

ENGINEERING.

GRÄF AND STIFT FOUR-CYLINDER TWO-STROKE OIL ENGINE.

By PROFESSOR S. J. DAVIES.

FOLLOWING the urge to make better use of material in the oil engine, two tendencies are to be observed,

Ingenieurbüro Professor Hans List, consulting engineers, of Graz, Austria, for Messrs. Gräf and Stift, of Vienna, builders of passenger vehicles, and was recently subjected to tests by the author in the laboratory of the Technische Hochschule at Graz. In what follows, the chief features of the engine will first be described, an account will then be given of the tests, and the performance and characteristics

normal output is 120 h.p. at 1,900 r.p.m., and the maximum speed is governed to be 2,000 r.p.m. The injection pump was provided by Friedmann and Maier, of Hallein, Austria, and the multi-hole injection nozzles by C.A.V., Limited, of Acton, London, W.3. The injection pressure is 2,600 lb. per square inch and delivery from the pump normally begins at 25 deg. before dead centre, and does not need adjustment in service. In addition to the governor to restrict the maximum speed, the engine is governed when running light. The blower is of the three-lobed Roots type and was constructed by the engine builders; it is driven by gearing at 1.51 times the engine speed. The combustion chamber is of the direct-injection type; the crown of the piston is plane, and the chamber proper forms a recess in the cylinder head, which is an aluminium-alloy casting. The edges of the chamber are protected by a cast-in ring of a special steel with a high coefficient of thermal expansion. The piston is of cast silicon-aluminium alloy; it carries four pressure rings and two scraper rings, but otherwise is of simple construction.

As regards the general arrangement of the design, it is seen in Fig. 2 that the engine-body casting, which is of light alloy, is integral up to the cylinder heads. This gives a very stiff construction and, at the same time, permits a closer spacing of the cylinders, leading to a shorter engine. It takes directly the water-cooled cylinder liners which are made of iron, centrifugally cast. The cylinder heads are each secured by four studs to the engine-body, so that the pressure forces are transmitted directly to the body. The cylinder liners are secured to the cylinder heads by flanges, each with six screws; they are thus relieved of all longitudinal forces, except those necessary for tightness, and otherwise may expand freely in an axial direction. The use of six screws for the joints, instead of four, reduces the stresses and makes for reliability. In addition to this, the cross-sections and the heights of the cylinder heads have been designed with thought for stiffness against bending. The inner space of the V serves as a reservoir for the scavenging air, and is arranged to be stiffened up to the top edges of the cylinders, so as to form a closed triangle; this adds further to the rigidity of the construction. The blower is flanged directly to the housing. The injection pump, the compressor for the brakes, and the electrical generator are secured to a separate cover.

As may be seen in the drawings, the main crankshaft bearings, of which there are three, are provided with rigid bearing covers of light alloy, which are secured to the upper halves by grooved faces, thus adding to the stiffness. The very stiff crankshaft is located at the bearing at the flywheel end; the balance weights, which completely balance the out-of-balance forces of the first order, are fixed to each crank-web. The big ends of the connecting rods of each pair of cylinders are arranged side by side on the crankpins. The main and big-end bearings are all fitted with steel shells, lined with lead-bronze. The connecting rods are

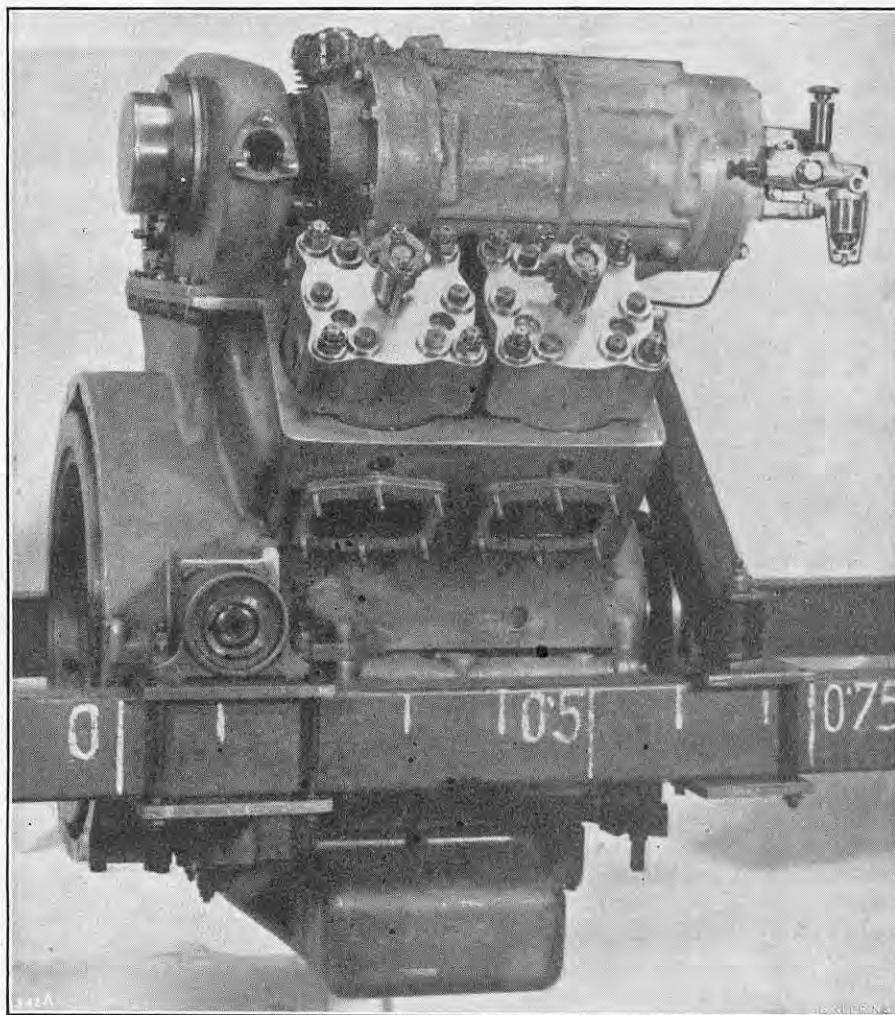


Fig. 1.

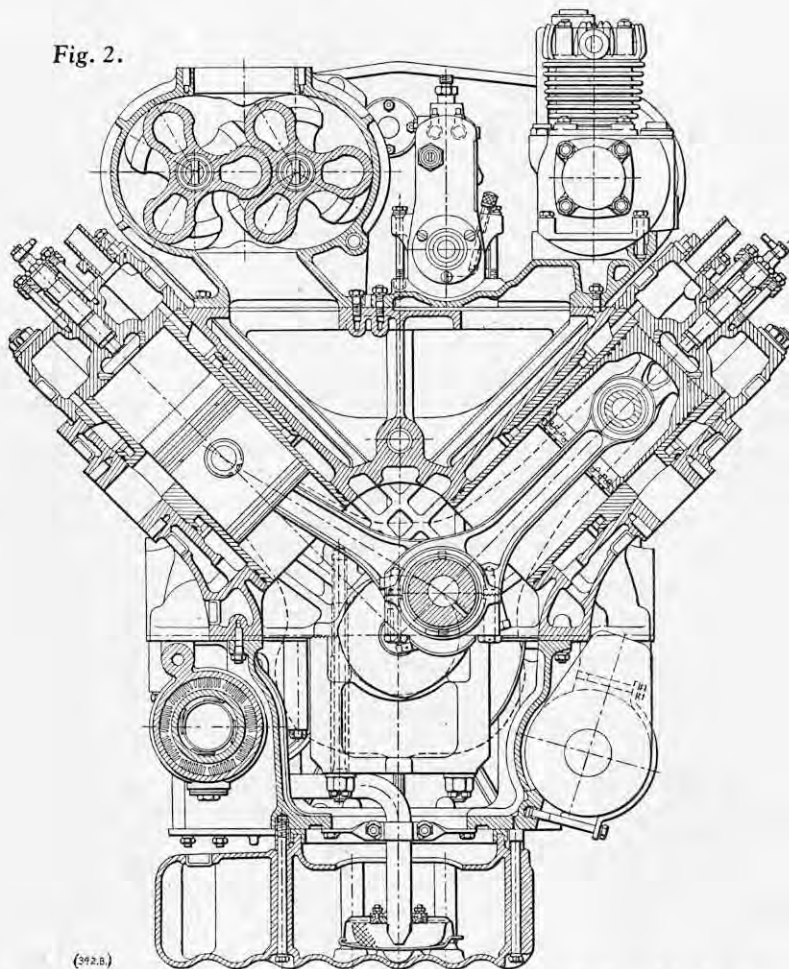
namely, a slow but steady extension of two-stroke cycle working and an increase in the number of designs of engine with their cylinder axes arranged in V-form. The engine which forms the subject of this report provides an interesting example of these tendencies: it has four cylinders, in two banks of two, works on the two-stroke cycle, and, since it works with piston control of the admission and exhaust ports of the cylinders, it combines simplicity with compactness. It was designed by the

of the engine will be discussed on the basis of the test results.

Fig. 1 is a side view of the engine and Figs. 2 and 3, on page 2, show, respectively, a transverse sectional elevation and a longitudinal section. The cylinder bore is 120 mm. (4.73 in.) and the piston strokes are all 140 mm. (5.51 in.), giving, for the four cylinders, a total swept volume of 6.33 litres. The compression ratio, based on the swept volume, is given by the designers as 16.5 : 1. The maximum

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Fig. 2.



(392.B.)

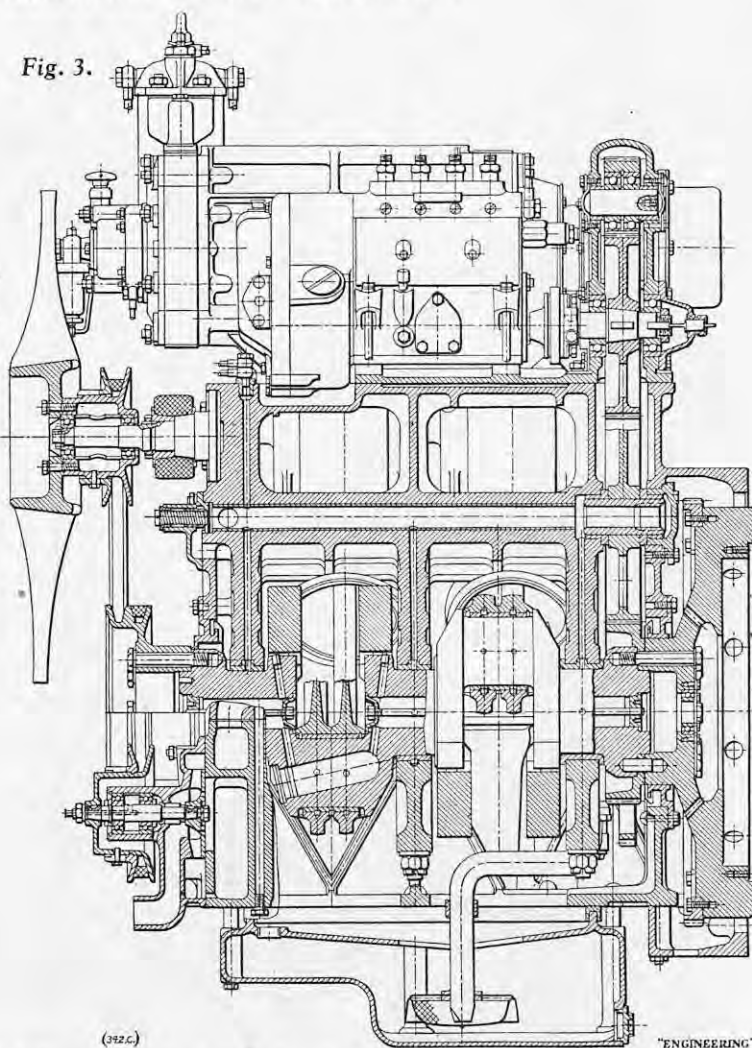
drop-forged. The gudgeon-pin bearings are of the needle type, so that special lubricating pipes or borings are unnecessary. The drives for the blower, the injection pump, the generator, and the gear pump for the lubricating oil, are carried in a gearcase at the flywheel end of the engine, which conduces to smoother running and a lower loading than would be possible if the case were at the other end. A damped elastic coupling is provided in the drive of the blower.

From the scavenging-air reservoir, the new charge of air to each cylinder is led through five admission ports on each side, while exhaust takes place through three ports, giving loop scavenging. The land between the exhaust ports is provided with longitudinal passages for cooling water. The ports are milled, which, bearing in mind the simple design of the liners, may be carried out readily and with cheap equipment. The advantages of loop scavenging are, first, that the elimination of valves and their drives leads generally to simple, cheaper and more reliable manufacture; secondly, since at high speeds of revolution, valves and their drives are more heavily stressed in two-stroke working than in four-stroke working, their elimination leads to easier maintenance and less fear of breakdown; thirdly, the cylinder heads are simpler in design, their manufacture is cheaper, and they are subjected to less complicated thermal stresses.

In selecting a Roots blower instead of a turbo-blower, the following points were taken into consideration; the Roots blower has better characteristics as regards delivery and volumetric efficiency in respect to speed; its speed of revolution is much lower, making lower demands on its drive; and the concordance of the admission and exhaust processes with the scavenge air delivered by the Roots blower over a wide range of speed is much simpler and more certain than with a turbo-blower, which presents serious problems in this respect.

The circuit of the lubricating oil is as follows: the gear pump is fixed low down in the sump from

Fig. 3.



(392.C.)

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which the oil is drawn and delivered to a heat exchanger, in which it gives up heat to the cooling water. The oil then passes through a laminar-flow filter, and through a magnetic filter, to the central distributing pipe in the bottom of the V, from which the main bearings are fed. Hollow spaces and passages in the crankshaft lead the oil to the big-end bearings, which are formed so that oil is suitably sprayed on to the cylinder walls. The bearing and gearwheels of the blower drive receive oil from the pressure system. The water-circulating pump and the radiator fan are driven by V belts from the forward end of the crankshaft. The flow of water is divided at the pump, one stream going directly to a bank of cylinders, while the other stream goes through the heat exchanger to the other bank of cylinders. The return pipes to the radiator are led off from the highest point of each cylinder head.

