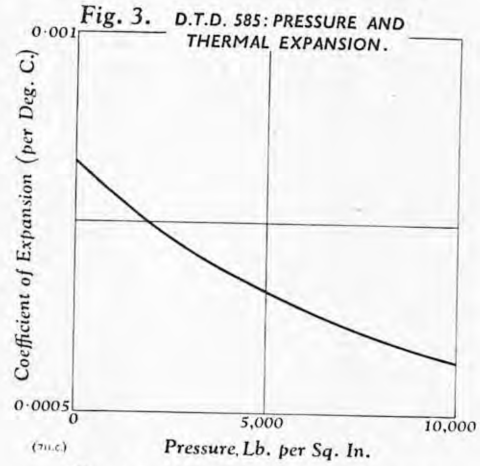


Fig. 3. D.T.D. 585: PRESSURE AND THERMAL EXPANSION.

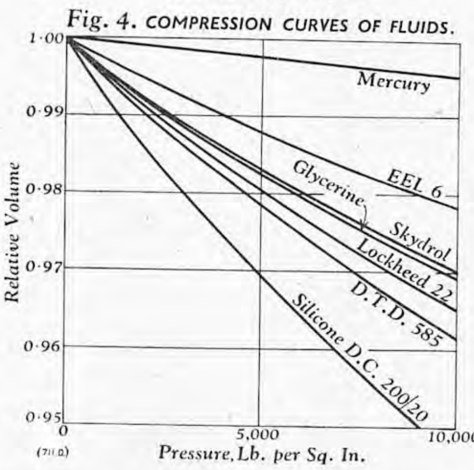


Fig. 4. COMPRESSION CURVES OF FLUIDS.

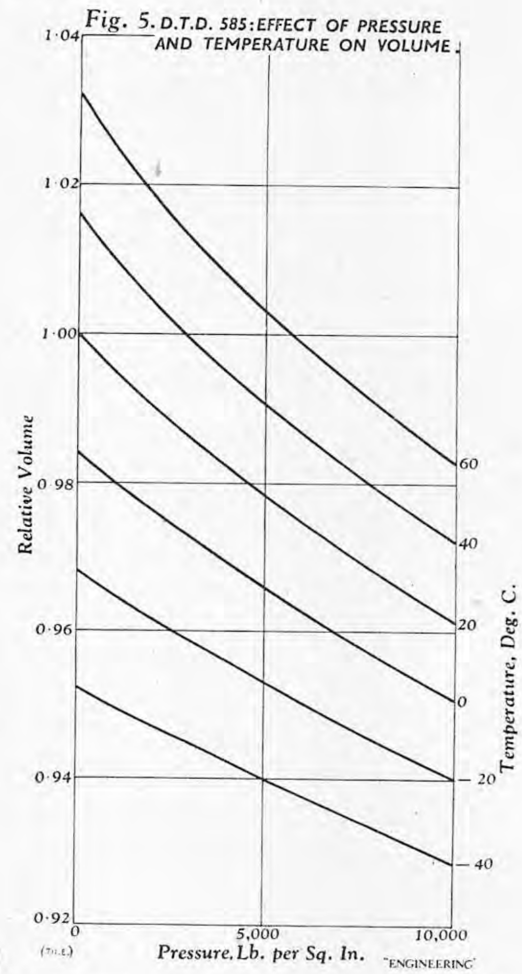


Fig. 5. D.T.D. 585: EFFECT OF PRESSURE AND TEMPERATURE ON VOLUME.

a rich blue (now superseded by Lockheed 22); D.T.D.585 is dyed a rich red; D.T.D.641 is brownish yellow (now superseded by Lockheed 22); D.T.D.44D is pale yellow; Lockheed 22 is yellow (now specification D.T.D.900/4081); Skydrol is coloured green; R.P.M. is dark brown.

Many of the commercial oils look similar to D.T.D.44D, but generally they are more viscous and, while they can be classified fairly readily into grades, it is extremely difficult and sometimes impossible to determine the supplier. This emphasises the need for proper storage conditions and control in the works.

TABLE IV.—*Viscosity in Centipoises, at 30 deg. C. (86 deg. F.) unless Otherwise Stated.*

Fluid.	0 lb. per sq. in.	2,900 lb. per sq. in.	5,800 lb. per sq. in.	14,500 lb. per sq. in.
D.T.D.585	14·4	20·1	28·2	71·7
D.T.D.44D	17·2	26·5	41·6	142
D.T.D.641	6·63	7·99	9·51	14·6
D.T.D.388	51·8	68·9	90·1	187
Hydraulic oil No. 1				
at 50 deg. C. (122 deg. F.)	5·5	7·8	10·8	23·8
at 100 deg. C. (212 deg. F.)	2·0	2·7	3·3	6·2
Hydraulic oil No. 3				
at 50 deg. C.	10·6	15·1	21·0	52·8
at 100 deg. C.	3·0	4·0	5·5	12·4
Hydraulic oil No. 5				
at 50 deg. C.	35	51	79	252
at 100 deg. C.	7·5	9·0	12·5	29

Gauge pressures are quoted.

Mineral-base fluids are not toxic and no toxic effects have been observed in the water-base fluids in Table III; but, owing to the solvent, the castor-base fluids are toxic and good ventilation is necessary when they are being handled. The toxicity of the synthetic and halogenated fluids is questionable, and, until more experience is gained, they should be handled with caution. The effect on the human skin of all fluids is very variable and persons subject to dermatitis should not handle the fluids. Others can handle mineral-base fluids with impunity, but, when first coming into contact with a new fluid, the operator should take precautions. In all cases, personal cleanliness is a first criterion; saturated overalls should be avoided. The toxic properties of a fluid are greatly emphasised by spray leakage in confined spaces, such as the fuselage or cabin of an aircraft, so that the use of toxic fluids is strongly deprecated. It is useless to reduce the fire risk by introducing the possibility of asphyxiation.

The storage of hydraulic fluids is important, especially when the drums are not used rapidly. The drums should be under cover, so that rain cannot accumulate in the dished ends when they are stood upright. No ordinary seal is absolutely tight against the rise and fall in pressure due to temperature variation and, when there is a partial vacuum inside, the water can be sucked in, with very detrimental results. If drums have to be stored in the weather, perhaps temporarily, they should be laid on their sides with the seals at the top. For preference, drums should be stored in a brick or concrete structure with a concrete floor, the drums being on chocks, so that, in the event of spillage, the floor can be swept clean. The building should be adequately ventilated. Before drawing off any quantity from a drum it should either be rolled on the ground or the contents stirred if more convenient.

The storage temperature for the fluids in Tables II and III should be not more than 30 deg. C. (86 deg. F.) or less than − 20 deg. C. (− 4 deg. F.); for the heavier commercial oils the lower temperature could be 5-10 deg. C. (41-50 deg. F.), but higher with advantage. If a drum has been left in the open in Polar regions the contents may have segregated, and will take at least two days to thaw out properly in a hangar at 20 deg. C. (68 deg. F.); the drum should be well rolled before the fluid is used. When drawing oil from a drum by means of a suction pipe, the lower end of the pipe should be kept off the bottom surface of the barrel, as any water which has accumulated will be at the bottom in the case of the petroleum-base or castor-base fluids. If the oil is being poured from the bung, this should not be at the lowest point.

The mineral (petroleum)-base fluids have little or no effect on the primers or finishing coats of normally-used oil-resistant paints, but the castor-base fluids strip off the usual paints. Once the fluid is in the system it should not be in contact with paint, but there is an enamel, D.T.D.399, which is resistant to hydraulic fluids having both mineral and castor bases. The clear varnish D.T.D.234A is suitable for coating the insides of vessels containing mineral oil or air. However, to avoid the possibility of damage causing flakes of varnish or enamel to become detached and a menace inside the hydraulic system, it is strongly recommended that the vessel (e.g., reservoir) be constructed of aluminium alloy and anodically treated, both inside and outside.

Ferrous parts are satisfactory when in contact with water-base fluids, but corrosion will soon start if the system be drained and not thoroughly dried or

TABLE V.—DENSITY AT VARIOUS PRESSURES. TEMPERATURE CONSTANT AT 20 DEG. C. (68 DEG. F.).

Fluid.	0 lb. per sq. in. Gauge.	2,000 lb. per sq. in. Gauge.	4,000 lb. per sq. in. Gauge.	6,000 lb. per sq. in Gauge.	8,000 lb. per sq. in Gauge.	10,000 lb. per sq. in. Gauge.	—
D.T.D.585	0·842	0·851	0·858	0·864	0·870	0·876	gm. per cub. cm.
Lockheed 22	0·943	0·952	0·959	0·966	0·971	0·977	gm. per cub. cm.
Glycerine	1·260	1·27	1·28	1·29	1·29	1·30	gm. per cub. cm.
Skydrol	1·067	1·076	1·083	1·089	1·094	1·099	gm. per cub. cm.
EEL.6	1·08	1·09	1·09	1·10	1·10	1·10	gm. per cub. cm.

TABLE VI.—DENSITY AT VARIOUS TEMPERATURES. PRESSURE CONSTANT (ATMOSPHERIC).

Fluid.	—40 deg. C. (—40 deg. F.)	—20 deg. C. (—4 deg. F.)	0 (32 deg. F.)	20 deg. C. (68 deg. F.)	40 deg. C. (104 deg. F.)	60 deg. C. (140 deg. F.)	—
D.T.D.585	0·880	0·867	0·854	0·842	0·830	0·818	gm. per cub. cm.
D.T.D.44D	0·906	0·894	0·883	0·871	0·860	0·850	gm. per cub. cm.
D.T.D.641	1·005	0·988	0·971	0·955	0·940	0·924	gm. per cub. cm.
Glycerine				1·26	1·24	1·23	gm. per cub. cm.
Lockheed 22	0·994	0·977	0·960	0·943	0·928	0·912	gm. per cub. cm.

inhibited. Copper and lead should be avoided as far as possible, as copper may act as a catalyst and lead, coupled with oxidation of the oil, may form a metallic soap. Corrosion may be enhanced if two types of fluids are mixed; e.g., should a system be drained of D.T.D.585 and a water-base fluid substituted, it is practically impossible to eliminate all the D.T.D.585 without dismantling all pipes and fittings, so that a small percentage of D.T.D.585 becomes mixed with the water-base fluid. In these circumstances, there may be a slight chemical action between steel and brass or steel and aluminium.

As there is no exact definition for "oiliness," nor any exact method of measuring it, the viscosity of a hydraulic fluid becomes its most important property when dealing with the functioning of the apparatus, but viscosity is not a measure of "oiliness." The accepted definitions of viscosity, as given by the Institute of Petroleum Handbook (tenth edition), are as follows:—

"(i) The viscosity of a fluid is that property to which is due the internal resistance offered to the motion of any portion of that fluid with a velocity different from that of a contiguous portion. It determines the resistance offered to shear, e.g., to slow stirring, to flow through a capillary tube, and the like. For the quantitative expression of viscosity, a distinction is made between the dynamic viscosity (symbol η) and the kinematic viscosity (symbol υ).

(ii) The absolute dynamic viscosity of a fluid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the planes is filled with the fluid in question and one of the planes moves with unit velocity in its own plane relatively to the other.

(iii) The absolute kinematic viscosity of a fluid is equal to the quotient of the absolute dynamic viscosity divided by the density of the fluid; thus, $\upsilon = \eta/\rho$ where ρ = the density of the fluid."

Determinations of viscosity cannot be made at present with sufficient accuracy to render necessary a distinction between cubic centimetres and millilitres; hence densities may be expressed, as usual, in gm. per millilitre, without, for practical purposes, introducing any error in the above equations. For convenience, the kinematic viscosity in centistokes is generally used when referring to aircraft hydraulic fluids. Other units, such as Redwood No. 1, Saybolt and Engler, are sometimes encountered; but, as these are on arbitrary bases, they should be converted for calculations. It is hoped that, in the near future, centistokes will be universally adopted. The American Society for Testing Materials (A.S.T.M.) viscosity chart has, for ordinates, centistokes on a log-log basis, and the abscissæ are on a log basis of the absolute temperature.

The graph for a petroleum-base oil over the working range then becomes a straight line in most cases. Other fluids deviate only a little from the straight line; but, with D.T.D.585, there is a slight bend at about 0 deg. F. This method of plotting has much to recommend it, but may be deceiving to those unfamiliar with the behaviour of fluids with temperature, and it is as well to plot the curve on ordinary squared paper with straightforward units. It will be apparent at once how steeply the curve rises at sub-normal temperatures—the important phase from the aircraft aspect (Figs. 1 and 2, opposite).

The "viscosity index" is a measure of the rate of change of viscosity with temperature, and, the greater this rate, the smaller the viscosity index. Another method of referring to the rate of change of viscosity with temperature is known as the "A.S.T.M. slope," which can be obtained directly from the A.S.T.M. chart to which reference has already been made. Viscosity also increases with pressure.

The measurement of viscosity at high pressure has many difficulties, and therefore the amount of data available is small, but Table IV, opposite, gives some information.

Density increases with pressure owing to the reduction in volume when compressed; all fluids are compressible. Also, density decreases with rise in temperature (Tables V and VI, opposite).

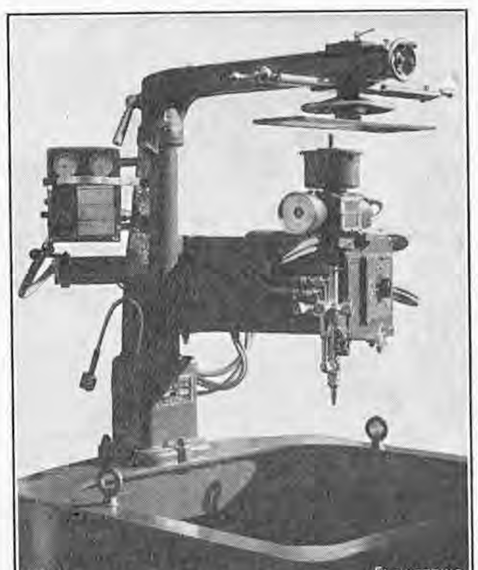
Compressibility (reduction in volume of unit volume per unit increase of pressure) is the reciprocal of bulk modulus. Both vary considerably with pressure and are somewhat cumbersome to use in calculations covering a wide pressure range. It is more convenient to use a compression curve, giving volume changes directly (Fig. 4, opposite).

At any pressure, the coefficient of volumetric expansion of fluids remains practically constant over the usual temperature range encountered in aircraft, but the coefficient decreases with increase in pressure. This can easily be deducted from the family of curves given for D.T.D. 585 (Figs. 3 and 5, opposite). From these curves, and a number of experiments which have been made, the necessity for thermal pressure-relief valves becomes obvious.