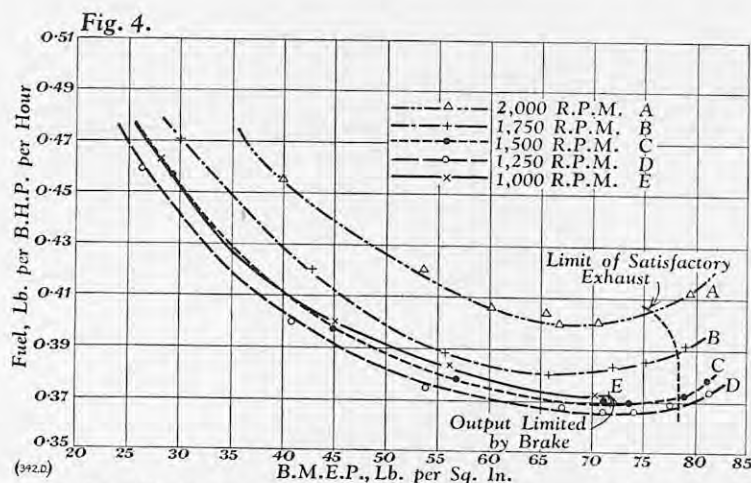
In the basic tests, the engine was run at a series of constant speeds, namely, 1,000, 1,250, 1,500, 1,750 and 2,000 r.p.m., and, in each series, the loads were varied from light to full. The principal data from these series are tabulated in Table I, opposite, and are derived from observations of the brake torque, the revolutions per minute and the fuel consumption. The power developed by the engine was absorbed by a hydraulic brake on which the force at the end of the brake arm was measured, through a lever system, by a spring balance. This brake was uncoupled from the engine; the brake arm, the lever system and the spring balance were all checked; and the values found were used in the subsequent calculations. The brake torques were converted into the equivalent values of brake mean effective pressure recorded in the table. A tachometer indicated the constancy of the speed of revolution, but the revolutions during the observed times to consume a measured volume of fuel, contained in a glass vessel of pipette form, were separately counted. The measured volume in question was weighed and found to be 433.35 gm. (0.9567 lb.). From the times, as observed by means

of a stop watch, the fuel consumptions, in lb. per hour, and the revolutions per minute were calculated. The small quantities of leakage oil from the fuel nozzles were neglected. The torque resistance offered by the brake was, unfortunately, not sufficient at the lowest speed, 1,000 r.p.m., to measure the higher values of brake mean effective pressure of which the engine was capable.

During these series, given as A, B, C, D and E, in Table I, the barometer readings were within the range 28.5 in. to 28.9 in. of mercury, while the room temperature was never below 66 deg. F. The engine was lubricated by Shell Single S.A.E. 20. The fuel oil used during the tests was investigated by Dr. Sablatnög, of the Department of Chemistry, the Technische Hochschule, Graz, who reported as follows: "The density was 0.878 at 61 deg. F.; the lower calorific value was 17,880 B.Th.U. per pound; and the higher calorific value was 19,010 B.Th.U. per pound; the carbon content was 86.92 per cent., and the hydrogen content was 12.69 per cent."

The data given in the test series were first plotted as specific consumption, in lb. per brake horsepower per hour, on a base of brake mean effective pressure. The curves are shown in Fig. 4, opposite, the limitation of load imposed by the brake in series E, and referred to above, will be at once noticed. A second note on this figure is concerned with the "limit of satisfactory exhaust." Flap valves were provided on the separate exhaust pipes from the four cylinders and, when these were opened, the exhaust passed into the open laboratory. The limit of satisfactory exhaust was taken to be reached at that brake torque, with increasing loads at constant speeds, at which the exhaust first became visible. While the state of the exhaust was observed throughout in these series, the increments of brake torque were too wide to allow of accurate determinations of the loads at which these limits were reached. Separate series of tests at constant speeds were afterwards run with gradually increasing loads and the limits were carefully

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observed; a line is drawn on the diagram through these limits.

From the curves in Fig. 4, some interesting conclusions may be drawn. Taking, for present purposes, the normal brake mean effective pressure as 71 lb. per square inch, it is seen that the limit of satisfactory exhaust is not reached until a value of the brake mean effective pressure of about 10 per cent. greater than this is reached, except at 2,000 r.p.m. The specific consumptions at full load at 1,000, 1,250 and 1,500 r.p.m. are all at or below 0.372 lb. per brake horse-power per hour, the best

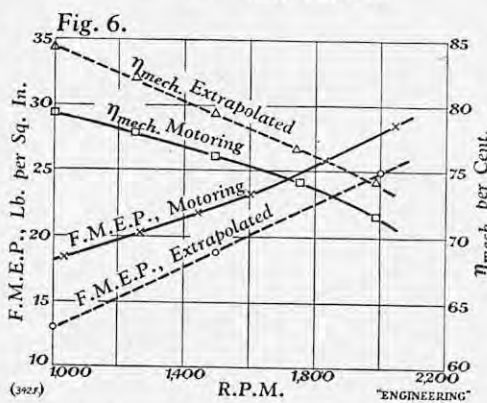
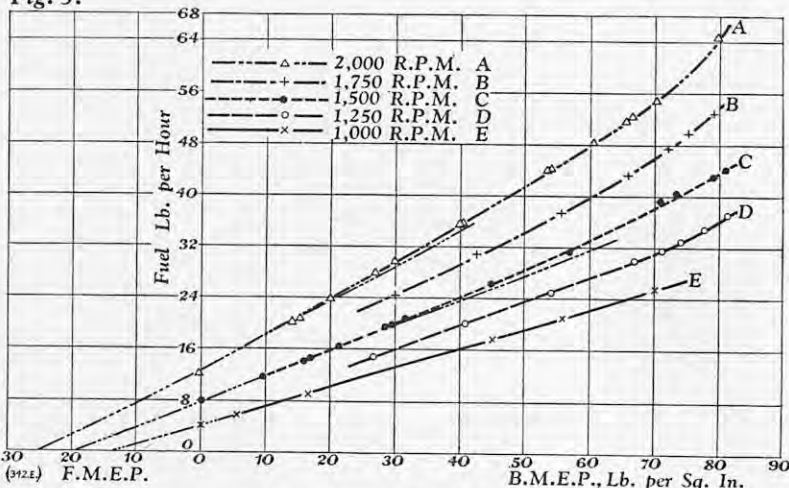
TABLE I.

Test No.	R.p.m.	B.M.E.P., lb. per sq. in.	B.h.p.	Fuel, lb. per hour.	Fuel, lb. per B.h.p., per hour.
A 1	1,988	14.2	27.7	20.4	0.737
A 2	1,990	27.3	53.2	27.9	0.525
A 3	2,000	39.8	78.1	35.5	0.455
A 4	2,000	53.6	105.0	44.2	0.421
A 5	2,003	60.5	118.9	48.3	0.406
A 6	1,990	65.5	127.8	51.7	0.405
A 7	2,010	66.5	131.0	53.4	0.399
A 8	1,985	70.4	137.0	54.9	0.401
A 9	2,008	79.4	156.4	64.5	0.412
B 1	1,760	30.0	51.8	24.4	0.471
B 2	1,755	42.8	73.6	31.0	0.421
B 3	1,752	55.7	95.8	37.2	0.389
B 4	1,765	65.9	114.0	43.5	0.381
B 5	1,755	72.0	124.0	47.6	0.384
B 6	1,755	75.1	129.1	49.9	0.386
B 7	1,755	79.1	136.0	53.2	0.392
C 1	1,500	9.9	14.6	11.7	0.796
C 2	1,500	16.2	23.8	14.3	0.602
C 3	1,510	29.3	43.4	19.8	0.457
C 4	1,505	44.8	66.1	26.3	0.398
C 5	1,510	56.8	84.0	31.8	0.378
C 6	1,495	71.0	104.0	38.6	0.371
C 7	1,510	73.6	109.0	40.3	0.370
C 8	1,499	79.0	116.0	43.2	0.372
C 9	1,495	81.2	119.0	45.1	0.379
D 1	1,250	26.4	32.3	14.9	0.460
D 2	1,247	40.8	49.9	20.0	0.402
D 3	1,260	54.0	66.7	25.1	0.376
D 4	1,259	67.1	82.6	30.4	0.368
D 5	1,250	71.1	87.0	31.8	0.366
D 6	1,243	74.1	90.4	33.0	0.366
D 7	1,262	77.5	95.6	35.2	0.369
D 8	1,253	81.4	100.0	37.4	0.374
E 1	965	4.9	4.6	5.8	1.270
E 2	980	16.4	15.7	9.1	0.582
E 3	995	28.2	27.4	12.7	0.463
E 4	995	45.1	44.0	17.6	0.400
E 5	995	56.1	54.7	21.0	0.384
E 6	1,000	70.3	68.9	25.6	0.372

value found being 0.366. Even at 2,000 r.p.m., at which the mechanical losses are highest, the value of 0.401 is obtained. Altogether, the results, as regards output, thermal efficiency, and speed range, are very good for a two-stroke engine of this relative simplicity of design.

If the fuel consumptions in pounds per hour, as given in Table I, are plotted on a base of brake mean effective pressure, some evidence may be obtained concerning the mechanical losses of the engine. Curves of this kind are given in Fig. 5, and, for the series A, C and E, additional values at no load have been added; these were obtained by measuring the fuel to drive the engine when running completely light, that is, when it was uncoupled from the brake. The points on such

Fig. 5.



curves at the smaller loads fall on straight lines, and, if these are extrapolated to cut the base line, the intercepts give the mean effective pressures corresponding to the total internal losses of the engine, expressed as frictional mean effective pressure (F.M.E.P.). The values given are 25 lb. per square inch in series A, at 2,000 r.p.m.; 19 lb. per square inch in series C, at 1,500 r.p.m.; and 13 lb. per square inch in series E, at 1,000 r.p.m. Reference will be made later to these values; for the present, the only comment called for is that the observed points all fall well on the curves. This gives evidence of the generally satisfactory accuracy of the observations.

A second method of measuring the F.M.E.P. was possible by "motoring" the engine by means of an electric motor, suspended in a rotatable cradle so as to make it possible to measure the torque to drive the engine against its internal losses. Such means were available, but it was not convenient to disconnect the hydraulic brake used in the power tests; and the drive from the motor to the engine passed through the brake, which was arranged so as to offer its minimum resistance torques. It was thus necessary, in every test, to subtract the torque necessary to drive the brake from that observed on the motor, in order to obtain the net torque to drive the engine. In making the tests, the temperature conditions of the engine were kept as nearly as possible the same as those prevailing when the engine was developing power. The values of F.M.E.P. derived at various speeds of revolution were as follows:

R.p.m.	1,033	1,263	1,442	1,604	1,830	2,041
F.M.E.P., lb. per sq. in.	18.5	20.2	21.8	23.2	25.8	28.6

The values are plotted in Fig. 6, above, and form the full-line curve; the three values obtained by the extrapolations in Fig. 5 are also given, and a broken line is drawn through these points. The differences, especially at the lower speeds, are considerable and call for some comment. Under the conditions prevailing when the observations in the upper curve were made, there was no combustion in the engine to assist the exhausting of the cylinders, and nearly all the work to displace the

gases out of the cylinder was provided by the blower; whereas, under the conditions prevailing during the observations giving the extrapolated curves in Fig. 5, combustion, even at zero brake horse-power, is, of course, taking place. This difference in the conditions would account for some of the differences between the full-line and the broken curves.

If the values on the upper curve, which may thus certainly be taken as conservative, are used, and the normal value of the B.M.E.P. (71 lb. per square inch) is taken, values of the mechanical efficiency may be calculated. At 1,500 r.p.m., for example, the value on the curve is 22.2 lb. per square inch; for this speed, therefore, the mechanical efficiency is $\frac{71}{71 + 22.2} = \frac{71}{93.2} = 76.2$ per cent., a good result when it is remembered that the work to drive the blower is included in F.M.E.P. Applying this reasoning to the actual tests at or near normal B.M.E.P. in the five basic series of tests, the corresponding values for mechanical efficiency, for indicated mean effective pressure (I.M.E.P.) and for the indicated specific consumptions, for various speeds, were calculated and are tabulated as the lines M, in Table II, below.