(*To be continued.*)

UNIVERSAL OXY-ACETYLENE CUTTING MACHINE.

THE British Oxygen Company, Limited, Bridgewater House, Cleveland-row, St. James's, London, S.W.1, introduced recently a modified and improved version of their 36-in. universal oxygen cutting machine. In general, the main structure of the new machine is similar to its predecessor and, as will be seen from the photograph reproduced below, the appearance remains much as before. Nevertheless, several detailed improvements have been made and the latest machine incorporates several modifications, notably to the cutter and its controls, the oxygen control panel and the drive and speed controls for the template follower. Before referring to these in detail, however, it might be advantageous to give a brief description of the actual machine. As will be seen from the illustration, it consists of a large welded-steel base which is arranged to support a vertical column. This, in turn, carries two arms, an upper arm for locating the template and a lower articulated arm, generally referred to as the "folding-gate" arm, for supporting the cutter and the tracing mechanism. The tracing mechanism comprises a roller arranged so that it makes contact with the edge of any template secured to the template arm. A magnetic roller is used so that it adheres to the template, and the tracing roller is caused to travel round the edge of the template by means of a small electric motor, to which it is coupled through a reduction gearbox. The tracing roller and cutter are in vertical alignment so that an exact copy of the template is reproduced when cutting.



The speed of cutting is not affected by the shape of the template and can be varied, if necessary, while the machine is working. Furthermore, the height of the cutter can be adjusted during working to compensate for any unevenness in the surface of the material being cut. Any thickness of material between the limits of $\frac{1}{8}$ in. and 6 in. can be dealt with and the longest permissible straight cut is 6 ft. 3 in. The maximum sizes of work that can handled depend, of course, on the shape, but circular cuts up to a diameter of 3 ft. and rectangular cuts up to a maximum of 4 ft. 6 in. by 2 ft. can be made. In brief, steel parts of almost any shape and having dimensions which may be inscribed within a semi-circle having a radius of 3 ft. can be produced. Both mild-steel plate and forgings can be cut, and so long as the carbon content is below 0·25 per cent., the former may be cut cold. For steels containing higher percentages of carbon, and medium high-tensile alloy steels, the manufacturers recommend preheating before cutting.

As previously mentioned, several improvements have been incorporated into the latest machines of this type. One that probably will be welcomed most by operators is the introduction of the company's MC6 cutter; this uses a one-piece nozzle so designed that it permits easy changeovers to be made and which experience has shown gives trouble-free service. The design also permits a powder-cutting attachment to be used for profile cutting and it is understood that such an attachment will be available shortly. The cutter is chromium-plated, and to render cleaning easier all corners have been smoothed. Changes to the control gear include the replacement of the sliding-type rheostat by a rotary model; the isolating and reverse switches also have been altered and, together with the rheostat, are now mounted on a panel fitted to the outer arm where they are within easy reach of the operator. The gate arms have been modified as well, the cast girders being replaced by panels which, in addition to lightening the structure, give a neater appearance.

The oxygen control panel, which is mounted on the left-hand side of the pillar, is now protected from damage by a chromium-plated steel strip. The panel consists of the latest type of O.R. 13 regulator which has been divided to permit grouping of the gauges at the top of the panel. Below the control valve is a master "knock-off" valve which governs both the oxygen and acetylene supplies to the cutter, thus enabling both gases to be cut off with one movement. The re-designed transmission assembly for driving the tracer head incorporates an oil bath the level of which is visible through a sight glass. Another refinement incorporated in the machine is the provision of a hinged bracket on the pillar, which can be fitted over the magnetic roller and thereby prevent the arm from moving when work is being set up.

THE UMTATA FALLS HYDRO-ELECTRIC STATION.

THE town of Umtata in the Cape Province of the Union of South Africa is the administrative centre of the Native Reserve known as Transkei, and has been supplied with electricity for the past 20 years from a hydro-electric station on falls of the same name. To meet the growing demand, this station, which has a capacity of 100 kW, has been extended by a 150-kW set built by the General Electric Company, Limited, Kingsway, London, W.C.2.

The new set, which is supplied through a pipeline 1,000 ft. long and 30 in. in diameter, operates under a gross head of 91 ft. and a suction head of 17 ft. It consists of a 225-h.p. Francis turbine running at a speed of 750 r.p.m. with a flywheel and governor, and is coupled to a 200-kVA alternator generating three-phase current at 400/230 volts. The output voltage is stepped up to 3·3 kV for transmission to the town power-station four miles away by a 200-kVA transformer.

Owing to its inaccessible position on a site about 2,300 ft. above sea-level, the Falls power station is unattended and the plant is controlled automatically through overhead pilot wires from the town station. To start the set a push-button is depressed and a three-phase current at 220 volts is then transmitted over the pilot wires to a metal rectifier at the Falls power station. This rectifier feeds a voltage selector relay which completes the circuit of an interposing relay. This relay, in turn, closes the main field contactor and at the same time energises a second contactor so that an electrically-operated sluice valve is gradually opened, the motor for this purpose being supplied from a 24-volt battery. The set consequently runs up to speed and the governor takes over control. When the voltage has built up to a predetermined value a relay, which is connected between one phase and the neutral of the alternator, closes the main circuit-breaker, thus connecting the machine to the line. As soon as the sluice valve is fully open its motor is disconnected by a limit switch. The "start" button can then be used for adjusting the speed through the governor for synchronising and for load-control purposes. At the same time, the "stop" button can be used to reduce the speed.

To shut down the plant, the "stop" button is depressed until the governor has ceased to function. The governor control circuit is then disconnected by a limit switch and the "close" contactor of the sluice valve motor is simultaneously shut. As the sluice valve starts to close its "open" limit switch is re-set. As a result, the circuit to the interposing relay is opened and the trip circuit of the oil circuit-breaker and main field switch is completed. The sluice valve motor continues to run until the valve itself is closed and the set is completely shut down.

The plant is fully protected against excessive bearing temperature, overspeed, governor failure and internal faults on both the alternator and transformer. The occurrence of any such faults causes a lock-out relay to operate so that the circuit-breaker and field contactor are tripped. The set is therefore shut down and cannot be restarted until the fault has been cleared and the lock-out relay re-set. The equipment is also provided with over-current and line-fault protection, the operation of which disconnects the alternator from the bus bars, but leaves the set running. If the fault has been cleared, the switches connecting the resistance to the bus bars can be closed again by depressing the "start" button. If the fault is still present, however, the switches will open again and the lock-out relay will operate, thus shutting down the set. The station must be visited to re-set the lock-out relay before the set can be started again. This is not necessary when the set has been shut down due to over-voltage or excessive temperatures.

Owing to the frequent occurrence of electrical storms during the rainy season, the pilot wires are protected by one-to-one isolating transformers and surge diverters at each end of the line.

AVAILABILITY AND USE OF AERONAUTICAL INFORMATION.

The need for a central information agency for the aeronautical industry was clearly revealed in a discussion organised by the Royal Aeronautical Society, in conjunction with the Aslib Aeronautical Information Group, on "The Availability and Use of Aeronautical Information," held in London on Thursday, February 7. Professor A. A. Hall, who was in the chair, said that the problem was, firstly, to keep engineers and scientists up to date in their knowledge of other people's discoveries, and secondly, to provide specific data when it was required quickly. The first speaker in the discussion, Mr. C. W. Cleverdon, said that about 450,000 reports were issued annually in the United States, of which 80 per cent. were relative to aeronautics. There were three distinct problems—to discover that a report had been written, to obtain a copy in the United Kingdom, and to bring it to the notice of everybody concerned. At present, the various organisations receiving American reports from different sources were unco-ordinated. In America, four major official organisations had combined to form the Armed Services Technical Information Agency, which was responsible for collecting, indexing, cataloguing, compiling and issuing bulletins, etc. He did not think that the United Kingdom had the resources to set up a similar organisation immediately, but it might be possible in the future. Meanwhile, the Aslib Aeronautical Information Group had been formed to make the best use of existing facilities.

Professor A. D. Baxter thought that a central information service to eliminate duplication was required, and that considerable economy of effort could be achieved if libraries were to share out the work of reviewing books and papers. He was followed by Mr. C. G. W. Ebbutt, who said that, in a small design office, analysing the technical papers flowing into the library must be carried out as a part-time job by one of the design staff. In his own organisation they used a coding system for tracing useful scraps of information buried in the body of papers. The reports, when coded, were indexed on punched cards, and could be traced quickly. The system had been described in a report, "The Card Index System for Technical Reports" (serial number A.03359), issued by the Heston Aircraft Company, Limited, Heston Airport, Middlesex. He suggested that reports should be issued already coded in an agreed system.

Professor R. L. Lickley thought that security measures were at present carried too far, and that information not involving national security was often withheld from students and teachers. The next speaker, Mr. G. W. S. Henson, said that it would often be useful to know how long it took to apply the method given in a theoretical report, a point seldom mentioned in abstracts. He thought that the lessons learned during the construction of an unconventional research aircraft should be made public; usually only the aerodynamic characteristics were reported. He was followed by Mr. J. A. Kirk, who thought that every piece of research work carried out should be properly recorded; at present, this was not so. The reports should be circulated as widely as possible, and indexed in a common system acceptable both to the small firm and the large establishment.

Mr. B. D. Jones complained that published reports were often not in a suitable form to be used by engineers. In a written contribution, Mr. G. F. Webb suggested that ruthless elimination of sub-standard material was essential. This required specialised knowledge. The average engineer, he thought, required to be trained in the use of information services, preferably during the educational period. The next speaker, Mr. Griffith, considered that the only way to assess the quality of a report was to have it read through or to know that it had been satisfactorily applied. The following speaker, Dr. D. Kuchemann, thought that a European journal should be established to receive all European contributions of real importance.

Mr. Maurer called attention to the difficulties of keeping maintenance engineers informed, owing to the expense of obtaining a number of copies of the manufacturer's service manual, and the problem of ensuring that amendments issued subsequently were incorporated in the manuals. Turning to the question of why information was secreted in the firm's files, he suggested that firms could not be expected to provide their competitors with information free of charge. The following speaker, Mr. J. W. Lane, thought that technicians within the design organisation should not be expected to produce reports, and that this should be undertaken by mobile specialists from a central information bureau. The last speaker in the discussion, Mr. R. W. Thorne, said that some users of information were obviously not fully aware of existing facilities. There was a need for educating both librarians and technicians. In concluding the meeting, Professor Hall suggested that there might be a part for the Royal Aeronautical Society to play in forming a central information agency.

LABOUR NOTES.

Longer working hours as an essential remedy for the existing trade recession, were advocated by Mr. H. Prince Bardsley, President of the Manchester Chamber of Commerce, in an address at the annual meeting of the Chamber on Monday last. Mr. Bardsley urged that where the working week was now 40 hours it should be increased to 44, and that where it was now 44 it should be increased to 48. The extra four hours' work must be real hard work and given as a bonus to the country, without expecting any increase in remuneration. It was one of the ways in which the nation could fight back. He realised that this view would not be popular in some quarters, but, sooner or later, it would have to be repeated and put into practice. There was no desire to see existing earnings reduced, but unless everyone was prepared to do that extra amount of work for the same earnings as now, the only alternatives that he could foresee were lower wages and unemployment, as direct consequences of the loss of export trade which the country would inevitably suffer.

Profit margins also would have to be severely curtailed, at all stages. High profits had been dictated, Mr. Bardsley considered, by the necessity for creating money for the re-equipment of industry and to meet the existing high taxation. During the period in which there was a world shortage of goods, British commodities could be sold, even at a high price, but now a change had come and "it behoved us all to look to our costings." Many firms in many industries had already done this, and, so far as the textile trades were concerned, he was sure that the effects of this new attitude would soon begin to show. It was essential, however, that every section of the industry should play its part. He referred appreciatively to the moderation of the banks in their handling of the difficult situation produced by the recent decline in overseas trade. Had the recession of exports been dealt with in any other manner, it could have brought disaster, or have caused irreparable harm to many industries.

Competition with British goods, he continued, was increasing in many directions. With respect to the difficult position in the cotton trade, Lancashire must prepare for a period of readjustment to the new conditions. Competition in this industry had been aggravated by the growing volume of production from local mills in markets which had previously been almost wholly dependent upon Lancashire. This was a world problem, but methods must be found of avoiding a repetition of the grave difficulties of the inter-war years. A sensible approach to the issues raised by the re-entry of Japan into competition for world markets would prevent much bitterness and hostility. On the other hand, unbridled competition at prices which bore no relation to those of other producers must invite protective action. Mr. Bardsley added that, in spite of the difficulties of the present time, he firmly believed that trade would regain a more settled outlook. If, in any future crisis, however, there was a repetition of the concentration of industry applied during the war years, it might well sound the death knell of the cotton trade.

A conference to consider methods for obtaining the greatest efficiency in the use of the country's man-power has been arranged by the Ministry of Labour and National Service under the title "Human Relations in Industry," and will take place in London next month. Sir Walter Monckton, K.C.M.G., the Minister of Labour, will open the conference and Sir Godfrey Ince, permanent secretary to the Ministry, will act as chairman. A conference on somewhat similar lines was held in 1948, but the new conference, although in the nature of continuation of that previously held, will cover a wider field.

On this occasion, the subjects to be discussed will include the employment of all who want to work, especially the older employees and part-time women; helping workpeople to make the best use of their capabilities; the physical wastage of man-power; and factors affecting management-employee co-operation and the will to work. It is not intended that the conference shall discuss the values of the different subjects, but how the use of related techniques can be stimulated and the practice of them improved. The Ministry hope that representatives of the Trades Union Congress, the British Employers' Confederation and other bodies interested in management problems will be able to attend. Dates and other particulars are given in a paragraph on page 212.

Resentment is being expressed in some directions at the Government's economy proposals. A special coalfield conference has been called by the executive council of the South Wales area of the National Union of Mineworkers, to discuss the charges and limitations to be imposed in connection with the social services. The abolition of workmen's fares on 'bus routes in South Wales will also be considered when the conference meets on February 27. Delegates representing some thirty thousand miners, mainly from the Dulais and surrounding valleys of West Wales, decided at a meeting at Neath on Monday last that miners' lodges in the district should be asked to tender 14 days' strike notice to colliery managements as a protest against the imposition of new fares rates. They also recommended that the working of Saturday shifts should be discontinued as a protest against the Government's economy intentions.

Some increases in colliery man-power have taken place recently and the total labour force is now the highest for two years. The latest figures issued by the Ministry of Fuel and Power show that there were 705,300 wage-earners on colliery books on February 2, 1952, against a total of 705,700 on February 25, 1950. The number of coalmining employees increased by one thousand during the week ended February 2, 1952, and this increase included an addition of three hundred miners at the coalface. Altogether, there was an increase of 7,400 in the industry's total labour force during the five weeks between December 29, 1951, and February 2, 1952. This improvement in the industry's man-power is probably due, in the main, to an influx of juveniles, on reaching school-leaving age at the end of the year. More than four thousand lads are reported to have joined the industry this year.

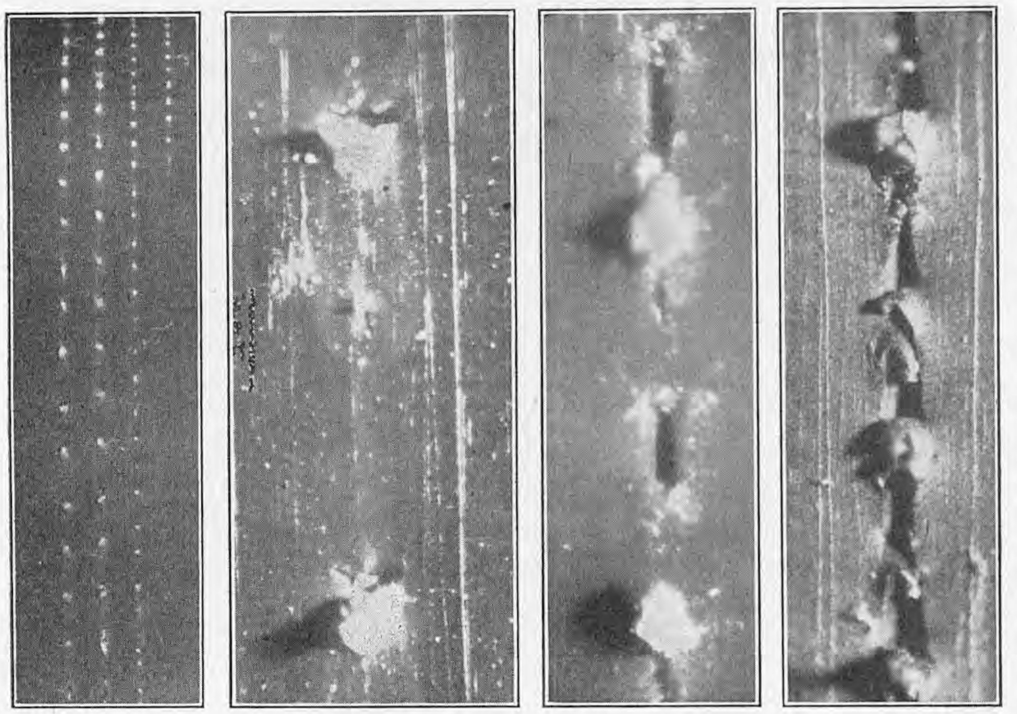
The average number of shifts worked per wage-earner, in spite of the increase in man-power, declined from 5·11 during the week ended January 26 last, to 5·03 for the week ended February 2. These figures, however, compare with a weekly average of 4·81 shifts for the whole of 1951, and with one of only 4·72 shifts for the whole of 1950. The total production of saleable coal for the week ended February 9 last was 4,532,600 tons, of which 4,321,100 tons was deep-mined and 211,500 tons opencast. During the week ended February 2, some 4,284,900 tons of deep-mined coal and 172,500 tons of opencast coal were produced. Coal consumption during the week ended February 2 totalled 4,912,000 tons, comprising 4,676,000 tons taken for inland use, 175,000 tons exported, and 61,000 tons for bunkers. Some 37,100 tons were imported during the same week. Total absenteeism was 12·65 per cent., of which 6·35 per cent. was voluntary.

Demands on behalf of London dock employees for a "substantial" increase in their wage rates, and for a second week's annual holiday with pay, came before an arbitration board set up by the Ministry of Labour, on Tuesday last. It is understood that, after the cases for the Transport and General Workers' Union and the employers had been presented, the board adjourned to consider its findings. These will probably be made known in a week or so. About 100,000 dock employees are involved.

Claims for an increase in pay of 1*s.* 6*d.* a day, made on behalf of nearly 4,500 Thames lightermen and tugmen have been rejected by the Industrial Disputes Tribunal. The Watermen, Lightermen, Tugmen and Bargemen's Union, to which the men belong, in announcing the Tribunal's decision on Monday last, stated that the demands had been for a daily "contingency allowance" for skill of 1*s.* 6*d.* and that lightermen and tugmen employed in the principal sections of the dock industry at London would have benefited from the award. The Tribunal recommended that the union's claim for a flat-rate incentive bonus of 3*s.* 4*d.* a day for some 2,500 lightermen engaged on loading and towing lighters with general cargoes should be the subject of further negotiation between the union and the employers' organisations. It was stipulated, however, that, should the parties concerned be unable to reach an agreement, they should be free to approach the Tribunal again.

The union's claims were referred to the Tribunal by Sir Walter Monckton, the Minister of Labour, after their rejection by the employers' organisations had resulted in bans on overtime at the London docks in November and December, 1951. The dispute regarding these claims has now been in progress for around six months and it may be recalled that an investigating committee, which was set up by the Ministry of Labour to consider the question, rejected the union's contentions. The union, in its turn, declined to accept the committee's findings and instructed some sections of its members to work to rule and to refuse overtime. The executive body of the union met on Wednesday to consider what action shall be taken in view of the Tribunal's decision.

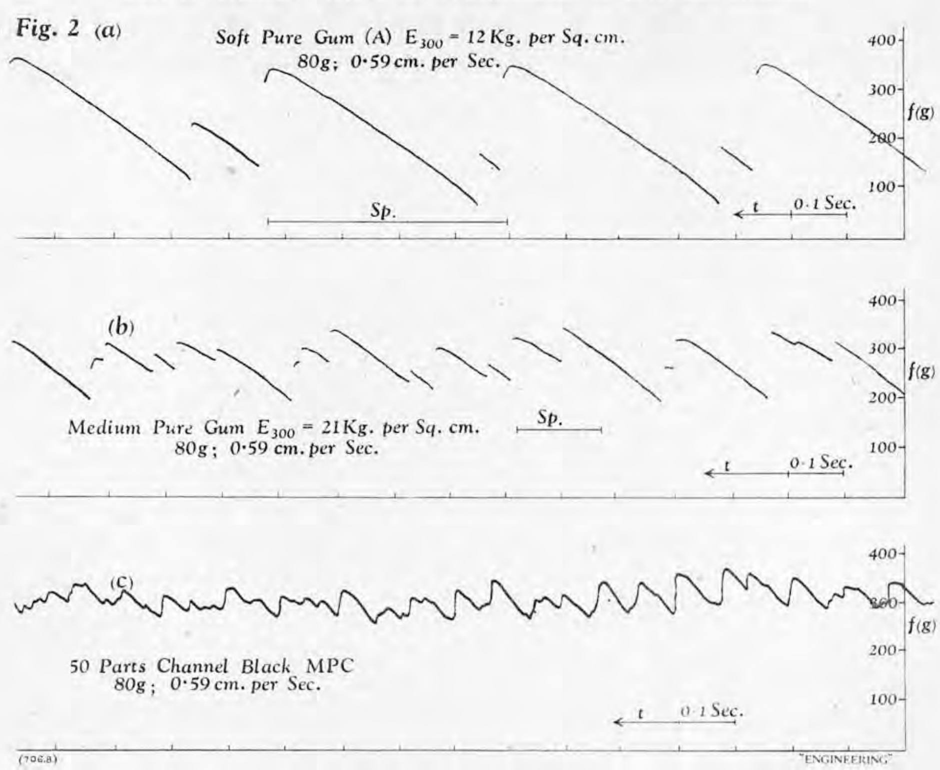
RUBBER ABRASION.



(a) (b) (c) (d)

(a) Soft Pure Gum; traces 1 and 2, 80g; traces 3 and 4, 50g; all at 0·6 cm. per sec. × 2.
(b) Soft Pure Gum; 80g, 1·71 cm. per sec. × 26.
(c) Medium Pure Gum, 50g, 5·98 cm. per sec. × 60.
(d) Tyre-Tread Compound; 80g, 5·98 cm. per sec. × 55.

FIG. 1. NEEDLE TRACES ON VULCANISATES OF NATURAL RUBBER.



ELEMENTARY ASPECTS OF RUBBER ABRASION.*

By DR. A. SCHALLAMACH.

THIS paper gives a survey of work which has recently been done by the British Rubber Producers' Research Association, with the object of investigating the nature of rubber abrasion. In the first part, we shall report the results of a very simple abrasion experiment in which rubber was scratched with a needle. The aim of this research was to investigate the elementary mechanism of abrasion, such as may be expected to occur under the proud particles of an abrasive. The second part deals with the so-called "abrasion pattern," a system of nearly parallel ridges which is found on abraded surfaces. In the third part, experimental evidence will be adduced in support of the view that the outermost surface layer of a tyre has the mechanical properties of an unloaded rubber in spite of the fact that it contains reinforcing carbon-black which conveys considerable hardness to the bulk of the tyre tread. A detailed account of this work is in course of being published elsewhere.

I.—"*Abrasion*" *by a Needle.*—The scratching experiments were carried out at constant velocities and with constant thrusts on the needle; provision was made for recording the instantaneous tractive force.

Examples of typical needle traces produced under these conditions are shown in Fig. 1, herewith. All the photographs were taken under oblique illumination from the right, and the scratching direction was vertically downwards. Fig. 1 (a) is an ordinary photograph of needle traces on a soft pure gum vulcanisate of M_{300} = 12 kg. per square centimetre which demonstrates two important properties of needle traces on unloaded rubbers: firstly, that the traces are discontinuous, and secondly, that the spacing between recurring features along the traces increases with increasing normal load on the needle, as is shown by a comparison of the first and second traces (normal load = 80 g.) and the third and fourth traces (normal load = 50 g.).

Fig. 1 (b) resolves the dotted line of Fig. 1 (a) into a row of widely separated pits on the rubber surface, with little mounds of rubber thrown up at the exits of the pits. Fig. 1 (c) shows the trace on a pure gum vulcanisate of medium hardness (M_{300} = 21 kg. per square centimetre). The difference between this trace and the traces on the soft pure gum appears to have been brought about by the fact that the tears, which were only initiated in the case of the soft pure gum, have been propagated here. As a consequence, the trace is now a succession of long grooves.

The trace on the compound contai ing 45 parts of channel black, which is a fairly typical tyre-tread loading, has, as can be seen from Fig. 1 (d), certain points in common with the medium pure gum, but, in contrast to traces on pure gum compounds generally, this trace is continuous. The rubber pieces which have been partially torn off remain attached to one or the other side of the trace like tassels, and they are mostly curled.

Fig. 2, herewith, shows three representative force-time records giving the variation of the tractive force with time during the production of the traces. The graphs of Figs. 2 (a) and 2 (b) are saw-tooth curves, but it will be seen that Fig. 2 (a) is more regular than Fig. 2 (b). The curve of Fig. 2 (c) has a large constant component superimposed on which are irregular, and, by comparison with Figs. 2 (a) and 2 (b), small fluctuations of the tractive force.

The explanation of these results can best be understood by reference to a model experiment which demonstrates the deformations which lead to the type of trace found on the soft pure gum. In this model experiment, parallel lines, about $\frac{1}{16}$ in. apart, were ruled on a large sheet of soft gum which was scratched with a pointed 4-B.A. screw in a direction at right angles to the ruled lines. The purpose of the lines was to indicate by their distortion the extent and general lie of the strain. The upper part of Fig. 3, on page 218, shows a crucial stage in the deformation of the rubber surface. The strain is widespread and, of course, very inhomogeneous. The most important part of the deformation is a lip bulging out in front of the needle, as it renders the whole strain system unstable. What happens when the needle is moved on slightly is shown in the lower part of Fig. 3; the lip rolls over and the needle pulls out a thong of rubber. Apart from the existence of this thong, the deformation of the surface has mostly relaxed, as witnessed by the reference lines which have returned to their original position. It has been found that the thong degenerates later to a thin filament which breaks either at its root or at the needle tip. Most of the elastically stored energy is released when the lip rolls over, because the extension of a thin filament involves only little energy; the "slip," i.e., the sudden drop of the tractive force in the record of Fig. 3 (upper part), coincides therefore with the periodical occurrence of an unstable state of strain.

It will have been noticed that the mechanism which has just been described depends on two factors: the rubber lip must adhere by friction to the tip of the needle, against the pull of the elastic forces; and the tensile properties of the material must admit large deformations without failure occurring.

The medium-pure gum cannot be deformed to the same extent as the soft compound. At about the time when the stage depicted in the upper part of Fig. 3 has been reached, the rubber begins to tear. The direction in which tearing takes place is at right angles to the maximum stress, i.e., outwards relative to the strained rubber. When the needle has passed and the rubber recovers, the tears move back with the rubber almost into the direction of the trace. The result is that strips are torn out of the surface, leaving the long grooves seen on Fig. 1 (c). The stick-slip character of the record of Fig. 2 (b) is due, therefore, to failure of the rubber. Failure is, to a certain extent, a random event, a fact which is responsible for the haphazard force-time curve of Fig. 2 (b). The tyre-tread compound of Fig. 1 (d) is much harder than either of the pure gums; when the stage of deformation shown in the upper part of Fig. 3 is reached, the frictional force no longer suffices to maintain static contact between needle and lip, and rubber begins to glide along the needle. The deformation is therefore stopped short and a dynamic equilibrium is established in which the lip is constantly re-formed in front of the needle, so that it precedes it like a bow wave. In this state, the relative motion between the needle and lip gives rise to a frictional force on the needle, which has a large vertical component downwards. This force constitutes an additional thrust on the needle which is large enough to prevent the needle from ever leaving the rubber surface and so is the cause of the continuous surface damage characteristic of tyre-tread compounds. The damage itself is produced at the tip of the needle, and it appears that the mechanism of failure here is similar to that described for the medium-pure gum.

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

RUBBER ABRASION.