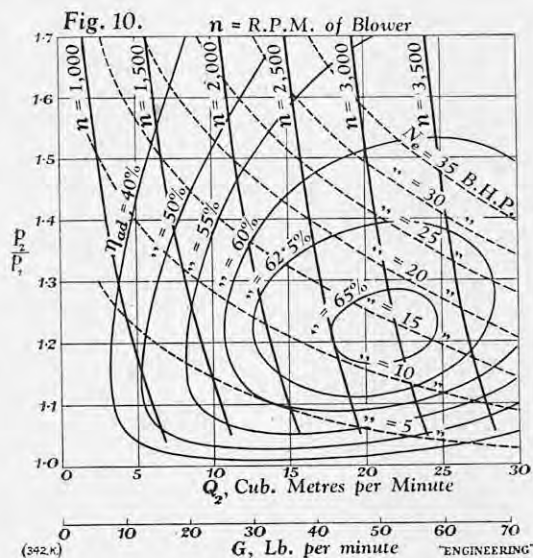
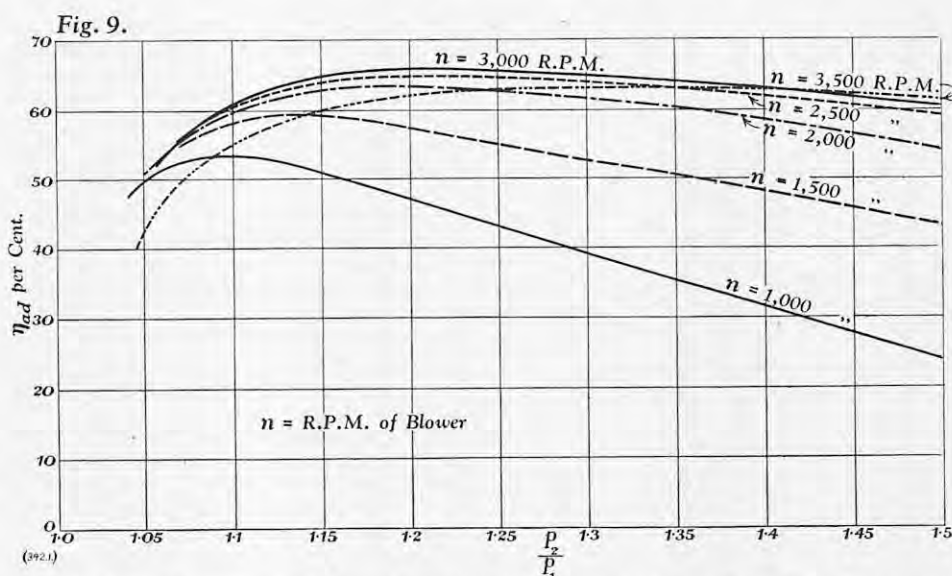
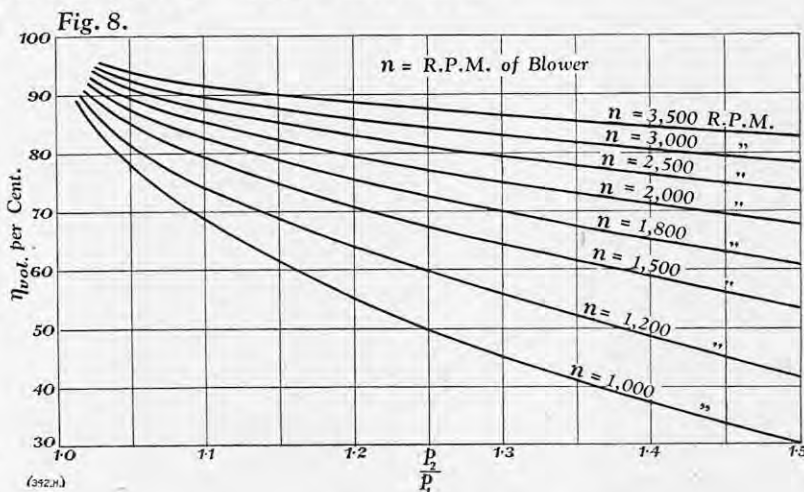
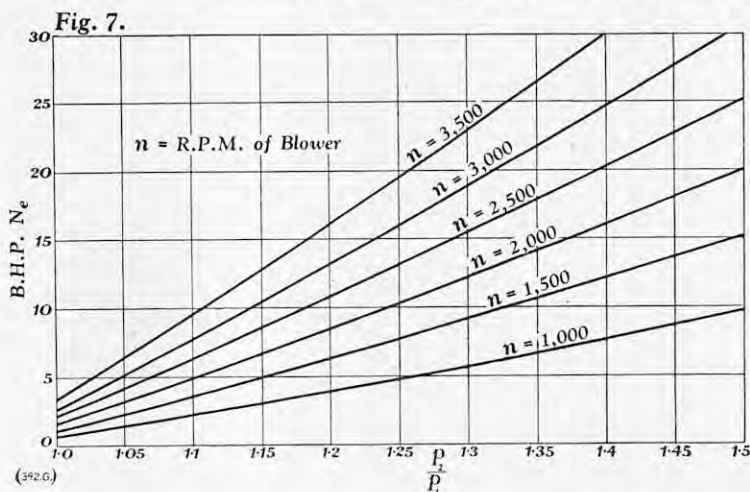
TABLE II.

Test No.	A 8	B 5	C 6	D 5	E 6
R.p.m.	1,985	1,755	1,495	1,250	1,000
B.M.E.P.	70.4	72.0	71.0	71.1	70.3
F.M.E.P.	27.8	25.0	22.2	20.2	18.3
I.M.E.P.	24.8	21.8	18.7	15.8	13.0
Mechanical efficiency, per cent.	98.2	97.0	93.2	91.3	88.6
Indicated specific consumption, lb. per h.p. per hr.	95.2	93.8	89.7	86.9	83.3
Indicated thermal efficiency, per cent.	71.6	74.2	76.2	77.9	79.3
Indicated thermal efficiency, per cent.	74.0	76.8	79.1	81.8	84.4
Indicated specific consumption, lb. per h.p. per hr.	0.288	0.285	0.283	0.285	0.295
Indicated thermal efficiency, per cent.	0.297	0.295	0.294	0.299	0.314
Indicated thermal efficiency, per cent.	46.0	46.4	46.7	46.4	44.9
Indicated thermal efficiency, per cent.	44.6	44.9	45.0	44.1	42.2

M: Values from "motoring." E: Values from extrapolating.

In order not to favour the engine unduly, however, as regards thermal efficiency, by taking the "motored" values, similar calculations have also been made for the values of F.M.E.P. taken from the curve through the extrapolated values. The second lines of values, for each quantity, marked E, are derived from these results, and show that, in spite of the differences between the two sets of values for F.M.E.P., given in Table II and plotted in Fig. 6, the values in the respective pairs of results for indicated specific consumption and indicated thermal efficiency are not markedly different from each other. Both sets of values for mechanical efficiency are plotted in Fig. 6, and it is reasonable to assume that the true values lie somewhere between these two curves. The values for indicated specific consumption and indicated thermal efficiency must similarly lie between the extreme values given for each pair in Table II; they are all very good and indicate a high efficacy of combustion throughout.

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In the term "combustion" must be included, not only the quality of the combustion process itself, namely of the suitable correlation of the injection and distribution of the fuel in the charge of air in the combustion chamber, but also the completeness with which the exhaust gases are discharged from the cylinder and the degree of purity of the new charge introduced into and trapped in the cylinder during the scavenging and charging processes. That these values are so favourable, and that they lie, in each line, within an extreme range of value of about 6 per cent., is indeed worthy of remark, especially when the range of speed in these tests—1,000 to 2,000 r.p.m.—is taken into consideration. A second point, touching the efficacy of charging the cylinder, is concerned with the values of the I.M.E.P. set out. When it is remembered that these values are based on the swept volume of the cylinder, and not on the effective volume above the exhaust ports, it is seen that not only must the purity of the new charge be high, but the mass of oxygen supplied in the new charge must also be high over the whole range of speed. These results, incidentally, provide convincing proof of the soundness of the reasons for preferring the Roots blower, as set out above in the description of the engine.

Any value for F.M.E.P. is, of course, the sum of the general mechanical losses (namely, the friction losses and the power taken to drive the fuel pump, lubricating oil pump, etc.) and the power to drive the blower. The latter depends on three factors: the amount of air found necessary for the effective scavenging and charging of the cylinders; the pressure to which the air must be raised—that is, the scavenging pressure; and the overall adiabatic or isentropic efficiency of the blower in compressing the desired quantity of air through the necessary range of pressure. It was not possible for the author himself to investigate the separate performance of the blower, and certain results, now to be

presented, were derived from a comprehensive investigation carried out by the engineers at the Graz laboratory. The author had, however, in connection with another engine, the opportunity of making measurements of this kind with the equipment, and thus has confidence in their methods of testing and in the accuracy of their results.

The three-lobed rotors of the blower have a diameter of 179.8 mm. (7.08 in.) and a length of 325 mm. (12.8 in.); the theoretical delivery volume of the blower is 8.63 litres (0.305 cub. ft.) per revolution. To give smooth running, the rotors are arranged in helical form, with a pitch of 2,820 mm. (111 in.). The blower was mounted on a test-stand, separately from the engine, and driven by an electric motor arranged for the measurement of the torque reaction. The air supply was passed through a gas meter and thence to a reservoir, from which it was drawn into the blower. Suitable manometers and thermometers were provided, from which the pressure and absolute temperature of the air in the reservoir (p_1 , T_1) and after delivery from the blower (p_2 , T_2) are derived.

The quantities of air aspirated, in cubic metres per minute, are derived from the readings of the gas meter; the values of r.p.m. of the blower are calculated from the numbers of revolutions recorded on a counter by the blower during the observed times of passing certain given volumes of air through the meter. From these times and volumes the weights of air aspirated, in lb. per minute, were found. The adiabatic or isentropic work per lb. of air, in ft. lb.

$$= \frac{\gamma}{\gamma - 1} R T_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{\gamma - 1}{\gamma}} - 1 \right],$$

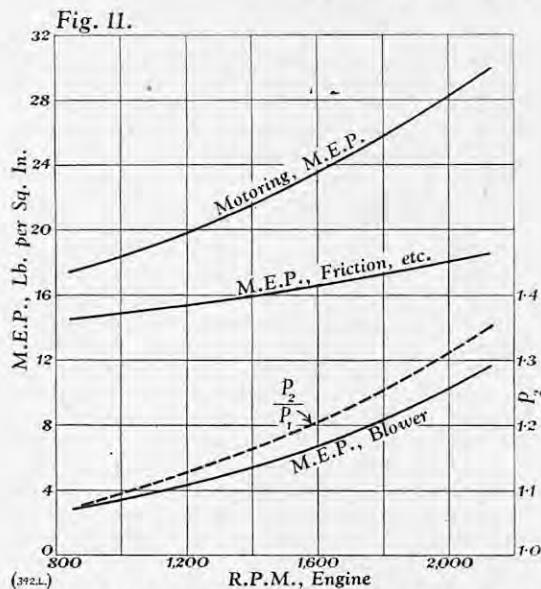
in which γ was taken as 1.4, and R as 53.2 ft. lb. per lb. per deg. F. From this the adiabatic work, expressed in horse-power, was calculated for the corresponding values of air aspirated in lb. per minute. The overall adiabatic or isentropic efficiency, η_{ad} , of the blower is given by: adiabatic

work in horse-power divided by brake horse-power. The volumetric efficiency, η_{vol} , of the blower is equal to the volume of air aspirated, reduced to the prevailing atmospheric conditions and divided by the swept volume of the blower.

A convenient summary of the results of the tests is given in Figs. 7 and 11, on this and the opposite pages. In Fig. 7, the values of the brake horse-power (N_e) to drive the blower at a series of constant speeds, from 1,000 to 3,500 r.p.m., are given on a base of the pressure ratio, $\frac{p_2}{p_1}$. In Fig. 8, the corresponding values of the volumetric efficiency, η_{vol} , are plotted on the same base. In Fig. 9, curves of the adiabatic efficiency, η_{ad} , are plotted for the same series of constant speeds, also on a base of the pressure ratio $\frac{p_2}{p_1}$. In Fig. 10, the results from Fig. 7, 8, and 9 are combined into a single diagram, giving the characteristics of the blower; the base of this diagram is two-fold, namely, air aspirated in lb. per minute (G), and in cubic metres per minute (Q_2), referred to the prevailing atmospheric conditions. Since, as was stated earlier, the blower rotates at 1.51 times the engine speed, the range of speed of the blower, corresponding to the range, 1,000 to 2,000 r.p.m., of the engine, is from 1,510 to 3,020 r.p.m. As may be seen later, if Fig. 11, opposite, the values of the pressure ratio, $\frac{p_2}{p_1}$, increase from 1.095 to 1.33 over this range of speed. From Fig. 10 it may be deduced that, over this range, η_{ad} lies always between 57 and 65 per cent., and mostly above 60 per cent. These are very high values for a blower of this type, and provide evidence both of satisfactory design and of precision of manufacture.

In Fig. 11, the broken curve gives the values of the pressure ratio, $\frac{p_2}{p_1}$, which were observed during the "motoring" test of the engine, plotted on a base of engine speed in revolutions per minute. For the

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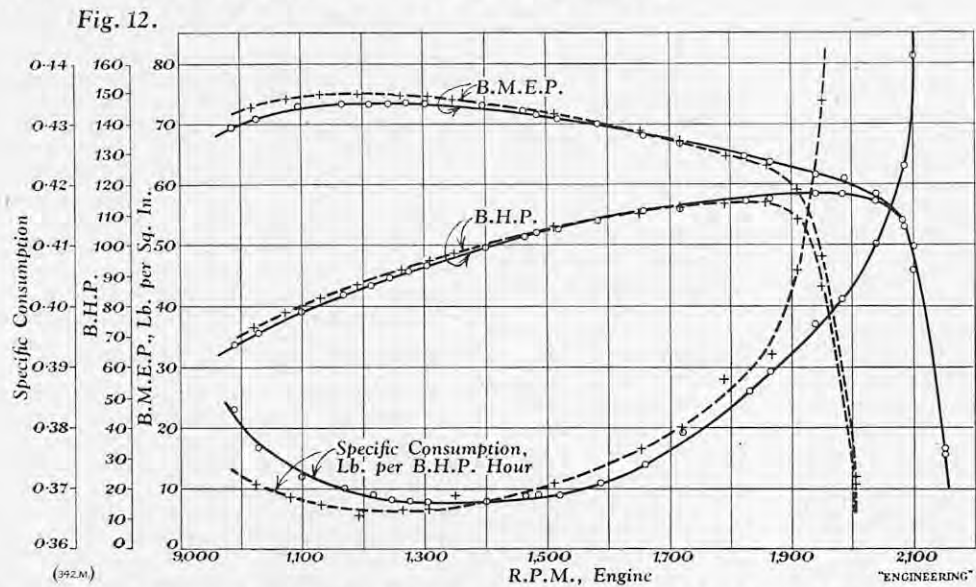


points on this curve and the corresponding revolutions per minute of the blower, the values of the brake horse-powers may be directly converted to the equivalent mean effective pressure on the engine piston; the corresponding values form the bottom full-line curve of Fig. 11. The top full-line curve is a reproduction of the full-line curve of Fig. 6, giving the total internal losses (F.M.E.P.) of the engine. The intermediate full-line curve shows the intercepts between the other two full-line curves and gives the values of the mean effective pressure equivalent to the remaining general mechanical losses of the engine. It will be noticed that the work on the blower, expressed as a percentage of the total losses, is very low, being 19 per cent. at 1,000 r.p.m., 27.7 per cent. at 1,500 r.p.m., and, at the maximum speed of 2,000 r.p.m., only 36.4 per cent.

Figs. 7 to 11 thus provide an interesting analysis of the performance of the blower. This performance is clearly of a high order, but, in view of the author's results given earlier, especially in relation to the high values of I.M.E.P. and the low values of the fuel consumptions, this is to be expected. Only when the efficiency of the blower is itself high, and when the correlation of the blower action with the operations of scavenging and charging the cylinder is well carried out, can such satisfactory results for the engine be realised over the observed wide range of speed.

Although the results discussed so far furnish evidence in relation to the basic performance of the engine, they are not concerned directly with its behaviour when used as a power unit in a heavy vehicle. When used in a vehicle, two limitations are usually applied to an engine, and are determined by the characteristics of the injection equipment and by the settings of the governors. The first limitation is that of the output, or B.M.E.P., at any one speed, and is intended to ensure that the quantity of fuel per injection does not permit the engine to run above an output at which the combustion ceases to be satisfactory, and above which the engine would be overloaded by the pressures during the combustion process.

As the speed of an engine is increased, there is a rapid increase in the inertia forces, roughly as the square of the r.p.m. A second limitation is thus applied to the speed, by means of a maximum-speed governor, in order to prevent the inertia forces from becoming excessive. Two further series of tests were therefore carried out, by the author, in order to investigate these matters. During the first series, the engine was run with the normal setting of the injection, in which, it will be recalled, delivery from the pump begins 25 deg. before top dead centre. During the second series, the delivery was advanced to begin 27 deg. before top dead centre. In both series, the control lever, that is, the accelerator pedal, was fixed to give maximum output at all speeds, and observations were made of the speed, in r.p.m., of the brake torque, and of the fuel consumption. From these, the values of B.M.E.P.,



of the brake horse-power, and of the specific consumption, in pounds per brake horse-power per hour, were calculated. Curves of these three quantities are given, for the two series, on a base of r.p.m., in Fig. 12; the curves for the first series, with the normal setting, are shown by broken lines and those for the second series by full lines.

It is seen that, in the first series, the maximum-speed governor begins to exert an influence at 1,800 r.p.m., and reduces the power to a negligible value by 2,000 r.p.m.; in the second series, this influence does not begin until 2,000 r.p.m., the power being reduced to a negligible value at 2,150 r.p.m. The maximum output, in the two series, is practically the same, at about 116 brake horse-power. The B.M.E.P. in both cases is a maximum at about 1,250 r.p.m. and decreases gradually until, at 1,800 r.p.m., it is some 14 per cent. less than the maximum. The torque characteristic is thus favourable. The specific fuel consumptions over the speed range are good: the lowest values are about 0.368 lb. per brake horse-power per hour and a value of 0.38 is not exceeded, over the whole range from 1,000 r.p.m., until a speed of over 1,700 r.p.m. is reached. The curves in Fig. 4, page 3, show that the best values of the specific fuel consumption are obtained at full load; to obtain the lowest values of fuel consumption from the engine, therefore, when running under service conditions, the engine should be run as often as possible at full throttle at all speeds from 1,000 r.p.m. upwards.

Altogether, the results of these various series of tests show the engine to have extremely good characteristics, both as regards output and consumption, over its whole range of probable operation. When the absence of valves in the cylinder, and the other reductions in the number of the working parts following the employment of the V-form, are taken into consideration, it will be seen that this design has many advantages. Its turning moment has, of course, the same regularity as that of an eight-cylinder four-stroke engine, and during the tests the engine ran with an especially pleasing smoothness.

A six-cylinder engine of similar design, to run over the same range of speed, has been built to give a nominal output of 180 brake horse-power. While the majority of the parts are identical with those of the engine under test, it is found desirable with the three-throw crankshaft to fit a torsional-vibration damper. One of these engines had been installed in a casing at the back of a single-decker bus, and the vehicle loaded to an extent equivalent to a normal passenger load, for the purposes of test and observation under service conditions. The author took a short ride as a passenger in this vehicle, but prevailing foggy conditions did not permit of a test at speed. The engine ran smoothly, the acceleration of the vehicle was excellent, and the placing of the engine at the back gave a definite advantage in relation to the amount of engine noise to penetrate into the body of the vehicle.

LITERATURE.

The Mechanism of the Watch.

By J. SWINBURNE, M.I.C.E., F.R.S. N.A.G. Press, Limited, 226, Latymer-court, Hammersmith, London, W.6. [Price 10s. 6d. net.]

THAT Sir James Swinburne, already distinguished in so many fields, should take up, in his eighties, the study of the mechanism of watches may not surprise anyone who is acquainted with the versatility of his interests; but it recalls to mind the parallel instance of James Watt, who, in old age, applied himself to the study of the German language in order to demonstrate, at least to his own satisfaction, that his mental abilities were still in good working order. Sir James Swinburne, in the preface to this book, adduces a somewhat different motive: "It is not odd," he observes, "that an engineer should be interested in the ways of a watch, as it is a very beautiful mechanism"; adding that, "In my case, finding that nobody over 40 is thought to be of any use in any capacity during the war, I decided to experiment on the behaviour of a watch." The result is a book of unusual interest, which draws freely upon published material, but does so in a critical spirit and with such a wealth of original comment that no suggestion of plagiarism is likely to enter the mind of even the expert reader. On the contrary, a careful perusal of the author's arguments should convince even the expert of the value of bringing a fresh mind to bear on a subject which, to those daily concerned with it, may appear to have been studied already to the point of exhausting the subject and the student.

The greater part of the book consists of articles reprinted from the *Horological Journal*, with slight amendments to make them conform to the separate chapters. Without having compared the book with the original texts, it is not possible to say how extensive these amendments are, but the impression received is that they are comparatively slight; each chapter, therefore, stands more or less independently of the rest, though their arrangement suggests that the author probably had in mind, from the outset, the possibility of their eventual appearance in book form. All the principal components of a watch—the mainspring, the train, the jewels, the escapement, the hairspring, the balance, etc.—are given a chapter apiece, in which each is discussed with a refreshing originality; and further chapters are devoted to such "engineering" considerations as pivot friction, oil, magnetism, adjustment, and "disturbing factors." Perhaps somewhat apart from the purely mechanical aspects of watch construction is the introductory chapter on "The Centimetre-Gram-Second System," in which the author takes a line that shows him to hold views opposed to many of those expressed by Dr. H. S. Rowell in the article on the metric system, printed in *ENGINEERING* of June 22, 1951. From the standpoint of the professional watch

maker, some of these views may appear unorthodox; but they are supported by arguments of some weight, which are not the least attraction of his thought-provoking survey.

Telecommunications Principles.

By R. N. RENTON. Sir Isaac Pitman and Sons, Limited. Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 37s. 6d. net.]

TELECOMMUNICATIONS is an unscholarly word—though its hybridism may be excused by its convenience—which has come into use during recent years to comprise the telegraphic, telephonic and radio systems which now play so large a part in civilised life. The importance of this branch of electrical engineering is recognised by the inclusion of "Principles of Telecommunication" in the examination syllabus of the City and Guilds Institute, and the present book is designed to meet the needs of students who have that particular examination in view. As may be inferred from its title, the work is essentially of a theoretical nature. It assumes no previous knowledge of electricity on the part of the reader, who is taken from the very elements of the science through the whole range of electrical phenomena having any bearing on telecommunication, the subjects under discussion being illustrated as far as possible by reference to apparatus used in the industry.

After a brief chapter on the electronic theory of electricity, the plan adopted by the author is to deal first with direct-current circuits and batteries; electrostatic phenomena and magnetism are taken next, followed by the principles of generators and motors; alternating currents and their transmission are then given two chapters, occupying nearly a quarter of the book; meters and measurement have another long chapter to themselves; electronics are dealt with in a chapter of 54 pages in which television is only briefly referred to, and the final chapter deals with telephonic apparatus and acoustics. No mere summary of contents, however, can convey an adequate idea of a course of instruction ranging from Ohm's Law to the principles of frequency filters and cathode-ray oscillographs. The vast extent of the ground to be covered naturally compels a great conciseness of treatment. Because of this, a student without other sources of instruction would probably find parts of it rather difficult to assimilate; but, by an orderly arrangement and a lucid style of exposition, the author has succeeded in giving about as good a survey of his subject as appears possible within the compass of a single volume. At the ends of their appropriate sections will be found an aggregate of nearly 300 questions selected from City and Guilds examination papers, each with its answer worked out. Another feature which many students will appreciate is that, except for the occasional use of the symbol of a differential coefficient—the meaning of which is explained in an appendix—to signify a rate of change, nothing more than a knowledge of simple algebra is required to follow any of the reasoning.

COURSES IN FUEL TECHNOLOGY.—The University of Leeds is offering post-graduate instruction in fuel technology and allied subjects from October, 1951. Courses, normally lasting one or two years, will be available on fuel technology, gas and chemical engineering, metallurgy, refractory materials and general ceramics. They will be open to graduates in pure science or engineering, applied science graduates who have taken courses in fuel, chemical engineering, metallurgy or ceramics, and new graduates, with suitable qualifications, who have had industrial experience. Students will be required to take some or all of the following first, second and third-year courses: preliminary training in technology with such additional training in pure science and engineering as is necessary; advanced technology; advanced study and research in a selected field. A post-graduate diploma will normally be awarded after one year's attendance at the second course. By attending the second and third, students will be eligible for an M.Sc. degree after passing the requisite examinations and submitting a thesis. The tuition fee is 47l. per session. A few maintenance grants will be available. Inquiries should be addressed to the Livesey Professor, Department of Coal Gas and Fuel Industries with Metallurgy, The University, Leeds, 2. Application forms can be obtained from the University Registrar.

THE JOINT ENGINEERING CONFERENCE, LONDON.

WE resume below our report of the technical sessions of the Joint Engineering Conference, held in London from June 4 to June 15. Previous instalments appeared in the preceding volume of *ENGINEERING*, in the issues of June 8, 15 and 22, 1951. The first session with which we deal below is that of June 8, on "Public Health," and was held at the Institution of Civil Engineers, where Mr. H. J. B. Manzoni, C.B.E., M.I.C.E., City Engineer of Birmingham, presented a paper on "Public Health in Municipal Engineering." The chair was taken by Sir T. Peirson Frank, M.I.C.E.

PUBLIC HEALTH IN MUNICIPAL ENGINEERING.

Mr. Manzoni presented his paper in the form of a summary which was also, to some extent, an amplification. In the paper, after commenting on the highly insanitary conditions of urban life until comparatively recent times, he said that the two most important subjects which concern the municipal engineer were the collection and disposal of refuse from buildings, and street cleansing. Before the second world war, it was computed that the annual quantity of refuse collected and disposed of was 14 million tons, and the cost of dealing with it was about 11,000,000l. Highway engineering had a direct bearing on public health, and so had housing, much of which was the responsibility of the municipal engineer.

Most of the diseases, the prevention of which was fairly well understood to-day, were caused by bacteria of some sort. Some had been overcome by cleanliness. He had been responsible for designing buildings which were vermin-proof, and for improvements in plumbing and sanitary arrangements. There was also a class of preventable diseases spread by human contact, with which the engineer had little to do; leprosy was an example. There were too, however, the water-borne diseases, the enteric diseases, of which the best-known was typhoid. Here, most spectacular results in prevention had been obtained. Water-supply, and sewerage and sewage disposal, to which the almost complete elimination of the spread of enteric diseases was due, had been made the subjects of separate papers, because of the great advances made in these matters and their technical interest. There was a fourth category of preventable disease about which less was known, and this included the air-borne or dust-borne diseases. Because none of them had such an obvious and sometimes fatal effect as typhoid or typhus, there had been less research into them and less progress in their treatment, but a very great proportion of the low standard of health which existed was due to air-borne or dust-borne diseases. It was not known how the common cold was spread, but it was probably spread by droplet infection, which was largely air-borne. Even less was known about the spread of influenza, but it was quite possible that influenza was dust-borne.

Amongst the air-borne diseases there was another range which were not due to bacteria but to chemical effects, such as the lung diseases which were due to carbon and sulphur from atmospheric pollution. He wondered what would have happened if engineers had not found a method of rendering roads dustless. Had they remained as dusty as they used to be, there might have been such a prevalence of lung trouble as would have made it essential to find a solution. It seemed probable that the greatest progress in the future would be in connection with these dust-borne diseases.

DISCUSSION.

The Chairman (Sir Peirson Frank) said that there was a great deal for which to be grateful to the municipalities. The author had said that the Ministry of Health "governed the affairs of local authorities," but that might be misconstrued. The Ministry of Health had been most helpful to local authorities in advising and guiding them, but, while they might have gone some way in the direction of "government," there were some councils which would object to being governed by the Ministry. Everything possible should be done to combat the dust-borne diseases. It was regrettable

that, at many of the large power stations, every possible step was not being taken, for economic reasons, to deal with the flue gases.

Colonel F. G. Hill said that this country could claim to lead in refuse disposal; on the other hand, they had to thank their Continental and American friends for some excellent designs of refuse and other collection vehicles. He had been much interested in the number of ways in which refuse and garbage could be disposed of in association with the disposal of sewage and sewage sludges; for instance, by composting sludge and screenings with refuse to produce a fertiliser or fertiliser base, burning refuse in furnaces and kilns with dehydrated sewage sludges, the use of methane gas from sludge digestion tanks to incinerate refuse, the discharge of shredded organic refuse into sludge digesters to produce increased volumes of methane, and the use, at Chester, of a controlled refuse tip as a low-rate trickling filter to purify sewage. All those methods had been successfully applied where local conditions were favourable, but they were unlikely to have widespread or general application. There was one method, however, which was likely to have an increasing use and which had been termed by an American sanitary engineer the greatest sanitary invention since that of the water closet and the water carriage system. This was the household or kitchen grinder, the advantage of which lay in the elimination of the household storage of putrescible matter and of its street collection. The collection of dry inorganic refuse—paper, cartons, tins and bottles—would still remain. In America, the kitchen grinder would reduce the bulk of collection by at least one-half, and in this country by not more than 20 per cent. It was estimated that, if universally used in an American town, it would add about 3 per cent. to the volume of sewage and about 35 per cent. to the strength of domestic sewage, but would almost double the production of methane gas. Corresponding figures for this country would be about a 10 per cent. increase in the volume of sewage and less than 20 per cent. increase in the strength.