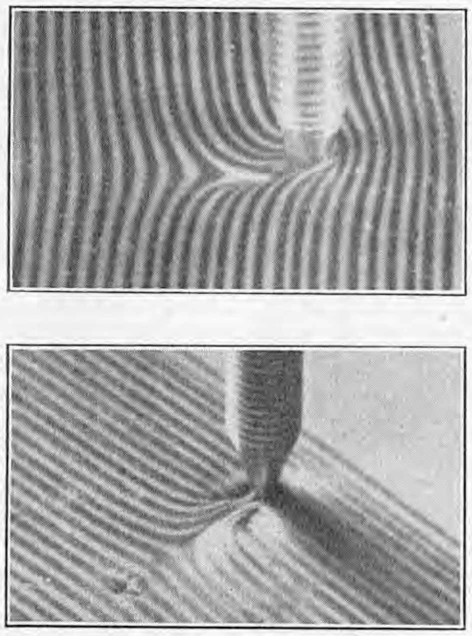
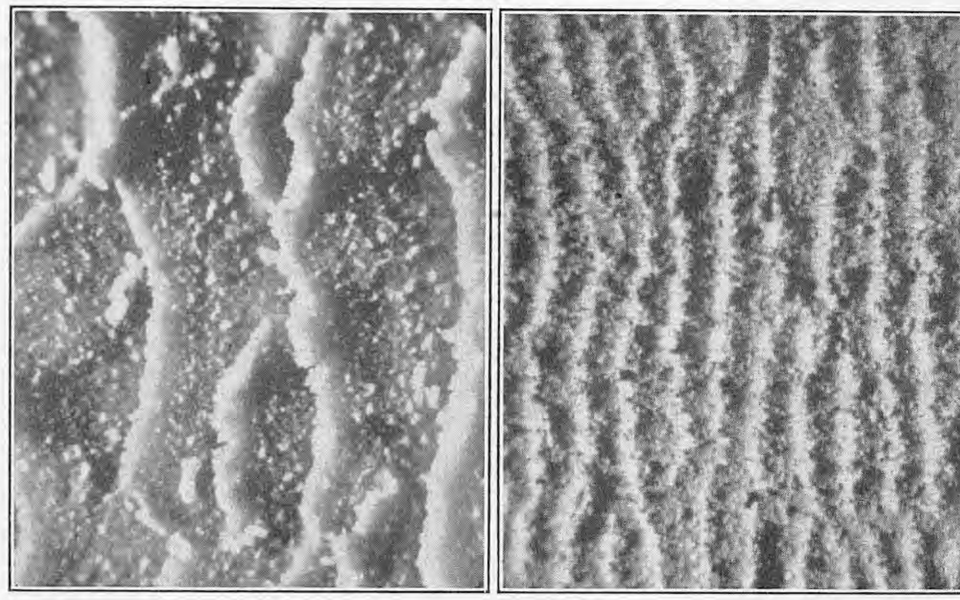


FIG. 3. MODEL EXPERIMENTS.



(a) Medium Pure Gum Vulcanisate. × 20. (b) Tyre-Tread Compound. × 20.

FIG. 4. ABRASION PATTERNS.

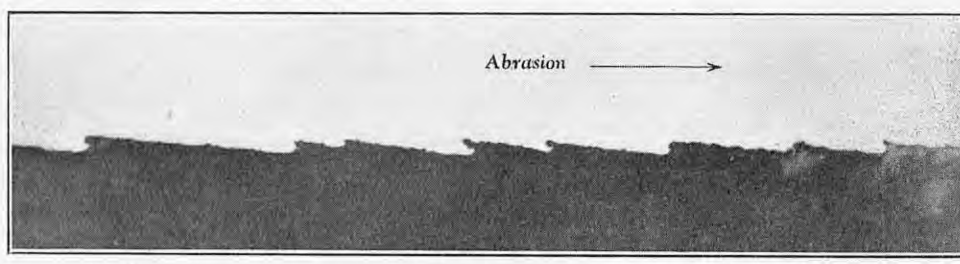


FIG. 5. PROFILE OF ABRASION PATTERN ON MEDIUM PURE GUM. × 10.

The interpretation of the force-time record of Fig. 2 (c) follows from the proposed explanation of the trace. The large constant component is the force necessary to overcome friction between needle and tip, and also to maintain the rate of deformation. The superimposed fluctuations arise from the tearing-off and subsequent clearing of the tassels. The changes of the force are less sudden than in the case of the pure gums because carbon-loaded rubbers are more sluggish.

Our findings may be summarised as follows. When a needle is passed over a rubber surface, its trace is discontinuous on pure-gum vulcanisates, and continuous, but irregular, on carbon-loaded compounds. In either case, small pieces of rubber become partially detached and are left as little mounds or tassels which are raised above the surface of the sample. Now and then, pieces of rubber are bodily removed from the bulk material, but this occurrence is rare, and scratching rubber with a needle cannot be called "abrasion" in the customary sense of the word. What the needle does, however, is to prepare the surface for abrasion, because the partly-detached pieces of rubber are an easy prey in any subsequent attack on the surface.

II. *The Abrasion Pattern.*—The array of parallel ridges at right angles to the direction of abrasion which we call the "abrasion pattern" is found on all abraded surfaces of natural rubber, irrespective of composition, but it tends to be more pronounced on pure-gum vulcanisates, or on compounds containing only low loadings of carbon black, than on tyre-tread compounds. In spite of the common occurrence of the abrasion pattern, we have found only one reference to it in the literature.

Two samples of abrasion pattern produced in the laboratory are shown in Fig. 4, herewith; both the medium-pure gum of Fig. 4 (a) and the tyre-tread compound of Fig. 4 (b) were abraded under the same normal pressure of 1·6 kg. per square centimetre. When examining these photographs, due regard should be had to the optical difference between the two samples, which reduces the contrast on the photograph of the translucent pure gum. The pattern is more pronounced, and the spacing between the ridges is greater, on the pure gum than on the tyre-tread compound, but the difference is quantitative rather than qualitative.

For any one sample, the spacing of the ridges increases with increasing normal pressure. This relation is reminiscent of a similar result obtained when scratching pure gums with a needle, where it was found that the spacing between the pits also increased with increasing load on the needle (*cf.* Fig. 1 (a)).

Only the most important characteristic of the abrasion pattern will be discussed here, i.e., the profile of the ridges. Fig. 5, herewith, shows a micro-section through a well-developed abrasion pattern on the medium-pure gum vulcanisate. Special note should be taken of the abrasion direction as indicated on this illustration. It will be seen that the ridges are asymmetrical with respect to the direction of abrasion, and the overhanging crests which lean forward against the direction of abrasion present a somewhat surprising aspect. It must be remembered, however, that Fig. 5 shows the pattern in the relaxed state; during abrasion, all the ridges are strained backwards and expose their underside to the abrasive, thus leading to the undercutting effect seen in Fig. 5.

Traces of an abrasion pattern are found on all those parts of a tyre which come into contact with the road, but it is generally only the pattern on driving bands which can be interpreted without a detailed knowledge of the mechanics of tyres. We carried out most of our investigations with an experimental tyre which had a standard tread with five driving bands, but plugs of experimental compounds were inserted in the outside driving bands so that they could be studied under conditions of road wear. Fig. 7, opposite, shows specimens of the pattern on opposite driving bands, the photographs being mounted in the same relative positions in which their originals are situated on the tyre. To illustrate at the same time the influence of composition on the pattern, we have chosen one specimen each of the medium-pure gum and of the tyre-tread compound. The ridges of the abrasion pattern on these two driving bands make an angle of roughly 45 deg. with the equator of the tyre, in such a manner that they open out into the direction of rotation. This orientation of the ridges on driving bands is typical of all tyres we have been able to examine and is in no way a peculiarity of this tyre.

Two things emerge from Fig. 7. The first is that the patterns on the tyre-tread compound and on the pure-gum vulcanisate are not very different. Actually, the surface of the pure gum is still slightly rougher, although the difference is not very marked on the photograph. The second result demonstrated by Fig. 7 is of more general validity and signifies that the abrasion of a tyre occurs at an angle to the direction of motion of the vehicle, as an abrasion pattern is always oriented at right angles to the direction of abrasion. It has been shown elsewhere that this effect is a consequence of the deformation of the tyre when deformed by the road.

It has been mentioned that the profile of an abrasion pattern is asymmetrical, so the direction of abrasion can be determined unambiguously. We show a cross-section through the tread of the experimental tyre in Fig. 6, opposite. The similarity of this profile to the profile obtained in the laboratory, which is shown in Fig. 5, is immediately obvious and should remove any lingering doubt as to whether or not tyre wear is a manifestation of abrasion. The direction of abrasion as determined by the asymmetry of the ridges is indicated on Fig. 7, and it can be shown that most of the abrasion of a tyre occurs when it touches the road.

III. *Abrasion and the Mullins Effect.*—The results reported in Parts I and II of this survey appear to contradict each other. In Part I we have shown that, as far as needle scratches are concerned, there is a great qualitative difference between pure-gum vulcanisates and carbon-loaded compounds of the tyre-tread type. In Part II, evidence was adduced that, when exposed to abrasion on the road, the two compounds behave almost identically, and any difference between them is at most quantitative, certainly not qualitative. The similiarity goes, in fact, farther than that, because it was found that, after 8,000 miles of road-wear, the pure gum had abraded at the same rate as the bulk of the tyre.

We think that the resolution of this dilemma is to be found in the ephemeral nature of reinforcement by carbon black. Having subjected a reinforced sample to a given deformation, it is found that, in any subsequent deformation, its effective hardness is gradually reduced, until finally it is not much different from that of a pure gum. This effect is known as the Mullins Effect. We suggest that large local deformations are continuously produced on the surface of a tyre by the asperities of the road, which eventually, but not immediately, lead to local failure. As these local strains are distributed over the bearing surface, they will co-operate to create a thin surface layer, the mechanical properties of which, through the Mullins Effect, have been reduced practically to those of a pure gum. The thickness of the surface layer is most probably less than 1 mm. and the deformations which create it should be of the same order of magnitude. The layer is constantly renewed from the inside at the same rate at which the outside wears off.

The investigations with the experimental tyre have been made possible by the co-operation of Messrs. Henley's Tyre and Rubber Company, Ltd., and the work described here formed part of a programme of fundamental research undertaken by the Board of the British Rubber Producers' Research Association.

PRODUCTIVITY TEAMS.—The two productivity teams which sailed for the United States on February 12 will study, respectively, plastics moulding, and design and productivity. The latter team will make a special study of how design can be integrated with production o achieve the best utilisation of available materials.

RUBBER ABRASION.

(*For Description, see Opposite Page.*)

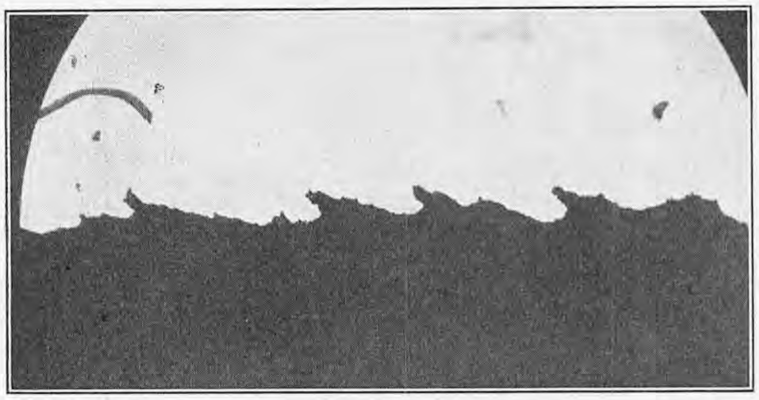
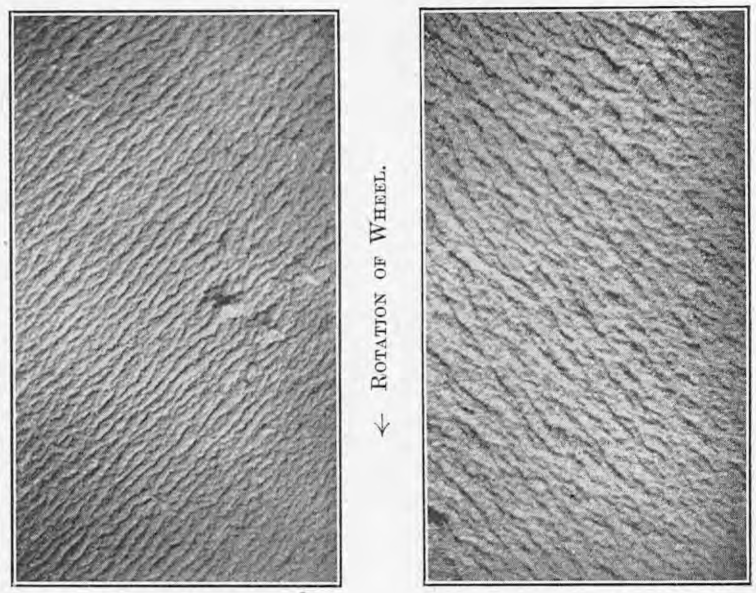


FIG. 6. PROFILE OF ABRASION PATTERN ON EXPERIMENTAL TYRE. × 60 HORIZONTALLY, × 86 VERTICALLY.



(*a*) (*b*)

(*a*) Tyre-Tread Compound. Abrasion Upwards at 45 deg. to Left.
(*b*) Medium-Pure Gum. Abrasion Upwards at 45 deg. to Right.

FIG. 7. ABRASION PATTERNS ON TYRE, × 5.

FACTORS INFLUENCING THE ROAD WEAR OF TYRES.*

By R. D. STIEHLER, M. N. STEEL, and J. MANDEL.

IT is well known that large variations in the wear of tyres in service are likely to occur from one position on a vehicle to another, from vehicle to vehicle, from day to day, and from winter to summer. In the evaluation of the tread wear of tyres, it is important to know the magnitude of these variations so that proper corrections or equalisation of conditions can be made. It is possible to study several of these variables during the routine evaluation of tyres without increasing the cost of the test by planning it in accordance with a statistical design. Buist, Newton, and Thornley† give a design for testing tyres which employs two-part and three-part treads. This paper deals with three designed tests for regular tyres, two of them involving the evaluation of different brands of 6·00-16 passenger-car tyres and the other being a study of the influence of type of rubber and black on tread wear, employing 9·00-20 truck tyres. A more complete description of the latter test is given in the paper by Mandel, Steel, and Stiehler.‡

Method of Measurement.—In the usual method for determining tread wear, the depth of the grooves in the tread design is measured periodically. Another method, found by Roth and Holt§ to have advantages over depth measurements, is to make periodic measurements of the weight of the tyre while it is mounted on a rim and inflated. In the test employing the 9·00-20 truck tyres, both methods of measurement were used in order to determine the relative advantages of each. Only the weight method was used in the two tests evaluating the tread wear of passenger-car tyres.

TABLE I.—*Comparison of Methods of Tyre-Wear Measurement.*

Characteristic.	Weight Method.	Depth Method.
Reproducibility of measurement	—	Better
Sensitivity of test	Better	—
Relation to mileage	Proportional	Not proportional
Effect of tread design on ratings	None	Biased ratings
Substitution of tyres during test	Unrestricted	Restricted
Testing of two-part treads	Not suitable	Suitable
Testing of wear behaviour at centre and shoulder of tread	Not suitable	Suitable

An analysis of the data for the truck tyres gives a coefficient of variation for a single determination of approximately 17 per cent. by the depth method and 20 per cent. by the weight method. If judged by precision alone, the depth method appears to have the advantage. Precision, however, is only one factor determining the sensitivity of a test. The other factor is discrimination of a test, or the differences in values obtained for two different samples. A consideration of the rate of wear during test as measured by both methods reveals the magnitude of this second factor. Fig. 1, on page 220, shows that a tyre loses weight at essentially a constant rate; whereas the depth of the tread grooves decreases rapidly during the early life of a tyre, and at a diminished but continually changing rate during its later life. Fig. 2, on page 220, makes a direct comparison of the loss in weight and in depth for the tyres included in this test. If two of these tyres, T and T′, are compared after a certain mileage, it is seen that tyre T′ appears to wear 1·5 times as fast as tyre T according to weight measurements, but only 1·36 times as fast according to depth measurements. Further, if comparisons are made at other mileages, the wear of tyre T′ compared to that of tyre T is the same within experimental error if weight measurements are used, but varies if depth measurements are used. If tread designs are different, then depth measurements may even give misleading ratings of tyres. Table I, herewith, lists the advantages and disadvantages of both methods of measurement.

Design of Test.—The three tests were designed round a four-by-four Latin square. This design permits the simultaneous testing of 16 tyres on four vehicles. The test of the truck tyres covered nearly a million vehicle-miles during an interval of 15 months. The test was divided into seasons of three months each. During each season, a different set of tyres was tested, all of which had shelf-aged during all preceding seasons. There were eight periods of approximately 1,680 miles each, in addition to an initial "break-in" period, in each season. Table II, herewith, shows the allocation of tyres to vehicles and positions for each of the eight periods of each season. The capital letters signify the rubbers and the small letters signify the blacks included in the test. Table III shows the design of

TABLE II.—DESIGN OF TEST OF 9·00-20 TRUCK TYRES.

Group 1*. Group 2*.		Summer and Winter, Autumn and Spring.				Autumn and Spring, Summer and Winter.			
		Vehicle.				Vehicle.			
Test Period.	Wheel Position.	1.	2.	3.	4.	1.	2.	3.	4.
1	LF	Ab	Cc	Da	Bd	Bb	Dc	Ca	Ad
	RF	Cd	Aa	Bc	Db	Dd	Ba	Ac	Cb
	RR	Ba	Dd	Cb	Ac	Aa	Cd	Db	Bc
	LR	Dc	Bb	Ad	Ca	Cc	Ab	Bd	Da
2	LF	Dd	Ba	Ac	Cb	Cd	Aa	Bc	Db
	RF	Bb	Dc	Ca	Ad	Ab	Cc	Da	Bd
	RR	Cc	Ab	Bd	Da	Dc	Bb	Ad	Ca
	LR	Aa	Cd	Db	Bc	Ba	Dd	Cb	Ac
3	LF	Bc	Db	Cd	Aa	Ac	Cb	Dd	Ba
	RF	Da	Bd	Ab	Cc	Ca	Ad	Bb	Dc
	RR	Ad	Ca	Dc	Bb	Bd	Da	Cc	Ab
	LR	Cb	Ac	Ba	Dd	Db	Bc	Aa	Cd
4	LF	Ca	Ad	Bb	Dc	Da	Bd	Ab	Cc
	RF	Ac	Cb	Dd	Ba	Bc	Db	Cd	Aa
	RR	Db	Bc	Aa	Cd	Cb	Ac	Ba	Dd
	LR	Bd	Da	Cc	Ab	Ad	Ca	Dc	Bb
5	LF	Ad	Ca	Dc	Bb	Dc	Bb	Ad	Ca
	RF	Cb	Ac	Ba	Dd	Ba	Dd	Cb	Ac
	RR	Bc	Db	Cd	Aa	Cd	Aa	Bc	Db
	LR	Da	Bd	Ab	Cc	Ab	Cc	Da	Bd
6	LF	Db	Bc	Aa	Cd	Aa	Cd	Db	Bc
	RF	Bd	Da	Cc	Ab	Cc	Ab	Bd	Da
	RR	Ca	Ad	Bb	Dc	Bb	Dc	Ca	Ad
	LR	Ac	Cb	Dd	Ba	Dd	Ba	Ac	Cb
7	LF	Ba	Dd	Cb	Ac	Cb	Ac	Ba	Dd
	RF	Dc	Bd	Ad	Ca	Ad	Ca	Dc	Bb
	RR	Ab	Cc	Da	Bd	Da	Bd	Ab	Cc
	LR	Cd	Aa	Bc	Db	Bc	Db	Cd	Aa
8	LF	Ca	Ab	Bd	Da	Bd	Da	Cc	Ab
	RF	Ac	Cd	Db	Bc	Db	Bc	Aa	Cd
	RR	Dd	Ba	Ac	Cb	Ac	Cb	Dd	Ba
	LR	Bd	Dc	Ca	Ad	Ca	Ad	Bb	Dc

* Seven blacks were tested in combination with four rubbers. In Group 1, blacks *a*, *b*, *c* and *d* were tested, and in Group 2, blacks *a*, *e*, *f* and *g* were tested. Blacks *e*, *f* and *g* replaced blacks *b*, *c* and *d* in the design.

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

† Buist, Newton and Thornley, *Trans. I.R.I.*, vol. 26, page 288 (1950).

‡ Mandel, Steel and Stiehler, *Ind. Eng. Chem.* (in press).

§ Roth and Holt, *J. Res. Natl. Bur. Stds.*, vol. 32, page 61 (1944).

ROAD WEAR OF TYRES.

Fig. 1.

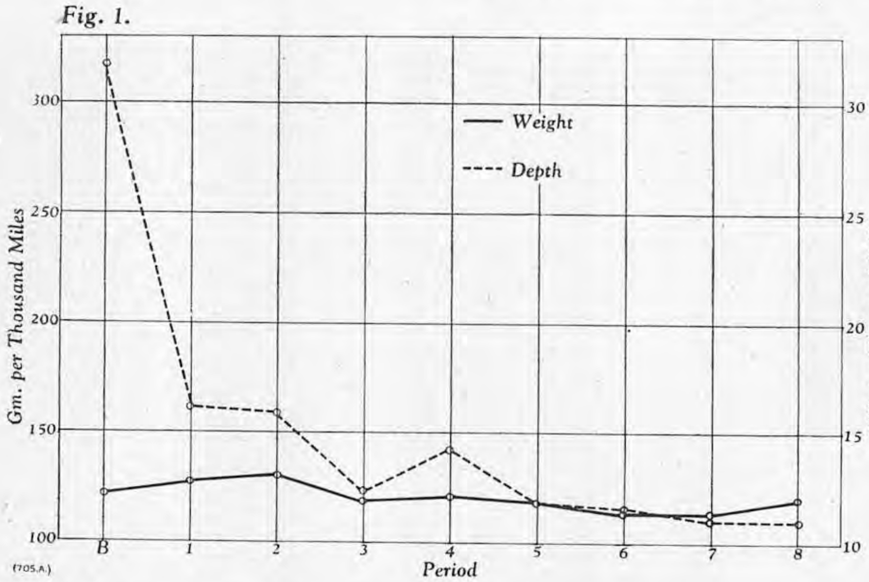
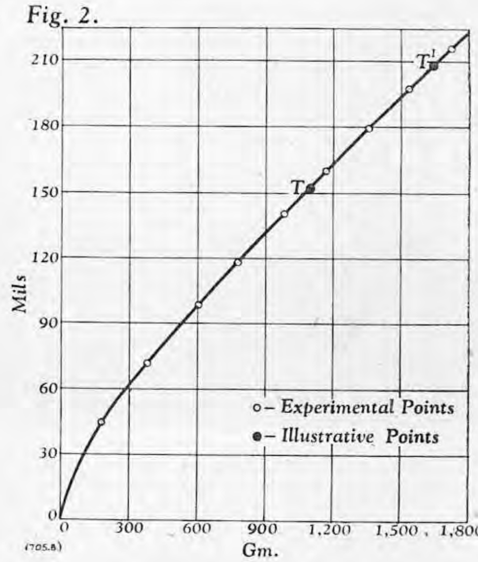


Fig. 2.



Test I of passenger-car tyres, which comprised 16 periods of 800 miles each. The capital letters in the Table signify the brands of tyres and the numerals identify the two tyres of the same brand. Test II of passenger-car tyres followed a design similar to that shown in Table III, with two exceptions, namely, the test comprised only eight periods of approximately 525 miles each, and four tyres of one brand and 12 tyres of another brand constituted the tyres tested.

It is apparent from an examination of Tables II and III that, in the course of 16 periods, each tyre is tested on each of the 16 wheels. Further, if the 16 periods are subdivided into sets of four consecutive periods, then, in each set, each tyre is tested once on each vehicle and once on each of the four wheel positions. Each set of four periods forms a balanced design from which certain valid conclusions can be deduced. Table IV, herewith, lists the variables studied in the two designs.

In addition to determining the effects of these vari-

Fig. 3.

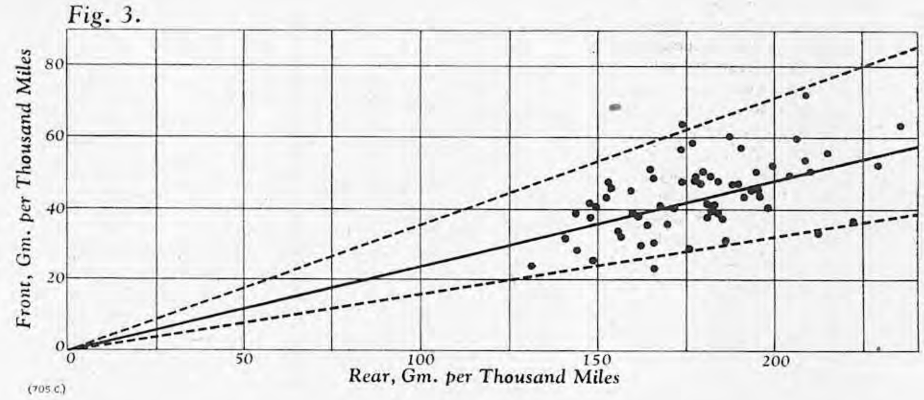


TABLE III.—DESIGN OF TEST I OF 6·00–16 PASSENGER-CAR TYRES.

Wheel Position.	Period.	Vehicle. 1.	2.	3.	4.	Period.	Vehicle. 1.	2.	3.	4.
RF	1	1A	1E	1D	1H	9	1F	1B	1C	1G
LF		1G	1C	1B	1F		1H	1D	1E	1A
RR		2B	2F	2G	2C		2E	2A	2H	2D
LR		2D	2H	2A	2E		2C	2G	2F	2B
RF	2	2E	2A	2H	2D	10	2B	2F	2G	2C
LF		2C	2G	2F	2B		2D	2H	2A	2E
RR		1F	1B	1C	1G		1A	1E	1D	1B
LR		1H	1D	1E	1A		1G	1C	1B	1F
RF	3	2G	2C	2B	2F	11	2H	2D	2E	24
LF		2A	2E	2D	2H		2F	2B	2C	2G
RR		1D	1H	1A	1E		1C	1G	1F	1B
LR		1B	1F	1G	1C		1E	1A	1H	1D
RF	4	1C	1G	1F	1B	12	1D	1H	1A	1E
LF		1E	1A	1H	1D		1B	1F	1G	1C
RR		2H	2D	2E	2A		2G	2C	2B	2F
LR		2F	2B	2C	2G		2A	2E	2D	2H
RF	5	2F	2B	2C	2G	13	2A	2E	2D	2H
LF		2H	2D	2E	2A		2G	2C	2B	2F
RR		1E	1A	1H	1D		1B	1F	1G	1C
LR		1C	1G	1F	1B		1D	1H	1A	1E
RF	6	1B	1F	1G	1C	14	1E	1A	1H	1D
LF		1D	1H	1A	1E		1C	1G	1F	1B
RR		2A	2E	2D	2H		2F	2B	2C	2G
LR		2G	2C	2B	2F		2H	2D	2E	2A
RF	7	1H	1D	1E	1A	15	1G	1C	1B	1F
LF		1F	1B	1C	1G		1A	1E	1D	1H
RR		2C	2G	2F	2B		2D	2H	2A	2E
LR		2E	2A	2H	2D		2B	2F	2G	2C
RF	8	2D	2H	2A	2E	16	2C	2G	2F	2B
LF		2B	2F	2G	2C		2E	2A	2H	2D
RR		1G	1C	1B	1F		1H	1D	1E	1A
LR		1A	1E	1D	1H		1F	1B	1C	1G

The capital letters signify the brands. The numerals signify tyres of the same brand.

ables, the features of replication inherent in the design permit an appropriate statistical analysis to estimate the precision or reproducibility of the results. The coefficients of variation determined from the data are 13 per cent. for Test I and 16 per cent. for Test II of passenger-car tyres (weight method), and 17 per cent. for depth method and 20 per cent. for the weight method of test of truck tyres.

The equalisation of treatment of each tyre through this type of design can best be seen from an examination of the results for Test II of 6·00-16 tyres, involving four tyres of one brand and 12 tyres of another. The results are summarised in Table V, opposite. It is seen that the vehicles travelled at 30 m.p.h. during four periods and at 50 m.p.h. during the other four periods. The variability in average rate of wear from period to period is very large even for periods run at the same speed, having a coefficient of variation of 20 per cent. This arge variation prevents an accurate estimate of the effect of speed, although it is apparent that wear is appreciably faster at 50 m.p.h. than at 30 m.p.h. One might expect that this variability, which interferes with the estimation of the effect of speed, might also appreciably reduce the precision of test and interfere with evaluation of the wear of the tyres. In fact, however, the agreement between the average rates of wear for tyres of the same make is remarkably good, the coefficient of variation being about 6 per cent. It should be noted that this reproducibility was obtained with only eight instead of 16 periods of test. It may be concluded, therefore,

TABLE IV.—*Test Variables.*

Variables in Table II.	Variables in Table III.
Rubbers	Brands
Blacks	Uniformity of brands
Vehicles	Vehicles
Wheel position	Wheel position
Periods	Periods
Climatic conditions	—
Ageing	—

that proper equalisation of treatment of the tyres by means of an appropriate statistical design can compensate to a very large extent for the large and often unavoidable variability in conditions that are encountered in the road-testing of tyres.