In general, the cleanliness of streets in this country would bear comparison with that of many cities abroad, but in view of the growing scarcity of sources of potable water, more consideration might be given to the use of clean but non-potable water for street cleansing. He would also emphasise the importance of frequent periodic gully-emptying; it was more hygienic to collect and remove the grit before it became contaminated with sewage solids than later. He favoured systems which dealt with road surface water separately from sewage. The Rivers Pollution Bill, now before Parliament, was expected to give increased powers to prevent pollution, and it would enable river boards to impose definite standards on discharges of industrial effluents and inflict penalties for infringement. The Engineering Department of the Ministry of Local Government and Planning supported the view that, wherever possible, industrial wastes should be discharged to the public sewer, provided that the waste would not harm the structure of the sewer or sewage works, or seriously impede the bacteriological process of purification. When selecting the site of a new factory, the problem of the ultimate disposal of the wastes from it should be kept well in mind, and sites avoided which would present major difficulties in this respect. The industrial processes themselves should be reviewed from the sanitary aspect, with the object of reducing the volume and strength of the waste discharged; and assistance could be given to the public health authorities by controlling the discharge of the waste in an even and continuous manner over the working period, or preferably in some cases over the 24 hours, and by arranging for any necessary neutralisation or conditioning, if of a strongly acid or alkaline nature.

Mr. Hal Gutteridge, referring to the process of composting house refuse and sewage sludge, or sewage screenings, to produce a high-quality organic fertiliser, said that this was a development which was taking place rapidly in all countries. The composting of what were termed habitation wastes resulted in the return to the soil of the humus content which had been removed from it in the

harvesting of crops, and thereby completed the natural cycle and kept the soil healthy. In this form the matured fertiliser was readily digestible by the soil, whereas crude refuse, even when pulverised, and sewage, when either was applied separately to the soil, were not readily digestible but absorbed nitrogen from the soil until fermentation had been completed. The author seemed to be unduly pessimistic in saying "the cost of the process appears to be the deterring factor," because with modern and complete mechanisation throughout the processes from reception to maturing the net annual cost was not necessarily more than that of existing methods of disposal.

From the public health point of view, it was an advantage to compost the materials, because the refuse could be pulverised locally and then transported to the sewage works, where composting took place. The pulverised material was virtually free from smell, and, perhaps more important, it was unattractive to flies and vermin. As soon as the sewage sludge or screenings were added, heat was developed and the temperature rose to 160 deg. F., or more, so that the fly larvae could not complete their life cycle and were exterminated at that stage. In the design of composting plants, arrangements were made to ensure, as far as practicable, that fermentation took place under aerobic conditions. Under these conditions, little if any offensive smell was produced, as putrefaction was avoided.

Mr. Z. Cornfeld, of Tel-Aviv, referred to the prevention of malarial disease in and around towns. In the new town of Natania, to which he was appointed as municipal engineer, one of his first tasks was to get rid of swamps, as the area was full of malaria, due to the anopheles type of mosquito. Modern methods were used of cutting drains by explosives, and the blocked outlet to the sea was also opened by explosives. The outlet to the sea was concreted, and the whole cross-section was designed to carry storm-water at the rate of some 50 cub. m. per second. Round the town were many small ponds, which had no outlet at all. There was still no central sewerage system, local septic tanks and cesspools being employed. It was essential to get rid of these local pools, and his problem had been to interconnect them and find the most suitable outlet to the sea. After a year or two from the inception of these works, they got rid of the incidence of malaria entirely.

Sir Arthur Dean referred to some of the problems of public health engineering in India. He had been in charge, on the engineering side, of the elimination of malaria from the area round Delhi. It had been largely a question of finding out, first of all, exactly how the malaria spread, because it was not just one type of mosquito, living a certain life cycle, that spread malaria. One thing which had been tried was the clearance of vegetation along streams, because it had been understood from previous experience that the anopheles mosquito deposited its eggs under the shade of grasses and bushes growing along streams. The result had been a considerable increase in malaria-carrying mosquitos because of the clearance which had been carried out, and which had been done entirely by engineers, without consulting the malariologists. The malariologists then found that, in the particular area in question, the malaria-carrying mosquito liked to lay its eggs in the sunlight on the edge of fast-running streams, so that the work which the engineers had done had encouraged rather than reduced malaria. In Delhi, the mosquito responsible for malaria was found to breed on the sides of streams, but it liked the shade, and so the clearance of shade and then the spraying of the area with copper arsenate from the air, and raising and lowering the water-level in reservoirs, which was very important and stranded the eggs, which died, proved very effective. Nearly all public health engineers in India regarded malaria as an engineer-made disease. The borrow-pits alongside the railways, roads and canals of India were responsible for collecting water in which the mosquito which carried malaria bred, and getting rid of those borrow-pits was now a matter of urgent importance and considerable expense.

Refuse composting was introduced in India by Mr. (later Sir Albert) Howard at Indore, in 1930. It was done without any water-borne sewage, the night

soil being collected as it was, and deposited with house and street refuse in a layer system and turned over after three days, after a further five, and again after another week. The compost was very valuable as manure. A more modern application of the same idea had been adopted in Delhi, using the digested sludge from the sewage works, again with household and garden refuse.

Mr. P. H. East recalled that the Electricity Commissioners, in 1930, set up a committee to deal with what they called "chimney emissions," and he represented them on that committee. The restrictions and conditions laid upon power stations with regard to the emission of dust from chimneys were entirely voluntary; there was no legal restriction whatever, except the common law of nuisance. The committee which the Commissioners appointed suggested in their report that, with stoker-fired boilers, it was sufficient to use mechanical collectors, but with pulverised-fuel boilers, it was almost essential to use electrostatic precipitators. They reported strongly against the wet washing of gases, because it produced in the resultant sludge a proportion of sulphur and gave rise to trouble in the disposal of the sludge. They also conducted experiments with a wind tunnel, to find out at what height above ground the chimney gases ought to be released. The empirical formula of $2\frac{1}{2}$ times the highest point of adjacent buildings had proved to be reasonably accurate. Taking the pulverised-fuel boiler with the electrostatic precipitator, some 80 per cent. of the ash in the coal was presented to the precipitator, but with the stoker-fired boiler, not more than 10 per cent. With the precipitator working efficiently, apparently something like 3 grains of dust per cubic foot would be presented to the catcher, and, with an efficiency of 90 per cent., that meant an escape of 0.3 grain per cubic foot. The committee, who were careful to apply the suggested recommendations to power stations only, arrived at the conclusion that it would be right to suggest to the supply industry that, when dealing with specifications for dust-extracting plant in generating stations, they should require a guarantee that the maximum concentration of dust escaping out of the chimney should not exceed 0.4 grain per cubic foot. To-day, the actual figure was nearer 0.2 grain. The supply industry, however, were being faced with a charge, whenever a new generating station was proposed, that, from the public health point of view, all sorts of special apparatus should be added to ensure that the health of the people of the locality would not be adversely affected. There was a tendency to call on the electricity supply industry to observe conditions which were not even faintly approached by industry. There was also the problem of sulphur washing. Sulphur washing in a closed system—the Battersea system was available only on a very large river—would add 10s. a ton to the cost of coal, and he hoped that they were not going to be asked to do that. Perhaps the author would say what attitude would be taken up towards the new station in Birmingham, and whether there was any hope of bringing local industrial users in the neighbourhood of that station up to the standard which that station would observe.

The Chairman (Sir Peirson Frank) said that Mr. Gutteridge had criticised the author's statement that the cost of the composting process appeared to be a deterring factor at present. The chairman thought that that observation was justified. The difficulty had been and still was partly climatic; they could not get the compost to mature quickly enough. Colonel Hill drew attention to the omission from the paper of any reference to the prevention of flooding, and rightly so; the Conference was concerned with engineering in the world as a whole, and enormous sums were being spent to eliminate some of the difficulties experienced, particularly in some of the towns in the Middle East and the Far East. With regard to the pollution of watercourses by industrial effluents, he had been concerned with a case in which three or four factories had been established within the confines of a small residential city; the amount of effluent from those works was three times the domestic effluent, and its potency was very high. Reference was made in the paper to district heating, and it was said that "The wholesale adoption of district heating schemes would

undoubtedly do much to reduce atmospheric pollution, especially from domestic fires; unfortunately, the present economic conditions in Britain may prevent such a course." He thought that another factor which prevented the more rapid expansion of district heating was the British climate; there was not the urge to adopt it in this country, because of climatic variations. However, if and when money could be found for it, he believed that economy would result from its adoption.

The author, in reply, said that the European equivalent of the household grinder was the Garchey system, which had been introduced in France and was being tried in this country. A considerable area of flat development at Quarry Hill, Leeds, was the first example of the system in this country, and he understood that it was working well. More recently, it had been introduced in London. Colonel Hill and Sir Arthur Dean had mentioned the question of alternative water-supplies. The author had had experience of an alternative water-supply in Birkenhead, where there was a separate system of mains with an alternative supply from the Mersey. This water was used for fire-fighting, street cleansing and for the swimming baths. It was really sea-water which had been filtered through anything up to 20 ft., and in some cases 50 ft., of sandstone into the Mersey Tunnel, from which it had to be pumped in any case. The discharge to sewers of industrial wastes was a difficult problem, and he was doubtful about the results of the new legislation; but he had no doubt at all that the new legislation, and the formation of river boards, and their powers over pollution were right.

Birmingham had required that industrial effluents should be taken to the sewers, and had done so for 30 or 40 years; and yet they got pollution in their streams, because some industries tipped waste products on the ground, and the rain came and washed the pollution through the ground into the watercourses.

Colonel Hill also mentioned sea defence works and the prevention of flooding from waterways. Sea defence works probably had no important bearing on health, but flooding did, and it should have been mentioned in the paper. There was, for example, its effect on the rheumatic diseases, which had been estimated to account for more ill health than almost all the others put together. Mr. Gutteridge talked about composting. There had been no intention to imply, in the paper, that it did not have a future, or that cost was a definite bar to its use. Although composting in one form or another had been carried out for generations, its application in municipal works was comparatively recent in this country.

Mr. East's contribution was very interesting. The author was not one of those who considered that the emission of power-station smoke and grit was necessarily worse than the emission from factory chimneys. He wished that it was possible to get better results from ordinary private industry. Considerable results were, in fact, being obtained. In Birmingham, they had an officer who was an engineer, and whose job it was to advise industrialists and to examine all plans deposited; and there was power to require details to be given of the mechanical plant which was put in. He had been interested to find that the improvement in atmospheric conditions in and around the Midland area was so great that Portland stone buildings, which, at one time, became almost completely black within four or five years, would now only begin to show discoloration after nearly 20 years. Moreover it was no longer the pollution from industrial chimneys which was the menace, but mainly the emission from domestic chimneys.

The chairman had commented on a number of matters, including industrial effluents and district heating. The author had been a member of the Egerton Sub-Committee on district heating for about four years, and had prepared five schemes of district heating, the last one being to deal with an estate of some 2,000 houses with special buildings, schools and an industrial area. What killed it was the increasing cost and the lower calorific value of fuel, the calorific value having come down by something like 25 per cent. since before the war. The effect was that the cost per house was doubled. He had

made inquiries and found that almost every other scheme in the country had suffered similarly, including those at Wythenshaw, near Manchester, and at Westminster. A stage was reached where one could not introduce a scheme which was going to impose on people a very large payment as rent or dues, because they would not accept it; they preferred a system which was less efficient but which cost them less money. He thought that district heating would come when new forms of power were available, but at present, it was such a doubtful benefit, because of the British climate, that he was not surprised to see it lagging.

APPLICATION OF POWER TO AIRCRAFT.

A paper on "The Application of Power to Aircraft" was read by Mr. F. M. Owner, C.B.E., M.Sc., at a meeting on June 8, at the Institution of Mechanical Engineers, with Dr. R. W. Bailey, F.R.S., in the chair. After surveying the historical development of aircraft propulsion and accessory-power requirements, he reviewed current practice and future prospects in the choice of propulsive system, power-plant installation, and accessory power services and supplies. The piston-engine field, he said, was likely to be confined to low-altitude low-speed aircraft; for very long ranges, compounding might be used. The propeller-turbine engine could be expected to improve appreciably in power output and specific weight as combustion temperatures were increased from the current values of 800 or 850 deg. C. to 1,000 deg. C., in the fairly near future, and later to 1,200 deg. C. or higher. These increases would be made possible by improved materials and design, and by blade cooling combined with external coatings. The effect was cumulative, since higher flame temperatures made it possible to use higher compression ratios. The development of the supersonic propeller would simplify, or even eliminate, reduction gearing and make the weight of the propeller turbine comparable with that of the pure jet. The propulsive efficiency of the propeller would, however, fall as the supersonic speed increased, whereas the jet efficiency continued to rise. The use of the supersonic propeller would, therefore, be limited to aircraft Mach numbers between 0.8 and 1.2; within this range, significant improvements in range might be obtained. The field of application of ducted-fan or by-pass engines also lay within this speed range. Whether either the by-pass engine or the supersonic-propeller turbine would have an overall advantage over the pure jet in the trans-sonic speed range could not yet be foreseen.

In the turbo-jet, higher combustion temperatures would improve the specific thrust but would increase the fuel consumption both at sea-level and at altitude. The only possibility of improving turbo-jet fuel consumption was to use higher compression ratios; unfortunately the optimum compression ratios, from the standpoint of specific thrust, were already being approached. At supersonic speeds, the propulsive efficiency increased up to a Mach number of at least 3. The high thrusts for trans-sonic and supersonic flight would, however, necessarily limit range and duration; for high specific thrusts of short duration, combustion temperatures might be increased by blade-cooling, which was less extravagant than after-burning, did not require a variable-jet nozzle, and need not prejudice good cruising consumption at lower temperatures. Up to a Mach number of 3, the overall efficiency of the turbo-jet was much higher than that of the ram jet, which had a poor thermodynamic efficiency, and would be confined to short-duration applications such as "assisting" a turbo-jet or as a missile power plant. Other possibilities mentioned by Mr. Owner were the use of the turbine engine to provide boundary-layer suction, and the development of a light compact heat exchanger for utilising the surplus heat from the turbine.

DISCUSSION.

In opening the discussion on Mr. Owner's paper, Sir Harry Ricardo, F.R.S., said that, in the compound engine, probably the best results would be obtained by sharing the power output more or less equally between the piston engine and the exhaust turbine. Discussing the possibilities of higher working temperatures in gas turbines, he

wondered whether it would be possible to make the structure surrounding and supporting the turbine wheel stand up to much higher temperatures; although not so highly stressed as the turbine blades, appreciable distortion could not be tolerated. In common with other speakers in the discussion, Sir Harry wondered whether the supersonic propeller would be intolerably noisy. Finally, he said, he was aghast at the amount of auxiliary and servo equipment required by the modern aeroplane.

Air Commodore Sir Frank Whittle, K.B.E., C.B., F.R.S., thought that the author was too optimistic about the future of the propeller turbine. Engine weight was almost as important as fuel consumption, and he would like the author to give a comparison of the weight per horse-power at 500 m.p.h. for a propeller turbine and a turbo-jet engine. In first cost and maintenance of the engine, the turbo-jet was greatly superior; and above all, the turbo-jet contributed much less to the drag of the aircraft. He estimated that the skin friction and interference drag of the nacelles of a propeller turbine installation, plus the slipstream drag, might give rise to a 25-per cent. difference in drag between the propeller-turbine and turbo-jet installation. He thought, however, that the propeller turbine might be suitable for anti-submarine work. The steady increase of the auxiliary loads on the engines, which might require a substantial proportion of the power available, could make for a very slow acceleration when opening up from idling at great heights; for some time he had been urging that a clutch should be incorporated in the auxiliary drives so that the load did not come on to the engine until it was running at a reasonable speed. The jet engine was much more sensitive than the piston engine to altitude and temperature effects; one method of restoring power was by coolant injection; he hoped that the author would say something on that point. The author, said Sir Frank, had passed lightly over the case for the ducted fan, a great advantage of which was that it could have a very large ratio of take-off power to cruising power; fuel could be burned in the by-pass air to give a large increase in take-off thrust. With the present trend towards larger ratios between take-off and cruising powers, therefore, there was a strong case for the ducted fan.

Professor R. L. Lickley said that the choice of engine for commercial aircraft was affected by air-traffic control at airports; the greater flexibility of the propeller turbine engine, compared with the jet engine, made possible a saving in fuel. Discussing the design of air intakes for fighter aircraft, he disagreed with the author that the nose entry was more efficient than the root entry, since considerable losses were incurred in the ducts necessary to take the air past the pilot. He thought that there was an advantage in the coupled-engine layout, in which one engine could be shut down for cruising, for the long-range jet fighter. One of the reasons for mounting jet engines on "pods," as in the Boeing X47 jet-propelled bomber, was because it was impossible to bury the engines in thin wings. He asked the author to state the probable weight of high-speed propellers.

In reply to the discussion, Mr. F. M. Owner said that, if the highly-stressed blading could be made to withstand higher combustion temperatures, he was sure that the flame tubes and turbine casings could also, by use of such methods as film cooling, sweat cooling, etc., that were less difficult to apply than blade cooling which had to be effected without interfering with the gas stream in which the blades worked. He thought Sir Frank Whittle had not made a fair comparison between a buried jet engine and a propeller-turbine engine which was not buried. He agreed that the power required to drive the accessories constituted a serious problem, but pointed out that if the accessory drive was taken from the free turbine, the functioning of the compressor was not affected; by putting the aircraft in a shallow dive, accessory power was available even if the engine had stopped. He agreed that liquid injection was probably the most suitable method for civil use of overcoming the power loss due to altitude and temperature; this problem would become of still greater importance when higher

compression ratios were adopted. Regarding the ducted fan, he thought that the increase in take-off thrust obtained by after-burning in the by-pass, at a compression ratio of the order of 2 to 1, would entail a relatively high consumption, and its use would be limited to short periods. His impression was that, so far from being over-powered for cruising, the cruising-power requirements of aircraft at high altitudes were going to be difficult to fulfil.

As regards suitability of the power unit in relation to air-traffic control, he thought that the problems posed by the propeller turbine lay about half-way between those of the piston engine and the turbo-jet. Discussing air intakes, he thought that insufficient attention was being paid to the increased mass flow of the turbine engine compared with the piston engine, which must affect considerably the airflow over the aircraft surfaces; study of the problems caused by spill from the intakes when the engine was not making its full demands—which might call for variable intakes—and the use of the engine jet to induce airflow where it was wanted, could do much to assist aircraft design. He agreed that there was a considerable advantage in being able to shut down one engine in flight, but thought that fighter aircraft required the largest engine which could be efficiently made in a single unit. Referring to supersonic propellers, the blades of which would have to be of thick hollow or solid steel, he thought that the weight of the complete power unit might be a little over half that of a normal propeller-turbine unit. There were as yet no flight measurements of supersonic propeller efficiencies. He thought that the noise level would be of the order of 140 to 150 decibels, which would rule out the use of supersonic propellers for civil aircraft. For similar reasons, the ram jet was unlikely to be used in civil aircraft.

ELECTRICAL MEASURING INSTRUMENTS.

A meeting was also held on Friday, June 8, at the Institution of Electrical Engineers, when a paper on "British Achievements in Electrical Measuring Instruments" was presented by Dr. S. Whitehead. Mr. G. A. V. Sowter occupied the chair. Until fairly recent times, said the author, the progress of electrical science and, to a large extent, of the physical sciences, had depended on a few basic types of instrument which could be classified under the general headings of the galvanometer and its derivatives; the electrometer; the bridge network; the potentiometer; and the magnetometer. The early scientists in this field, and their successors, had done their work so well that new methods, apart from developments of old principles, had lain principally in the recent introduction of new components, such as valves, cathode-ray oscillographs, semi-conductors, crystals, photo-sensitive cells and a number of other electronic and ionic devices, descriptions of which the author gave.

There was, in fact, little room for fundamental improvement. The principles of rapid and accurate readability had been explored, both for normal and difficult conditions, as had the best designs of pointers and the use of optical and projection devices in self-contained instruments. Similarly, the application of kinematic principles to reach the minimum number of restraints would economise precision work, except in the essential parts. More important improvements would come from the exploitation of existing and future materials. Future magnetic materials might extend the frequency range of electromagnetic instruments to the limit set by the natural frequencies of the coils. The potential transformer could be raised to the precision of the current transformer. The wider use of the geared pointer was probable and improved magnetic materials might replace the jewel and pivot by a frictionless suspension. Electrostatic instruments might be raised to the electromagnetic class by using vacuum or high-pressure, and, more speculatively, by the employment of high permittivity dielectrics. A great revolution would come from the production of stable valves or of equivalent semi-conductors; still greater would be the revolution if auxiliary supplies could be eliminated or minimised.

The main extension of measurement science would lie in its adaptation to multifarious uses, such as the production of automatic and recording

instruments. The future also offered a vast field where the phenomena considered had been imperfectly or not at all translated into electrical quantities. Once the translation had been made there was scarcely a mathematical operation that could not be carried out by an electric circuit. Furthermore, the data could be transmitted for purposes of central control and interpretation. A more important problem was the initial translation into electrical quantities, especially of subjective phenomena. Even such a simple concept as firmness was difficult to assess and those with a semi-aesthetic flavour would probably never be settled to general satisfaction. The attempt now in progress to make the computational machine act with some of the properties of a brain might have incalculable consequences.

DISCUSSION.

The Earl of Mount Edgumbe said that it was high time such a paper, giving chapter and verse for the contributions made by the British nation to electrical measurement, should be written. He thought that the taut-suspension moving-coil oscillograph should definitely be ascribed to Duddell. Crompton's name might have been mentioned in connection with the development of the potentiometer, while another pioneer who had not received his due was Evershed, with his ohm-meter. He was glad that Sturgeon and his galvanometer had been mentioned, since d'Arsonval had received undue credit for it. Ockenden deserved a good deal of credit for making the moving-coil instrument as accurate as the dynamometer.

Dr. W. G. Radley thought that during the past few years industrial instruments had become more robust, more weatherproof and smaller, owing to the availability of new materials and the use of miniature components. The new magnetic alloys had a very high energy content and very low corrosivity, making for great simplification in the design of all instruments employing permanent-magnet systems. So far the effect of new dielectrics had not been so marked, but much research was being carried out with a view to finding new materials for use in communication and high-frequency equipment. Instruments for use in the very high frequency region necessitated great precision in dimensions. At a frequency of 100,000 megacycles the penetration of current was only 10^{-5} in. and surface roughness extending to half that depth increased the attenuation by 20 per cent. This meant that in the manufacture of devices for measuring these frequencies precision methods of machining had to be used.

Mr. G. F. Shotter pointed out that there were more problems to solve, especially in connection with the ordinary recorder. He was opposed to the use of valves and valve techniques where it was possible to employ accepted methods. He thought that in this respect the magnetic amplifier would have a useful future.

Mr. L. J. Matthews said he regarded the comparator as an outstanding achievement of British instrument practice. The clock type of meter should be mentioned as it was one of the earliest supply meters to be invented and was still used with a very high degree of accuracy for certain purposes. British engineers had always taken a leading part in the development of the induction meter. These meters were now employed for measuring the bulk of the domestic and power supply with an accuracy within ± 1 per cent. from 1/120th of the marked load up to three or four times the full-load current continuously.

Dr. A. H. M. Arnold said there was still a need for a better alloy from which a current transformer with higher accuracy and lower impedance could be produced. Improvement in regard to higher frequencies was also necessary; this could only be obtained by increasing the resistivity of the material.

Dr. A. C. Menzies remarked on the fact that in the past instruments had been developed by individuals. In physics, at any rate, the day of "gangs" now seemed to be beginning and whether this country would be good at that kind of thing he did not know. Perhaps, however, there would still be room for the individual to produce his stroke of genius.

Mr. J. F. Coales hoped that with the more com-

plicated circuit arrangements it would be possible to reduce the signal level employed. At frequencies above 30,000 megacycles the comparison of voltages in wave guides and the use of the standing wave pattern in the guide to measure impedances became very difficult, if not impossible. Bridge methods with hybrid junctions, exactly analogous to the Wheatstone bridge, were therefore being employed.

Mr. W. Bamford thought that in these days basic ideas in instrument design must be adapted to new methods of production. In the application of instruments, flameproofing, hermetic sealing, the use of inhibitors for parasitic growths, and resistance to the shock of gunfire might be mentioned. The employment of the direct-current amplifier on tele-metering equipment enabled a relatively large amount of power to be produced and all contacts to be eliminated.

Mr. C. W. Pettitt considered that there was need for research on how ink could be eliminated from recorders. In this connection, Dr. W. B. Whitney mentioned the Masson perturbograph in which any disturbance on the system was recorded. In an instrument which had been developed by the Electrical Research Association, 72 simultaneous occurrences could be recorded magnetically on a drum and the record thrown on to a cathode-ray tube screen. Mr. C. Phillips thought a tribute should be paid to Drysdale, who had not only invented many electrical instruments, but had built up the optical industry in this country.

Dr. S. Whitehead, in reply, said that in high-frequency work it was the techniques rather than the instruments which were new. He did not think that instrument design or ideas about instruments would become a matter for gangs. It would always be one person who had the idea and did most of the work.

(To be continued.)

BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

ON Wednesday, July 4, the first British Instrument Industries Exhibition was opened at Olympia, London, by the Minister of Supply, the Rt. Hon. G. R. Strauss. The exhibition, which will remain open until July 14, covers a wide field, ranging from drawing-office instruments, laboratory equipment and tool-room gauges to completely automatic process-control equipment operated from a central station, and many special instruments for particular industries and research projects. A description of some representative exhibits follows.

The Baldwin Instrument Company, Limited, Dartford, Kent, are showing their new industrial beta-ray thickness or weight gauge, known as the Atomat, for gauging such materials as paper, board, plastics, metal foil, etc. The instrument, a photograph of which is reproduced in Fig. 1, on page 10, uses a radioactive source directed at a detecting ionisation chamber, separated from it by a 1-in. gap. Any material placed between the source and the detector will cut off the beta radiation reaching the ionisation chamber by an amount proportional to the mass of the material. The product to be gauged is therefore fed between the source and the detector, and the ionisation current gives a measure of the average weight per unit area across the width of the material and thus, in the case of sheet material, of its thickness. If it is desired to measure the variation across the width of the material of its weight, the source and the detector can be arranged to traverse the width or, alternatively, several source and detector units, suitably disposed, can be employed. The ionisation current, which is very small, is amplified electronically and fed to indicating instruments.