Effect of Wheel Position.—The relative rate of wear of tyres on each of the 16 wheels in each test is shown in Table VI, on page 222. It is seen that, in all three tests, the variation in rate of wear on different vehicles was relatively small, the wear on individual vehicles differing from the mean by less than 10 per cent. On the other hand, it is observed that the variation in wear on different wheel positions varied from test to test. In the tests of passenger-car tyres, the maximum difference in wear on different wheel positions is about 25 per cent. from the mean; whereas, in the test of the truck tyres, the rate of wear on rear positions is more than four times that on front positions. This large difference in rate of wear is probably due to loading. The passenger-car tyres carry the same load in all positions, whereas the truck tyres carry a 45 per cent. greater load in rear positions than in front

ROAD WEAR OF TYRES.

Fig. 4.

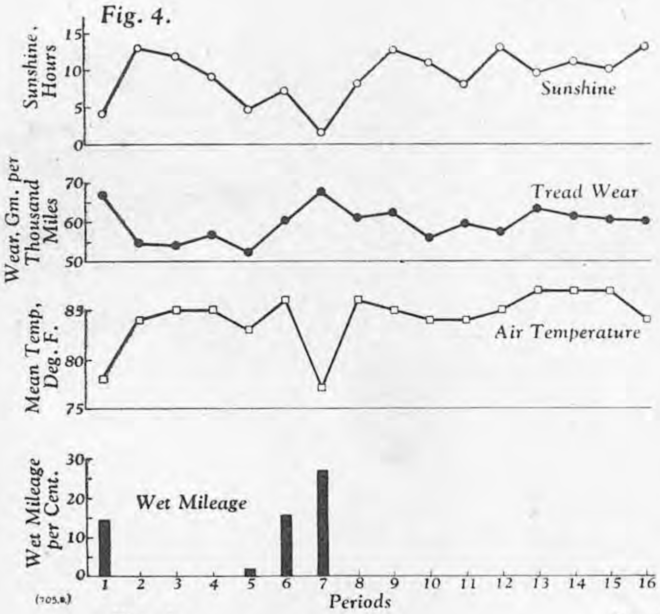


Fig. 5.

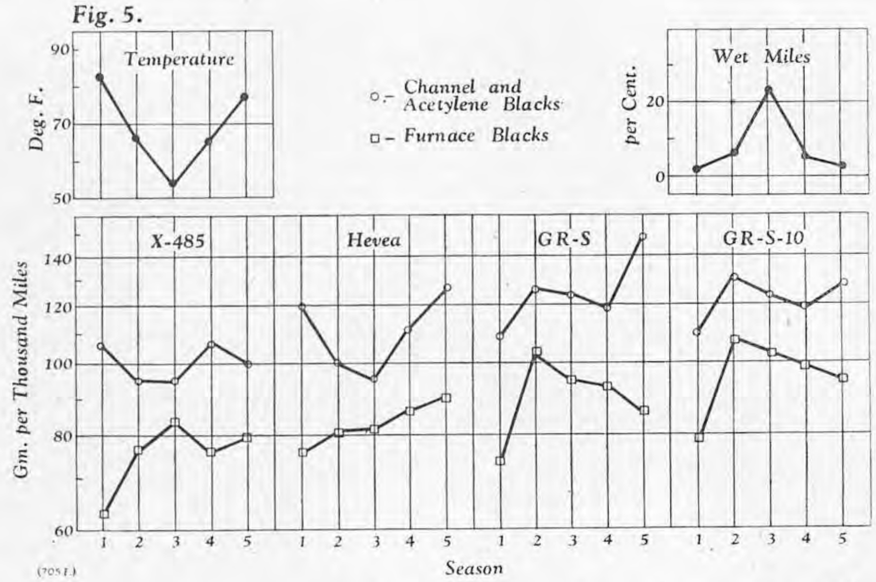


Fig. 6

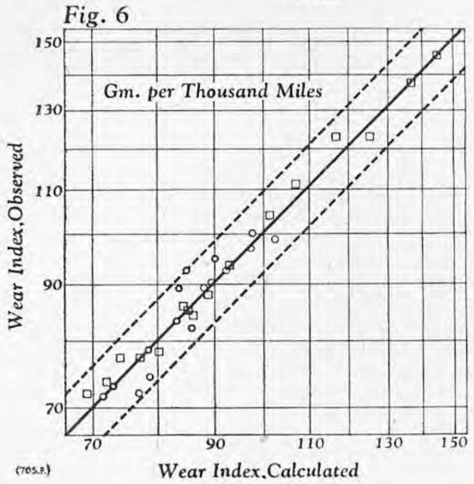
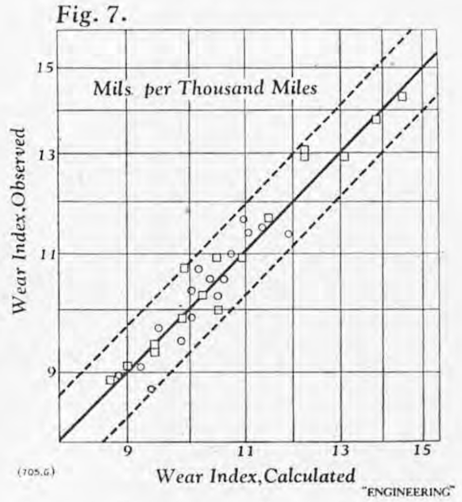


Fig. 7.



positions. It is also noted that there is some variation in wear between right and left positions, and that the front wheels of some vehicles were apparently not in good alignment. The higher rate of wear on front than on rear wheels in Test II of passenger-car tyres is probably due to the use of vehicles with four-wheel drive.

Fig. 3, opposite, illustrates the relationship between the rates of wear in front and rear positions of the trucks used in testing the 9·00-20 tyres. This relationship applies only to tyres having treads made from synthetic rubber and furnace black, which are influenced in the same relative manner by changes in temperature and other conditions of test. The broken lines represent the limits within which 95 per cent. of the points are expected to be, if wear on front and rear positions is proportional. The figure confirms the conclusion, based on a statistical study of the data, that the ratio of the rates of wear on front and rear wheels is constant within experimental error. Further, the coefficient of variation for tread wear of these tyres, when tested in front positions, is only slightly greater than that in rear positions, despite the large difference in rate of wear. These observations suggest that geometric averages or their mathematical equivalent—the arithmetic averages of the logarithms of the wear values—should be used in the analysis of these data. Failure to do so will result in an undue emphasis on the results obtained in rear positions, since even large significant differences in the wear on front wheels are small with respect to random variations in wear on rear wheels. Transformation of wear values into logarithms has the added advantage of permitting a direct estimation of the relative wear of different tyres. For these reasons, the data obtained on the 9·00-20 truck tyres were treated in this manner.

On the other hand, there is little gain in transforming wear data into logarithms if the variation in wear on different wheels is not large, such as in the case of the two tests of 6·00-16 passenger-car tyres. An analysis made on the logarithms of the data shown in Table V leads to identical conclusions to those inferred from the analysis of the original data, shown in this table. Further, the two methods of analysis yield estimates of experimental error that are in excellent agreement.

Effect of Daily and Seasonal Variations.—In Test I of passenger-car tyres, the 800 miles comprising a period were driven during a single day. Since the test was conducted during July, about 75 per cent. of the travel was made during daylight hours. The variations in

TABLE V.—TREAD WEAR IN TEST II OF 6·00-16 PASSENGER-CAR TYRES.

Period	1.		2.		3.		4.		5.		6.		7.		8.		Mean.	
Speed	30.		50.		50.		30.		30.		50.		50.		30.			
Brand	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.
Tyre 1	20	25	25	53	29	21	15	42	25	26	33	28	14	44	15	15	22·0	31·8
2	22	24	26	43	33	21	8	29	13	24	30	29	17	42	13	21	20·2	29·1
3	19	46	40	30	16	35	16	19	36	20	19	42	24	18	10	17	22·5	28·4
4	14	28	43	40	20	30	19	15	18	23	23	54	18	24	11	18	20·8	29·0
5		21		55		31		22		26		30		22		13		27·5
6		27		53		25		22		53		33		35		16		33·0
7		25		33		39		22		23		37		21		16		27·0
8		28		30		37		18		18		41		18		34		28·0
9		24		30		31		14		29		53		23		13		27·1
10		46		41		40		20		16		54		17		16		31·2
11		24		47		30		25		23		30		45		12		29·5
12		23		45		19		40		33		25		33		17		29·4
Brand mean	18·8	28·41	33·5	41·7	24·5	29·9	14·5	24·0	23·0	26·2	26·2	38·0	18·2	28·5	12·2	17·3	21·4	29·2
Period mean—30 m.p.h.	26·0						21·6		25·4						16·1		22·3	
50 m.p.h.			39·6		28·6						35·1		25·9				32·3	

ANALYSIS OF VARIANCE.

Source of Variation.	Degrees of Freedom.	Sums of Squares.	Mean Square.	Variance Ratio.
a. Speed	1	3,220	3,220	(*a*/*b*) 6·8*
b. Period-to-period	6	2,852	475	(*b*/*h*) 22·6†
c. Tyre brands	1	1,488	1,488	(*c*/*d*) 62·0†
d. Tyres of same brand	14	342	24	(*d*/*h* 1·1 (N.S.)
e. Vehicles	3	661	220	(*e*/*g*) 1·5 (N.S.)
f. Position	3	4,132	1,377	(*f*/*g*) 9·4†
g. Vehicles X positions	9	1,324	147	(*g*/*h*) 7·0†
h. Residual	90	1,865	21	—

* More significant than 5 per cent. level. † More significant than 1 per cent. level.
(N.S.) Not significant on 5 per cent. level.

wear and weather from period to period are, therefore, the same as those from day to day. These variations can be seen in Fig. 4, on page 221. It is interesting to note that the rate of wear was greatest when the largest proportion of the mileage was on wet roadways. From this observation, one should not infer that wet roadways necessarily cause an increase in the rate of wear, but rather that, if wet roadways do decrease the rate o. wear, then some other factor which may be associated with wet roadways has a much greater effect than wetness of the pavement, and in the opposite direction. This factor is apparently not the atmospheric temperature, since, on days when the roadway was dry, the variation in wear can not be correlated with the variation in atmospheric temperature. Better correlation is obtained between the amount of sunshine and the rate of wear, although the data for periods 5 and 9 cause the correlation coefficient to be low. The results are suggestive, however, that probably road, and particularly tread-surface, temperatures may be responsible in large part for the variations in tread wear from day to day. There is some evidence that the amount and type of dust on the road may also cause some of the variation in rate of wear from day to day. Studies of these factors have not been made to date.

TABLE VI.—*Wear on Individual Wheels: Percentage of Mean Weight Loss.*

Position.	Vehicle.				Mean.
	1.	2.	3.	4.	
900-20 Truck Tyres.					
LF	33	35	33	32	33
RF	41	41	54	38	44
LR	167	171	163	142	161
RR	163	171	167	148	163
Mean	101	104	104	91	100
600-16 Passenger-Car Tyres: Test I.					
LF	89	72	87	79	81
RF	108	94	119	115	108
LR	104	98	106	102	100
RR	117	104	106	117	111
Mean	104	92	104	102	100
600-16 Passenger-Car Tyres: Test II.					
LF	104	115	111	122	113
RF	100	100	156	156	128
LR	89	82	85	82	84
RR	78	70	82	78	77
Mean	93	92	108	109	100

TABLE VII.—*Ageing and Temperature Coefficients of Tread Wear.*

Tread Compound.		Ageing Coefficient, per cent. per Year.	Temperature Coefficient, per cent. per deg. F.
Rubber.	Black.		
Hevea	Acetylene or EPC	11	1·0
	Furnace	20	0·1
GR-S or GR-S-10	Acetylene or EPC	14	0
	Furnace	5	—0·9
X-485-GR-S ..	Acetylene or EPC	1	0·3
	Furnace	16	—0·7

In the test on truck tyres, it was found that the seasonal variation of wear was different for treads made from natural rubber and channel black than for those made from synthetic rubber and furnace blacks. The difference in the behaviour of these treads can be seen in Fig. 5, on page 221, where the circles represent treads containing channel or acetylene black and the squares represent treads containing furnace blacks. It is seen that natural-rubber treads containing channel or acetylene black wear least in the winter time (Season 3) and most in the summer time (Seasons 1 and 5). The reverse appears to be the case for tread made of synthetic rubbers and furnace blacks. The other combinations (i.e., treads made from natural rubber and furnace blacks, or treads made from synthetic rubbers and channel or acetylene black) do not appear to be as sensitive to seasonal changes. Although the data for passenger-car tyres indicated that the wear during any particular day is not directly correlated with the atmospheric temperature, it is reasonable to assume that long-term seasonal changes are related to average seasonal temperature. On this assumption, it is interesting to calculate temperature coefficients of wear. The results are given in Table VII, herewith. Positive temperature coefficients are obtained for treads made from Hevea and channel or acetylene black, and negative coefficients are obtained for treads made from synthetic rubbers and furnace blacks. The temperature coefficient of the other treads is essentially zero.

TOOL-GRINDING MACHINES.

WALTER KRAUMENDAHL, G.M.B.H., LÖRRACH, GERMANY.

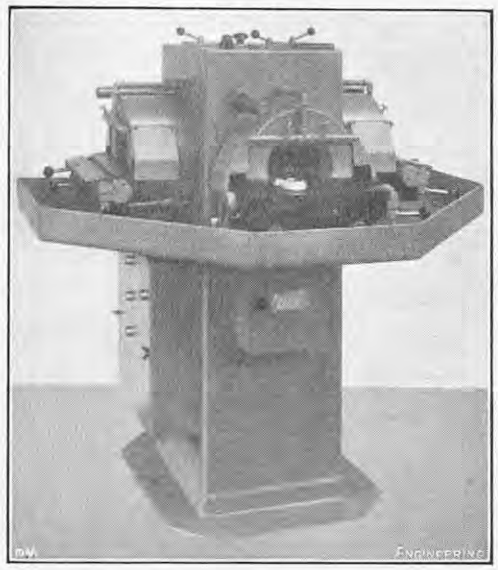


FIG. 1. THREE-HEAD TOOL GRINDER.