The radioactive source employed at present is thallium 204, which gives a range of 0 to 150 milligrammes per square centimetre (equivalent to a maximum thickness of aluminium sheet of 0.55 mm.). Other radioactive sources will be available in the near future, which will allow other ranges to be covered. The radioactive substance is mounted in a metal holder in a casing fitted with lugs for attaching to the user's feeding machinery (the sup-

plying blocks shown in Fig. 1 are not normally present). The casing is provided with a shutter in order to shut off all emission when handling the equipment or for checking the instrument setting. The standard ionisation chamber is in a hermetically-sealed container, and has a scanning area of $1\frac{1}{2}$ in. by 9 in. The ventilated steel cabinet shown on the right of Fig. 1 contains three racks, the top one carrying the indicating instruments and the control switches, the middle one carrying the amplifier, and the lower rack supporting the power pack and the voltage-stabilising transformer. Plug and socket connections are provided between the racks, so that each rack may be removed separately for servicing. Two moving-coil indicating instruments are provided, one indicating the weight per unit area of the material being gauged and the other showing the deviation above or below a preselected weight or thickness. Recording instruments can be fed from either of the indicators.

The Baldwin Instrument Company are also showing their rolling-mill extension gauge, which measures the small reduction in thickness (0.5 to 3 per cent.) which is given to steel strip in the "temper pass" to produce work hardening. Practically all the extension takes place in the direction of rolling and, therefore, the ratio of the velocity of the strip entering the rolls to the strip velocity leaving the rolls gives a measure of its extension. These velocities are determined magnetically; the output of an alternating-current generator, driven from the rolls, is fed to two "printing" coils, displaced relatively to each other across the strip-width, one impressing a magnetic pattern on the strip before it passes through the rolls and the other after the strip emerges from the rolls. The coil on the ingoing side can be adjusted by a micrometer; the other coil is fixed. Two pick-up coils, in line with each printing coil, detect the magnetic patterns, which are then amplified and fed to a phase-selective indicating detector. With a thickness reduction of, say, 1 per cent., the outputs of the pick-up coils will be in phase when the distance between the ingoing printer and pick-up coils is 1 per cent. less than that between the outgoing coils. The instrument is operated, therefore, by setting the ingoing printing coil with the micrometer to a distance from its pick-up coil to give the desired velocity ratio and reduction in thickness, and the rolling mill is adjusted so that the phase detector indicates zero.

On the stand of the Department of Scientific and Industrial Research, a wide range of scientific instruments, developed by the National Physical Laboratory, the Chemical Research Laboratory, the Road Research Laboratory, and several of the industrial research associations, is on view. Among these exhibits may be mentioned a pneumatic surface-roughness gauge developed by the Metrology Division of the National Physical Laboratory, consisting of a measuring head connected by a flexible rubber tube to a pneumatic amplifier fed by compressed air. The measuring head is housed in a small metal cylinder, open at one end. Within the cylinder is an air jet, slightly set back from the open end. The cylinder is placed with its open end upon the surface to be gauged; the roughness of the surface allows air to escape from the cylinder, the degree of roughness being gauged by the variations in air pressure in the measuring head.

The British Iron and Steel Research Association, 11, Park-lane, London, W.1, are showing a wire-drawing die profilometer developed for measuring the profiles of bores with minimum diameters ranging from 0.02 in. to 0.5 in., to an accuracy of 0.0001 in. For industrial use, the instrument is manufactured under licence by Messrs. Hilger and Watts, Limited, Watts Division, 48, Addington-square, London, S.E.5. It is illustrated in Fig. 2, on page 10; the die is mounted in a chuck fitted to a headstock similar to that used on a small lathe. A pivoted probe arm, with an enlarged tip, is carried on a carriage which can be traversed by a micrometer screw so that the probe is moved axially through the die bore. As the probe arm is rotated about its pivot to follow the profile, it is observed by sighting an autocollimator on to a mirror fixed to the probe arm; at each reading, the rotation of the probe arm is "nulled" by adjusting the height of the pivot on the carriage with a second micrometer screw. The

EXHIBITS AT THE BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

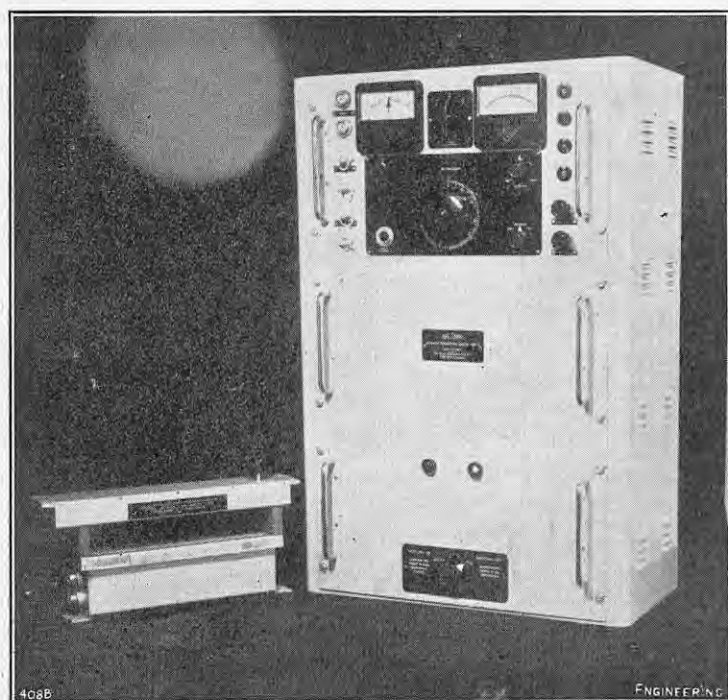


FIG. 1. BETA-RAY THICKNESS GAUGE; BALDWIN INSTRUMENT COMPANY, LIMITED.



FIG. 2. WIREDRAWING-DIE PROFILOMETER; BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

profile of the bore is plotted from the readings of the two micrometers.

The B.I.S.R.A. are also showing an electrical remote-indicating differential-pressure meter developed for measuring differential pressures in open-hearth furnaces, which is manufactured under licence by Messrs. Tinsley (Industrial Instruments), Limited, North Circular-road, West Twyford, London, N.W.10. The measuring head consists of a diaphragm formed by a Paxolin disc mounted in an annulus of gold-beaters' skin forming a flexible airtight seal. It is carried on a horizontal rod supported by flexible pillars, and is free to move horizontally. One end of the rod carries a sensitive electrical displacement detector; on the other end is a coil moving in the air gap of a permanent magnet. The force exerted by the coil on the rod is proportional to the current flowing through it, which is supplied by the amplified output of the displacement detector. Its direction is arranged to oppose the motion of the diaphragm caused by differential gas pressure. On applying a pressure difference across the diaphragm, the rod moves through a distance sufficient to generate a current in the coil, causing an equal opposing force on the diaphragm; the output current, therefore, gives a measure of the differential pressure. The instrument has a pressure range from 0 to 1 in. water-gauge, with an output current of 30 milliamperes at full-scale deflection, and is sensitive to within 0.002 in. water-gauge.

The journey-shock recording instrument shown by the Printing, Packaging and Allied Trades Research Association, Patra House, Randalls-road, Leatherhead, Surrey, has been developed in connection with their researches on the strength and protective properties of containers used for transporting goods. The recorder, which is illustrated in Fig. 3, is used to measure the number of times that a container is dropped during loading, transport, and unloading, from a height above a pre-selected minimum value, within a range of 3 in. to 3 ft. The instrument consists of a brass tube, 1½ in. in diameter and 4 in. long, housing a counter mechanism operated by a mass spring system with oil damping. The recording dials can be read through a window in one end of the tube. Commercial organisations are co-operating with the Association to determine the drop hazards to which their goods are subjected in transit; several recorders are mounted on a wooden block, which replaces the goods in a standard case, and the weight is adjusted to be the same as that of a normally-filled case.

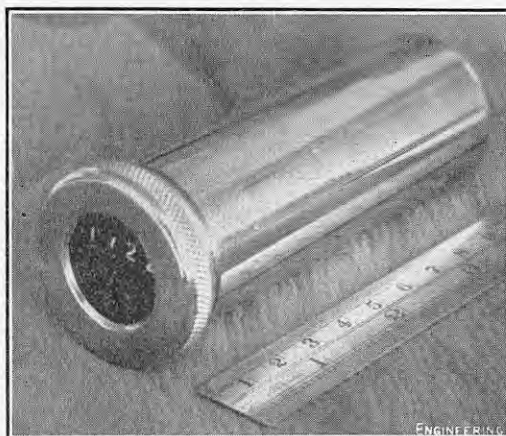


FIG. 3. JOURNEY-SHOCK RECORDER; PRINTING, PACKAGING AND ALLIED TRADES RESEARCH ASSOCIATION.

Messrs. W. Edwards and Company (London), Limited, Horsley Bridge-road, Lower Sydenham, London, S.E. 26, are showing a light-alloy melt gas-content tester which has been developed for commercial use in co-operation with the British Non-Ferrous Metals Research Association, being based on the techniques used in the laboratories of the latter organisation. A sample of the melt is cooled under reduced pressure; the presence of gases is detected either by bubbles breaking through the surface of the solidifying sample, or, in the case of aluminium-based casting alloys which form a pasty mixture of solid and liquid metal during cooling, the whole sample will swell as it solidifies. The degree of bubbling or swelling gives a qualitative measure of the gas in the melt which is usually sufficient for determining whether de-gassing treatment is necessary. The apparatus consists of a chamber which is evacuated by a Speedivac 1S50 pump; the rate of evacuation is controlled by a valve, which also serves to isolate the chamber from the pump. A barometrically-compensated aneroid dial gauge is used to measure the pressure in the chamber. The chamber is provided with an air inlet to enable the vacuum to be destroyed, and is fitted with a hinged lid sealed by a synthetic-rubber O-ring. A hard-glass window is provided for observing the test sample, which is contained in an uncooled iron crucible supported on a fireclay triangle.

(To be continued.)

THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

As was reported in last week's issue of *ENGINEERING*, the International Conference of Naval Architects and Marine Engineers was formally opened at the Central Hall, Westminster, by the Lord Mayor of London, Sir Denys Lawson, Bt., on the morning of Tuesday, June 26. Our note of the proceedings was necessarily brief, but it recounted the principal events of the week's programme down to the reception by the Lord Mayor at the Mansion House on the Wednesday evening. The following day, June 28, was devoted entirely to technical sessions, with no evening engagement; and the Friday, June 29, to all-day tours of the Surrey hills and the Thames Valley, followed in the evening by a banquet at Grosvenor House, Park-lane, which terminated the official proceedings in London. There were, however, various other gatherings, not in the printed programme; for instance, the luncheon given to the overseas delegates by the Worshipful Company of Shipwrights, which was held in the Vintners' Hall on June 29, under the chairmanship of the Prime Warden (the Hon. Geoffrey Parsons), and the dinner given by the President (Mr. J. H. King) and delegates of the Society of Naval Architects and Marine Engineers at the Dorchester Hotel, Park-lane, on Saturday, June 30—a kind of post-conclusion to the London proceedings, for, on the Sunday morning, those who were visiting the Clyde and the Tyne left Euston for Glasgow by special train.

The complete programme of papers numbered ten, of which the first eight were presented and discussed in London, and the remaining two were to be read in Newcastle-on-Tyne; there were no technical sessions in Glasgow. The first paper—on "Ships' Structures: A Century of Progress"—was delivered by Mr. R. B. Shephard, C.B.E., B.Sc., Chief Ship Surveyor of Lloyd's Register, on the morning of June 26; it is reprinted in this issue. The second, taken at the same session, dealt with "The B.S.R.A. Resistance Experiments on the 'Lucy Ashton.' Part I—Full Scale Measurements," and was presented by Sir Maurice Denny, Bt., K.B.E., chairman of the Research Board of the British Shipbuilding Research Association. On the following morning, June 27, a paper on "Higher Steam Conditions for Ships' Machinery"

was contributed by Mr. Mark L. Ireland, Mr. H. W. Semar and Mr. N. L. Mochel; and one on "Boiler and Turbine Testing" by Captain (E) L. F. Ingram, R.N., and Captain (E) L. A. B. Peile, D.S.O., M.V.O., R.N. On Thursday, June 28, there were technical sessions in both the morning and the afternoon, when the following papers were discussed: "Marine Fuel Oils," by Mr. M. Blancher, and "Ship Motions," by Mr. John C. Niedermair; "A Proposed Design for a Combined Research Training and Cargo Ship," by Professor Ir. H. E. Jaeger and Ir. J. C. Arkenbout Schokker, and "Some Aspects of Pre-fabrication in Ship Construction," by Mr. Nils Eckerbom.

The papers to be discussed at Newcastle—which, of course, had not been presented when this paragraph was written—were to form the programme for a meeting on the morning of Thursday, July 5. They were on "U.S. Fleet Maintenance and Battle Damage Repairs in the Pacific during World War II," by Captain Ralph K. James, U.S.N., and "Stresses in Propellers and Propeller Shafting Under Service Conditions," by Dr. S. F. Dorey, C.B.E., F.R.S., President of the Institute of Marine Engineers.

As Mr. R. B. Shepherd's paper on "Ships' Structures" is reprinted elsewhere in this issue, there is no occasion to summarise it before proceeding with our report of the discussion. Viscount Runciman of Doxford, the President-elect of the Institution of Naval Architects, who, in the absence through illness of the President, Admiral of the Fleet Viscount Cunningham, had taken the chair at the formal opening of the Conference, also occupied it during the technical session.

SHIPS' STRUCTURES: DISCUSSION.