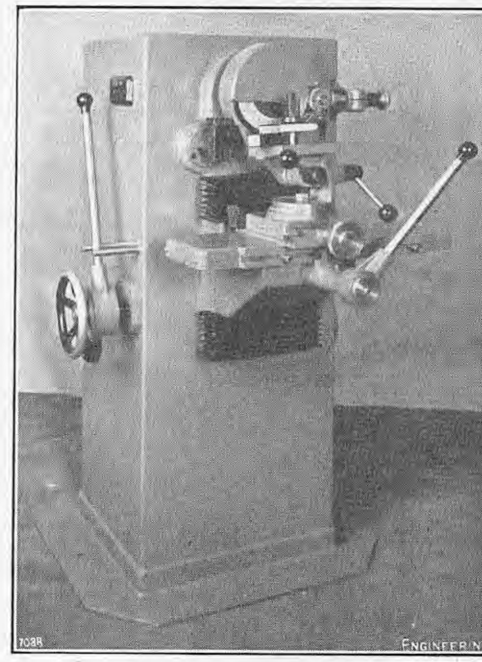


FIG. 2. MACHINE FOR GRINDING CHIP GROOVES IN TURNING TOOLS.

It is also interesting to note that a higher rate of wear occurred in winter than in summer for some treads, even though the wet mileage was 20 per cent. greater in winter. In fact, if the effect of a lower coefficient of friction due to wet pavement is to decrease the rate of wear, then the temperature coefficients in Table VII should be algebraically smaller. There is some indication that a lower coefficient of friction decreases tread wear, since the rate of wear was appreciably reduced during one period of Season 3, when 85 per cent. of the mileage was wet. This lower rate of wear may also account for the fact that some treads having negative temperature coefficients wore slower in winter (Season 3) than in the autumn (Season 2). Present data do not permit a reliable estimate of the re'ative effects of temperature and coefficient of friction on tread wear, since information on road and tread-surface temperatures are lacking. Both the tests of passenger-car and truck tyres, however, indicate that the temperature effect frequently overshadows the effect of a lower coefficient of friction on wet roadways.

Table VII also gives the coefficients of wear relating to the age of the tyre. It is apparent that rate of wear increases on ageing in most instances. The rate of wear of some treads, however, does not appear to change significantly during one year of storage. It should be emphasised that these coefficients are qualitative indices rather than quantitative estimates, since other factors than time affect the amount of deterioration during storage. Further, the effect of ageing is generally much less on rate of wear than on other characteristics, such as tread cracking.

TABLE VIII.—*Rating of Rubbers and Blacks.*

Rubber.	Basis of Rating.		
	Weight.	Volume.	Depth.
Rating of Rubbers.			
X-48GR-S5 ..	123·9	123·4	119·4
Hevea* ..	114·8	113·2	111·7
GR-S	105·2	105·1	105·7
GR-S-10 ..	100·0	100·0	100·0
Rating of Blacks.			
HAF	100·0	100·0	100·0
VFF	90·6	91·0	96·2
EPC* & RF ..	83·9	83·8	88·3
Acetylene* ..	60·9	61·1	73·0

* Rating applies only for the conditions of this test.

Effect of Type of Rubber and Black.—As mentioned previously, the test of the 9·00-20 truck tyres was made primarily to determine the wear characteristics of treads made from different rubbers and blacks. An analysis of the data was made to determine whether the effect of type of black is consistent or differs from rubber to rubber; i.e., if there is "interaction" between rubber and black. Within experimental error, no interaction was found. This conclusion was demonstrated by calculating a wear index for each rubber-black compound on the assumption of no interaction between the two components. Then, the calculated values were plotted against the observed values, as shown in Figs. 6 and 7, on page 221. If there is no interaction between the rubbers and the blacks, approximately 95 per cent. of the points should be within the broken lines, and it is seen that such is the case. It may be concluded, therefore, that the rubber and black are mutually independent in their effects on tread wear.

This finding simplifies the study, although the difference in the behaviour of natural and synthetic rubbers or of channel and furnace blacks with a change in temperature makes it impossible to state definite ratings of tread wear. The ratings given in Table VIII, herewith, are applicable only for the conditions of this test. The treads made from the synthetic rubbers and the furnace blacks will have the same relative ratings under apparently all conditions of test, but a comparison of these ratings with those for treads containing natural rubber or channel black must be made with discretion.

The authors gratefully acknowledge the co-operation of the Government Tyre Test Fleet of the Office of Rubber Reserve for furnishing the data on the test of 9·00-20 truck tyres and of the Southwest Research Institute and Consumers Union for making available the data on Test I of 6·00-16 passenger-car tyres.

TOOL-GRINDING MACHINES.

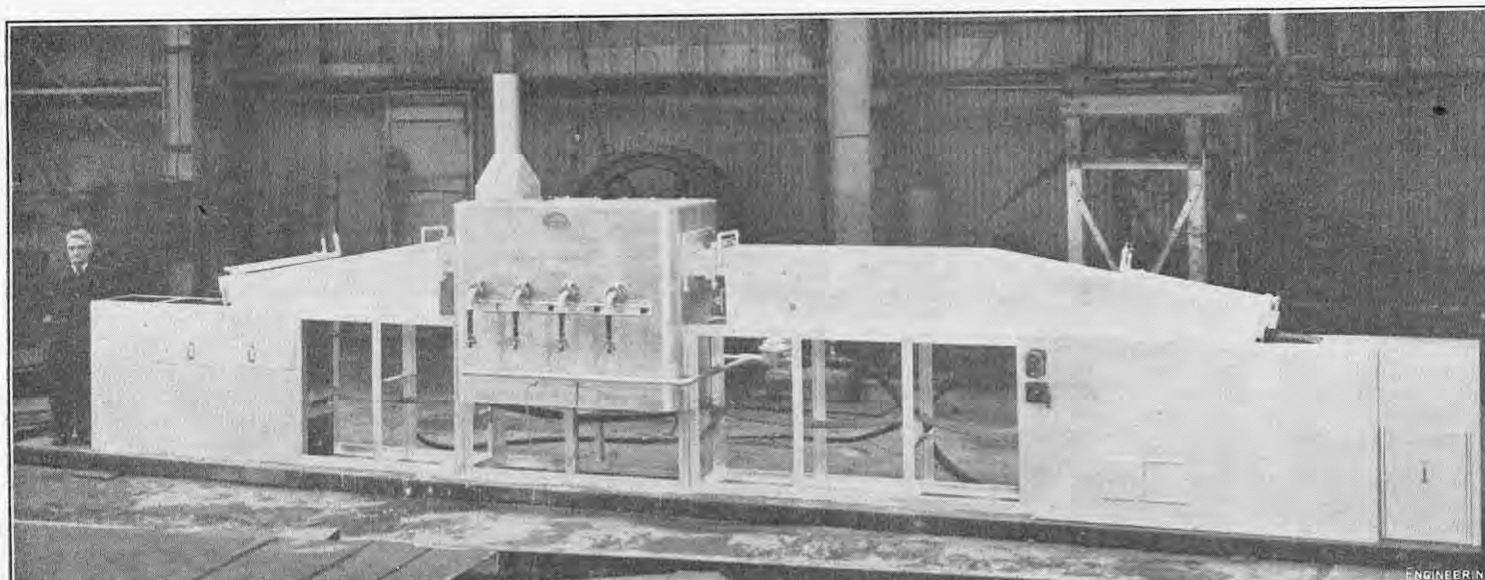
THE two machines illustrated above are, respectively, a three-head machine for grinding tungsten-carbide tools and a machine for grinding chip-breaking grooves in turning tools. Both have been introduced recently by Messrs. Walter Kraumendahl, G.M.B.H., Lörrach, Germany, for whom the agents in this country are the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2.

The "Triax" machine shown in Fig. 1 has three wheels 300 mm. in diameter and 70 mm. wide, each driven by a 1-h.p. motor; the faces of the wheels are used for grinding. Reversing switches are fitted to the motors so that the wheels can be run in either direction. All spindles are mounted in precision roller bearings protected by oil seals. The three grinding heads can be used simultaneously by three operators, with sufficient room to grind the tools, and setting-up is easy as there are only two levers to be operated. An adjustable angle table is provided at each position. Another machine, known as the "Quart," similar to the Triax but with four instead of three grinding wheels, is now also made by Messrs. Kraumendahl. The fourth wheel, driven by a $1\frac{1}{2}$-h.p. motor, is 350 mm. in diameter and 40 mm. wide, and is used on the periphery.

The Spanex machine shown in Fig. 2 is fitted with a grinding wheel 200 mm. in diameter and from 6 to 12 mm. wide, according to the width of chip-breaking groove required. It is driven by a 1-h.p. motor. The tool being ground is held in position on an adjustable and tilting support table, which can be swivelled in two directions so that the groove can be ground at whatever angle is required. An adjustable setting gauge is fitted to the machine at the side of the grinding

CONTINUOUS BRIGHT-ANNEALING FURNACE.

DOWSON AND MASON GAS PLANT COMPANY, LIMITED, MANCHESTER.



wheel, and the tool is clamped in position while its cutting edge is resting against the gauge. The table is reciprocated for grinding the groove by means of a hand lever. The machine will grind a groove in a 1½-in. square tool in about two minutes, including the time for setting. The peripheral speed of the grinding wheel is arranged so that it is impossible for tungsten-carbide tips to be cracked due to over-heating while being ground. Diamond-impregnated wheels or standard soft grinding wheels are supplied with the machine.

THE RAND WATER BOARD.

DURING the war, the annual reports of the Rand Water Board fell rather badly into arrear, as happened with so many such periodical returns while the staff who compiled them were engaged elsewhere; but in the past three years considerable efforts have been made to recover the leeway, and with the recent publication of the 46th report, covering the twelve months ended March 31, 1951, it may be said that normal conditions have been restored.

The area in which the Board are responsible for maintaining the water supply is some 4,300 square miles, in which the most important consuming centres are Johannesburg (where the Board's headquarters are situated) and Pretoria. The estimated population within the municipal areas of the various local authorities concerned is 1,877,000, contained in some 733 square miles; and the estimated total population depending on the Board is 2,354,000. Most of the water raised is taken from the Vaal River, 93·85 per cent. coming from that source in 1950-51; the remainder is drawn from wells. The total quantity obtained from all sources, during the twelve months covered by the report, was rather more than 36,341 million gallons; a daily average of 99·565 million gallons, of which 92·713 million gallons was potable. The maximum quantity supplied on any one day was 120·453 million gallons, and the minimum was 71·205 millions.

The supply from the Vaal River is purified at Vereeniging, about 35 miles from Johannesburg; and, during the year, of the 34,105 million gallons drawn from the river, 32,559 millions of purified water was available for distribution. The report mentions that the amount of suspended solids (clay, silt, etc.) present in the river water varied from 1·5 to 141·6 parts per 100,000; and that the total quantity removed from the 34,105 million gallons passing through the purification plant was 43,325 tons—about 35,800 cubic yards, or enough, in the form of dry soil, to cover 22 acres to a depth of 1 ft.

The Rand Water Board are fortunate in having available some of the cheapest coal in the world, for use in their pumping plants. At Vereeniging pumping station, the total quantity of coal delivered for steam-raising was 106,909 tons, of an average calorific value of 9,316 B.Th.U., at a cost of 37,045*l*., or 6*s*. 6*d*. a ton, to which had to be added a cost of 6*d*. a ton for crushing and 8·909*d*. for haulage, including maintenance. At the Zwartkopjes pumping station, the cost was 9*s*. 2¼*d*. a ton, but the coal was of slightly higher calorific value (9,399 B.Th.U.). The cost of pumping 1,000 gallons into supply was 1·5894 pence, which compares with 1·5902 pence in the previous financial year—a slight reduction; but the average cost of pumping 1,000 gallons against 100 ft. head was higher—0·1035*d*. as against 0·1014*d*. in 1949-50.

ANNUALS AND REFERENCE BOOKS.

Mechanical World Year Book, 1952.

Emmott and Company, Limited, 31, King-street West, Manchester, 3, and 21, Bedford-street, London, W.C.2. [Price 3*s*. 6*d*. net.]

THE present issue of this very popular compendium is the 65th—or, at least, 1952 is the 65th year of publication, which we understand to be the same thing; and it is pleasant to record that the particular virtues—accuracy and cheapness—that it exemplified at the outset are still in evidence. The price is now seven times what it was originally, but the book is at least twice the thickness; so that, page for page, and making due allowance for the changing value of the sixpence, it is probably cheaper, if anything, than it was originally. The new feature in the 1952 edition is a section on "Inventions and Patents," contributed by Mr. Robert F. McKay, M.Sc. The section on "Gas Turbines" has been retained, as are all the usual tables, British Standard Specifications, etc. While appreciating the economics of the matter, however, we are of opinion that the average user of the book would prefer not to have the index interleaved with advertisements, whatever may be done elsewhere in the book; and that he would welcome a thick-paper page, with a thumb tab, to mark the position of the list of contents. We would suggest, too, that it would be well to renumber the pages continuously, so as to avoid the "*a*" suffixes.

Hutchinson's Pocket Technical Encyclopaedia.

Compiled by DR. L. E. C. HUGHES, A.M.I.E.E., and JEAN P. BREMNER, B.Sc. Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 7*s*. 6*d*. net.]

IT is a little difficult to decide in what category to place this small reference book, when it is regarded from the engineering standpoint. Many of the items that it contains present information about terms that are of common usage without being at all generally understood; others are such commonplaces that, it might have been supposed, they required no elucidation; and a large number are of so special a nature that the ordinary reader is as unlikely to need them as the *cognoscenti* are to need the help of this book. Many scientists, philosophers and engineers are given a brief mention, while others, of not less fame, are either ignored or are mentioned only incidentally in some other connection. Thus Watt, Boulton, Bramah, Trevithick, Telford, Rennie, Whitworth, and Sir Frank Whittle appear in their alphabetical places, but Murdock, Stephenson, Smeaton, Maudslay, Bessemer, and even Sir Charles Parsons are not. Fokker and Zeppelin have their paragraphs, but not the Wright brothers. Diesel will be sought in vain, alphabetically, though he is mentioned under "diesel-engine" (which is listed with a lower-case "d"). Heaviside is there, and also Sir Robert Watson-Watt, but not Sir Edward Appleton; Bohr and Soddy, but not Rutherford; Planck, but not Lanchester or Prandtl; Galileo and Newton, but not Bacon, Hooke, Carnot, or even Leonardo da Vinci. There are other curious features—for example, the use of initial capitals for some items and not others, which seem to indicate a difference of opinion or practice between the two authors.

CONTINUOUS BRIGHT-ANNEALING FURNACE.

THE application of bright-annealing processes to finished metal products and components is now well established in industry and such processes are used regularly for sheet and strip and also for small parts, such as pressings, stampings, and screws. A continuous town-gas heated belt-conveyor furnace which uses hydrogen as the medium for the bright annealing of small parts for the radio and telephone industries is illustrated above. The furnace is of the "hump-back" type, and it is pointed out that this and the adoption of adjustable mouthpieces at the inlet and outlet ends keep the consumption of hydrogen down to comparatively low proportions. The plant has been designed, built and placed in service by the Dowson and Mason Gas Plant Company Limited, Levenshulme, Manchester, 19, and is of the natural-draught muffle type. It consists of an inlet zone 6 ft. 3 in. in length, seen on the left in the illustration, a heated section 5 ft. long and a cooling zone measuring 11 ft. 3 in. The overall length of the installation is 29 ft., and this includes the charging and discharging structures with their conveyor-belt pulleys. A 7-in. wide heat-resisting steel-mesh conveyor belt passes through the furnace and over pulleys, the faces of which have been specially treated to afford a good grip. The belt passing round the pulley at the discharge end is also pressure-loaded to enhance its smooth transmission and, as a consequence, no tensioning need be applied to the return strand.

The belt is driven by a ½-h.p. electric motor, connected through a 4 : 1 variable-speed gear unit to worm reduction gears and finally, through a roller chain, to the driving pulley at the discharge end of the installation. A time variation of throughput of between 15 and 60 minutes is provided, and the installation is capable of an output of 80 lb. of non-ferrous metal pressings or other components per hour. The driving motor is totally enclosed but adjustment of the speed is easily effected by opening a sliding door in the sheet-steel case. The furnace section is built up of light-weight refractory blocks, backed with diatomaceous insulating material and enclosed in a steel casing made with rounded corners, as may be seen in the illustration. The heating is provided by eight Venturi-type atmospheric burners firing under the muffle alternately from side to side. The maximum gas capacity of the furnace is 600 cub. ft. per hour at 3 in. water-gauge pressure and this enables the furnace to be heated up from cold to a temperature of 800 deg. C., in 1¼ hours. At a temperature of 800 deg. C. the consumption of town gas is approximately 300 cub. ft. per hour. The maximum operating temperature of the furnace is 1,050 deg. C.

ROAD-CONSTRUCTION PROGRAMME FOR BELGIUM.—According to information published by the International Road Federation, Belgium is to construct 580 miles of motorways at a cost of 136 million pounds sterling during the next 15 years. Priority is to be given to those routes parallel to the Brussels-Ghent and Brussels-Antwerp roads, 30 miles of the former having already been completed. When finished, the system will include a ring road round Brussels with five radial roads leading to Ostend, Antwerp, Liège, Namur and Charleroi.

NOTES ON NEW BOOKS.

The London Tramcar, 1861-1951.

By R. W. KIDNER. Locomotion Papers No. 7. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 5s. 6d. net.]

London's Tramways: Large-Scale Plans.

Prepared and published by F. Merton Atkins, 24, Devonshire-way, Shirley, Croydon, Surrey. [Price, 3s. 9d. each except "Euston" and "Hackney" sections, which are 2s. 9d.; postage extra.]

THESE two publications, though published independently, may well be studied together; and the reader who finds interest in either may be recommended to acquire the other without delay, for they are largely complementary. Mr. Kidner starts farther back than most would expect, beginning in 1829 with the granite-paved tracks for horse-carts in Commercial-road, which, he claims, were called "tramways" in current usage. The first London tramway in the modern sense, however, was George Francis Train's short-lived line in Bayswater-road, from Marble Arch to Notting Hill Gate. From that date to the present day, Mr. Kidner carries the story forward with his customary skill and the aid of numerous contemporary illustrations. Mr. Atkins's tramway plans, to the scale of 1 : 2,500, have been prepared as "a serious individual attempt to record for posterity the ramifications of a great phase in the history of London's surface transportation, now rapidly nearing its close under pressure of economic circumstances." They show not only the routes, but the adjacent topography, with incidental historical details that may be unfamiliar to many Londoners. The series—22 in all—is not yet complete, but an index sheet, showing those available, may be obtained from the publisher.

In the Workshop. Vol. III.

By "DUPLEX." Percival Marshall and Company, Limited, 23, Great Queen-street, London, W.C.2. [Price 9s. 6d. net.]

THE literary partnership of Erckmann-Chatrian lasted for 42 years and has given pleasure to connoisseurs for some 60 more. How long the dual personality that is "Duplex" has been functioning as such, we do not know, but there is some reason to suppose that the productions of their experienced hands and pen(s) may continue to circulate for at least as long, as worthy successors to those practical little booklets that did so much to establish the name of the late Percival Marshall as a publisher and that of his brother "A.W." as an author. Those little manuals were good, so far as they went; but the "Duplex" series, in our opinion, are better, both relatively and absolutely, apart from any question of price. Clearly written, like its predecessors, and admirably illustrated, Vol. III describes the construction of a simple dividing gear and a number of other attachments and amplifications for a Myford M.L.7 lathe, the design and production of various fittings intended to promote its efficiency and accuracy (most being equally applicable, *mutatis mutandis*, to other types of lathe), the machining of sand-cast V pulleys, attachments for increasing the speed range of drilling machines, etc., etc. Though it is written primarily for the amateur turner, the professional who reads it will probably not waste his time.

The Working of Aluminium in the Shipyard.

A.D.A. Information Bulletin No. 18. The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 2s.]

As is explained at the outset, the term "aluminium" in the title of this pamphlet is intended to cover also the various alloys of aluminium that are now used in shipyard use. In practice, indeed, pure aluminium is likely to be seen only very seldom by the shipyard tradesmen—platers, riveters, etc.—and the draughtsman in a shipyard drawing-office can have little occasion to study its uses, except for decorative purposes in passenger accommodation. The brochure is divided into four parts, dealing, respectively, with the working of platers' material, sheet-metal work, machining, and methods of joining. There are also sections on painting, anti-fouling compositions, deck compositions, and the precautions to be taken, where necessary, when aluminium or its alloys are attached to other materials. The alloys recommended for marine work are listed in an appendix; another gives references to the appropriate British Standard Specifications, and summarises the available forms and sizes; and a third appendix briefly outlines the heat-treatment that may be required, though it is pointed out that, for most shipyard applications, the material should not need heat-treatment.

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.

Solid and Split Taper Pins.—First issued in 1929 and revised in 1935, a second revision of specification B.S. No. 46 : Part 3 has now been issued. The previous edition related to a single class of mild-steel pin, but, in the present revision, provision is made for four classes of pins, each with appropriate hardness and bend tests. The table of standard sizes of pins has been extended to take in larger sizes, thus covering nearly all the multitudinous duties for which these pins are suited. The details of the materials to be employed and of the tests to be applied, and the limits of tolerances on dimensions, have been brought up to date. [Price 2s. 6d., postage included.]

Code of Practice for Street Lighting.—Of particular interest to lighting engineers and local authorities is the publication of British Standard Code of Practice CP 1004 : Part 1, concerned with street lighting but dealing with traffic routes only. It belongs to the series of engineering codes issued jointly by the Institution of Electrical Engineers and the British Standards Institution. The code is intended to develop the recommendations made in the "Final Report of the Ministry of Transport Departmental Committee on Street Lighting" (H.M.S.O., 1937). The present Part 1 deals with roads classed in the Report as Group A, and a fourth part, to deal with design of lighting for other routes, is in preparation. The code deals solely with matters of illumination and does not give advice on installation practice. Recommendations are made, for various circumstances, on the choice of light distribution and on the spacing of lanterns, while advice on methods of marking out a site is included. Recommendations for maintaining the performance of installations are also made. Appendices set out the information which should be supplied with inquiries and tenders. Numerous drawings, including diagrams of typical sites, are given in the text. [Price 4s., postage included.]

BOOKS RECEIVED.

Ministry of Fuel and Power. 28th Annual Report on Safety in Mines Research, 1949. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]

Factory Department, Ministry of Labour and National Service. Report by the Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization on Explosions in Oil Drums and Tanks. By DR. F. E. T. KINGMAN, E. H. COLEMAN and Z. W. ROGOWSKI. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]

Report of the Conference on the Use of Radioactive Isotopes in Industry. Organised by the F.B.I. Industrial Research Committee and the Atomic Energy Research Establishment and held at the Institution of Electrical Engineers, May 1, 1951. Federation of British Industries, 21, Tothill-street, London, S.W.1. [Price 2s. 6d.]

Department of Scientific and Industrial Research. Report of the Geological Survey Board for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 3d. net.]

Transactions of the Institute of Welding. June, August and October, 1951. Vol. 14, Nos. 3, 4 and 5. Containing the Proceedings of the International Welding Congress held in London and Oxford in July, 1951. Institute of Welding, 2, Buckingham Palace-gardens, London, S.W.1. [Price 21s., post free.]

Exercices de Radioélectricité. Lignes-Antennes-Hyperfréquences. By PROFESSOR S. ALBAGLI. Librairie Gauthier-Villars, 55, Quai des Grands-Augustins, Paris (6e). [Price 550 francs.]

Water. A Study of its Properties, its Constitution, its Circulation on the Earth, and its Utilization by Man. By SIR CYRIL S. FOX. Technical Press, Ltd., Gloucester-road, Kingston Hill, Surrey. [Price 30s. net.]

Instituto de la Soldaduro. Publication No. 21. *Experimentos sobre Tensiones residuales y Conclusiones Practicas.* By DR. R. WECK. Offices of the Institute, Goya 58, Madrid.

Overseas Economic Surveys. Switzerland. By L. G. HOLLIDAY. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4s. 6d. net.]

P.L.A. Railways. By THOMAS B. PEACOCK. The Locomotive Publishing Company, Limited, 88, Horseferry-road, London, S.W.1. [Price 15s. net.]

Eléments d'Optique Electronique. By PROFESSOR GASTON DUPUOY. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). [Price 260 francs.]

American Society for Testing Materials. Articles on Fatigue. References to articles published in 1950. Offices of the Society, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price 1.50 dols.]

Handbook of Dangerous Materials. By N. IRVING SAX. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 15 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 120s. net.]

The Magnetron. By DR. R. LATHAM, A. H. KING, and L. RUSHFORTH. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 18s. net.]

The Watchmaker's Lathe and How to Use It. By DONALD DE CARLE. N.A.G. Press, Limited, 226, Latymer-court, London, W.6. [Price 30s. net.]

Microphones. By the Staff of the Engineering Training Department, British Broadcasting Corporation. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 15s. net., postage 5d.]

Railway Motive Power. By HARRY WEBSTER. Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 30s. net.]

Ministry of Fuel and Power. Report of H.M. Chief Inspector of Mines Under the Coal Mines Act, 1911, *for the Year* 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 9d. net.]

Multi-Motor Traction for Cranes. By RICHARD A. WEST. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 21s. net.]

Canada. Department of Mines and Technical Surveys. The Utilization of Low-Grade Domestic Chromite. By K. W. DOWNES and D. W. MORGAN. The Director, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

LAUNCHES AND TRIAL TRIPS.

M.S. "PÉROU."—Single-screw cargo vessel, built by the Forges et Chantiers de la Gironde, Bordeaux, for the West Indies and Gulf of Mexico service of the Compagnie Générale Transatlantique, Paris. Second vessel of two. Main dimensions: 448 ft. 2 in. between perpendiculars by 62 ft. 6 in. by 38 ft. 11 in. to shelter deck; deadweight capacity, 8,300 tons on a loaded draught of 25 ft. 4½ in.; gross tonnage, 6,700; cargo capacity, 14,589 cub. metres bale, and 515 cub. metres refrigerated. Two eight-cylinder single-acting two-stroke Sulzer Diesel engines, developing 10,000 h.p., constructed by the Forges et Chantiers de la Méditerranée, Paris. Engines coupled to the same screw through two Vulcan hydraulic clutches and reduction gearing. Service speed, 16 knots. Trial trip, January 10 and 11.

M.S. "KADOURA."—Twin-screw refrigerated-cargo vessel for the carriage of bananas and with accommodation for twelve passengers, built by J. Samuel White & Co., Ltd., Cowes, Isle of Wight, for the Compagnie Maritime des Chargeurs Réunis, Paris, for trade between Le Havre, Marseilles, the West Coast of Africa and the Canary Islands. Main dimensions: 328 ft. between perpendiculars by 50 ft. 6 in. by 32 ft. 9½ in.; deadweight capacity, 2,520 tons on a draught of 20 ft. 8 in.; gross tonnage, 4,143; insulated-cargo space, about 190,000 cub. ft. Two eight-cylinder oil engines, together developing 6,500 b.h.p. at 165 r.p.m., constructed by Burmeister & Wain, Copenhagen, and installed by the shipbuilders. Speed, 17 knots. Trial trip, January 11.

M.S. "LADY SYLVIA."—Single-screw coaster, built by Philip and Son, Ltd., Dartmouth, for D. J. Bradley and D. J. Bradley, Junr., Rochester. Main dimensions: 135 ft. 3 in. between perpendiculars by 25 ft. by 10 ft. 9 in.; deadweight capacity, 400 tons. Diesel engine developing 570 b.h.p. at 400 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester. Launch, January 19.

M.S. "ENTON."—Single-screw cargo liner, built and engined by Alexander Stephen and Sons, Ltd., Glasgow, for Birt, Potter and Hughes, Ltd., London, E.C.3. Main dimensions, 432 ft. by 58 ft. 9 in. by 39 ft. 6 in.; deadweight capacity, 9,900 tons on a draught of 27 ft. 2 in.; gross tonnage, 6,350. Stephen-Doxford five-cylinder opposed-piston Diesel engine, developing 5,500 b.h.p. at 115 r.p.m. in service. Sea speed, 14 knots. Launch, January 29.

S.S. "MANCHESTER SPINNER."—Single-screw refrigerated-cargo vessel to carry twelve passengers, built and engined by Cammell Laird & Co., Ltd., Birkenhead, for the United Kingdom to Canada service of Manchester Liners, Ltd., Manchester. Main dimensions: 436 ft. by 60 ft. by 38 ft. 3 in.; deadweight capacity, 9,500 tons on a draught of 27 ft. 6 in.; cargo capacity, about 496,000 cub. ft. One set of geared steam turbines developing 6,000 s.h.p. and a speed of about 15 knots. Launch, January 30.

S.S. "MANCHESTER PIONEER."—Single-screw refrigerated-cargo vessel, built and engined by Cammell Laird & Co., Ltd., Birkenhead, for the Great Lakes service of Manchester Liners, Ltd., Manchester. Main dimensions: 246 ft. 6 in. by 43 ft. by 26 ft. 6 in.; deadweight capacity, 2,750 tons on a draught of 18 ft. 3 in.; cargo capacity, about 164,000 cub. ft. Two sets of geared steam turbines driving a single screw, to develop 1,650 s.h.p. and give a speed of about 11½ knots. Launch, January 30.