Mr. D. P. Brown, vice-president and chief surveyor of the American Bureau of Shipping, opened the discussion by remarking that, for several years, he had been closely associated with the author of the paper in the work of their respective classification societies, and that several of the problems mentioned had been the subject of common discussion; recent revisions in the Rules of the American Bureau of Shipping and Lloyd's Register of Shipping had brought them more closely into agreement so far as the distribution of material and the basic overall strength characteristics were concerned. Mr. Shepherd had referred to welding as a second revolution. It was true that the introduction of this method of connection had not involved such radical changes in the basic concepts of structural design as did the transition from wood to iron, or from iron to steel. On the other hand, it had introduced new problems, the importance of which was not fully realised before welding was extensively used. Some of the fractures in welded ships had their inception in such members as bulwarks, bilge keels, or in mouldings fitted to prevent the chafing of lines or merely for decoration, items to which only casual attention was usually paid with riveted construction. The large welded structure was appreciably more susceptible to poorly designed details and faulty workmanship, so that a very careful control was essential in the drawing office and also in the shipyard. Experience with welded ships had brought into prominence a property of ship-building steel which was not of such significance with riveted construction. Investigation of steel from fractured ships indicated that the material complied with all the standard tests required by the rules of classification societies, relating to tensile strength, yield point, ductility and bend tests; and further exploration of other properties were made in an effort to explain the sudden brittle manner in which those fractures developed. It was then that there came into prominence the property described by the author as "notch toughness," and which was not directly related to the other ordinary physical properties for which tests were made under the standard procedures. Testing of steel from ships in which fractures occurred indicated that the material in which the fractures had their inception had generally shown a low degree of notch toughness as indicated by the transition temperature. In those cases where the fractures had terminated, the material at the terminal had shown a comparatively higher degree, and any intermediate material through which the fractures passed generally showed values between the two limits. Universal agreement had

not yet been reached as to the most reliable test to establish a measure of notch toughness, or definite quantitative values to be associated with any particular type of test to provide a reasonable assurance against the inception or propagation of fractures. Laboratory research was still being carried on and complete investigations of material which had been involved in fractures were being continued. The recent modification by the classification societies of their specifications for hull steel plates took practical advantage of the knowledge acquired, and investigations of steel to the new specifications had consistently supported the actions taken.

Sir Charles S. Lillierap, Director of Naval Construction, Admiralty, said that the basic problem facing the naval architect when designing a vessel—that it must carry the largest possible load—applied equally to the merchant ship and the naval ship. To achieve this the light weight, and especially the hull structure, which formed the major part of the light weight, must be reduced to the absolute minimum. The author had shown what improvements in hull structure had been made, and this was a reminder of the need for continual improvements in materials and for their use to the best advantage. The effect of the repeal of the Navigation Acts had been mentioned. Everybody connected with the shipping industry should strive to ensure that any Act which mitigated against the design of efficient structures, by stressing considerations other than strength and safety, was amended or removed. Apparently, the liability to compressive deflection in the bottom plating of vessels had been enhanced by the greater use of welding in the bottom structure. This coincided with the tendency of the hogging moments in dry-cargo ships to increase. In the riveted ship, the lap joint, with its local stiffening effect, tended to break down the size of the panels; also, the absence of shell flanges or welded stiffeners meant that, with the same frame spacing, the unsupported width of plating was greater. The effect of these two items, though they might not have been great, were probably sufficient to reduce the critical stress in the welded ship to the point where some crippling took place.

The author mentioned the improvement in efficiency obtainable by adopting longitudinal framing in the double bottom and strength deck. This agreed with the beam theory applied to a vessel subjected to longitudinal bending moment, where the strength deck and keel absorbed most of the bending forces, and the sides and longitudinal bulkheads absorbed the shear forces. Scott Russell had recognised this almost a century ago. Longitudinal framing, especially of the double bottom, had been used for many years in the design of naval vessels, and was coming more and more into prominence. With regard to the rapid changeover to welded ship construction, it might well be said that the traditions of the riveted ship had done harm to the construction of welded ships; the initial tendency was to imitate instead of designing for a new medium. Now that light alloys were being used to a greater extent, he hoped that the lessons of the past would not be forgotten.

Ir. J. C. Arkenbout Schokker, referring to Mr. Shepherd's allusion to "panel breakers" in the plating between floors, asked whether these were the same as were proposed in the Gebbie-Abel system, which, to his regret, had hardly ever been used. To the advantages of the longitudinal construction mentioned by the author—greater longitudinal strength and greater resistance to buckling—he would add a third: in a transversely-framed vessel, the longitudinal stress in the bottom plating and the stress set up by the water pressure on a panel between the floors acted in the same direction, giving combined stresses which could amount to as much as 13 tons per square inch. If the framing was longitudinal, the stresses from the water pressure were perpendicular to the longitudinal stresses so that the virtual stresses resulting were lower—say, 9 tons per square inch. With regard to the strength of riveted *versus* welded butt laps, Montgomerie's experiments, as the author had stated, showed a falling-off in the case of heavier plates; it could be understood, therefore, how the crack in the strength deck of the *Majestic*, about 1925, found its way through a butt in this deck.

Mr. David Arnott quoted the author's observation that "Simplification and removal of redundant members in the internal structure proceeded slowly, and only by the end of the first decade of the present century had the stage been reached of assessing scantlings of individual components on comparative determinate methods to suit their particular functions." If, he commented, that meant that progress started only when Lloyd's Register revised their Rules in 1906, Mr. Arnott disagreed; at an earlier date, rules had been prepared by Jefferies, who died before they were published. Foster King carried on, however, and he believed that Sir Archibald Denny also did some research on the subject. With regard to welded ships, the research initiated in the early days in Britain and in the United States, and the interchange of opinion concerning materials, etc., had proved very valuable. Welded ships built in the United States, up to a length of 300 ft., had been quite successful, and gave no trouble; but he (Mr. Arnott) had predicted that there might be trouble if 300 ft. was exceeded. The plain fact was that a design which was suitable for a riveted ship would not do for a welded ship.

Professor Dr. G. Schnadel thought that, in the historical part of the paper, the merits of I. K. Brunel were not given full recognition. He was, in fact, the designer of the first sea-going steamer, the *Great Western*, and of the first ocean-going iron ship, the *Great Britain*, to be propelled by a screw and mechanical gearing. Before Brunel, only small craft were built of iron. The ships that he designed, had the modern features proposed later by Fairbairn and Scott Russell. The longitudinal system of ship construction was used on the orders of Brunel in the structural design of the *Great Eastern*. The plates of the strength deck were doubled and longitudinally stiffened. Sir William White considered Brunel to be the most able ship designer for a very long time. After the death of Brunel, Fairbairn continued to advocate the iron deck, and Scott Russell the longitudinal system. Brunel recognised the importance of the longitudinal bending moments for the strength of a ship; but William John, of Lloyd's Register, made a useful proposal for the calculation of those moments, and his proposal remained the basis of comparison. Professor Schnadel thought it preferable, however, not to make the Smith correction, using a wave with a height of one-twentieth the length of the ship, as the actual waves in the ocean had a height of one-twelfth the length of the waves, as measured during trials of the *San Francisco*.

There were some points to be considered in making a calculation of bending moments. The wave pressure was not distributed along the ship's length with trochoidal form; measurements of the pressure at the bottom of the *San Francisco* and on *Ocean Vulcan* and *Clan Alpine* showed that the pressure was much lower amidships than that calculated with the Smith correction; it was at the bow and stern that the Smith correction was most nearly applicable. Over the midship half-length of the ship, the form of the pressure curve was very flat, which meant that the hogging moments were smaller than the sagging moments.

With regard to the buckling stress of plating under compression, there was a double advantage to be gained by longitudinal framing. Most designers, including Brunel, believed that the longitudinal girders were the most essential addition to the longitudinal strength of ships, but the buckling strength of the shell and the strength deck of the longitudinally-framed ship was much higher than the buckling strength of the transverse-framed ship. It was not possible to determine the buckling stress of transversely-stiffened plating by experiments with unstiffened samples; it was influenced to a high degree by the stiffness of the deck beam.

Mr. Shepherd had made some important remarks on riveted and welded connections. It was not necessary for elasticity that rivets should slip. Some research had been done on that subject in Germany and it was found that the longitudinal connections in the normal range of stress did not slip. Experiments made in a 1,000-ton testing machine showed that rivets in an end connection would slip only slightly when the stress exceeded 13 tons per square inch, and also that an overlap

was better than a butt strap. In the case of the destroyer Wolf, the larger deflections were caused by buckling of the plating, not by the slipping of the rivets. The improvement in building methods and the adoption of large panel connections, introduced by Mr. Arnott into welded ship construction, represented important progress.

Professor Sir Westcott Abell, in a written communication which was read by the chairman, supported the suggestion that more credit was due to I. K. Brunel for his part in the design of the Great Eastern; it was he who had that vision 50 years before its time. In the period since the Great Exhibition of 1851, great strides had been made also in the hull structures of warships; a paper ought to be given on that subject also, for the naval constructors had given shipbuilders a great lead in developing lighter structures, and in the use of welding. It would help future students who might turn to Mr. Shephard's paper if there could be added to the bibliography a reference to Sir Edward Reed's *Shipbuilding in Iron and Steel*, published in 1868, which contained particulars of the process of erection as then practised; it was one thing to design a structure, but quite another thing to erect it. Another addition that he would suggest was Dr. S. J. P. Thearle's paper on "Fifty Years Developments in Mercantile Ship Construction," in the *Transactions* of the Institution of Naval Architects for 1911.

The author, in acknowledging a vote of thanks, proposed by the chairman and carried by acclamation, said that he would not attempt, at that juncture, to reply to all the points raised.

(To be continued.)

PROVING GROUND OF THE MOTOR INDUSTRY RESEARCH ASSOCIATION.

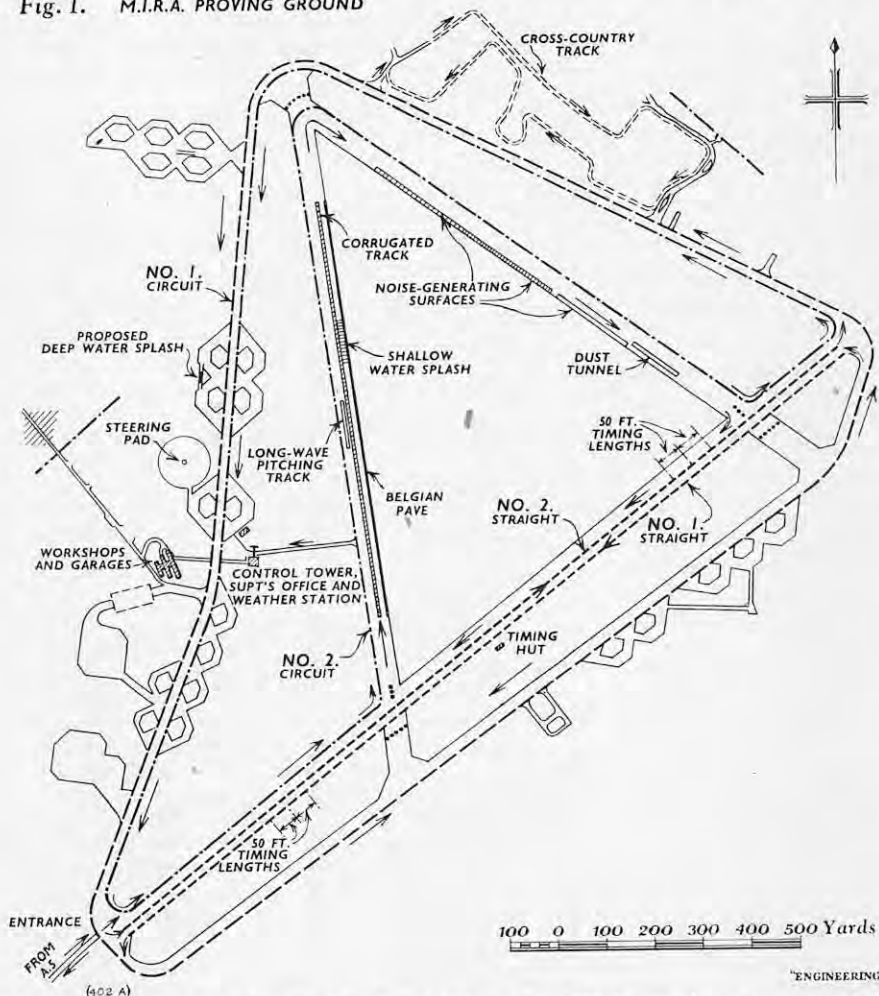
THE Council of the Motor Industry Research Association decided this year to hold an open day at their new proving ground, near Nuneaton, instead of opening their laboratories on the Great West-road, as had been the custom in former years. Accordingly, the ground was open for inspection on Thursday of last week so that members could inspect the work in progress and discuss common problems with the staff of the Association. The new proving ground, it will be remembered, is situated on a disused airfield, namely, Lindley Airfield, near Nuneaton, Warwickshire, the original runways and perimeter track forming the test roads. The Association took over the airfield at the end of September, 1948, and after certain necessary repairs had been carried out, the six miles of roadway were divided into circuits which were marked with white lines and various barriers and traffic signs erected. Since then, many improvements have been incorporated and important additions have been made to the testing facilities, including the building of a section of Belgian pavé roadway, a "corrugated" road typical of those found in parts of Africa and Australia, a rippled surface for the investigation of noise, a skid "pan" and a dust tunnel.

A diagram showing the layout of the airfield and the disposition of the various test tracks is reproduced in Fig. 1, on this page, from which it will be seen that the pavé road and corrugated track are located alongside each other. The pavé road surface, approximately half a mile in length, has been laid to reproduce permanently a Belgian road of this type in a bad state of repair, the specification for its construction having been drawn up on the basis of detailed measurements made on an actual main road in Belgium. The surface is most definitely rough and undoubtedly forms an excellent means of carrying out accelerated endurance, or fatigue, tests on complete vehicles. It has proved very popular and almost half of the total vehicle hours on the proving ground are spent on it; some manufacturers, in fact, are now running prototype vehicles on this track for several hundred miles, thereby ensuring that no major failure will occur during the useful life of the production machines. So popular has this track become, in fact, that its extension to a complete circuit approximately $1\frac{1}{2}$ miles in length is being considered.

The corrugated road, which is built of concrete, is illustrated in Fig. 3, on the opposite page. It has been built to reproduce the effects on a vehicle of the corrugated, or "washboard," surfaces which build up on unmetalled roads in hot, dry climates such as in Africa and Australia. Considerable data on such roads were collected from various countries and these showed that, in general, the dimensions of the corrugations were, within an inch or so, the same in all parts of the world. In the actual road constructed, the crests of the corrugations are of approximately 30 in. pitch and

PROVING GROUND FOR MOTOR-VEHICLE RESEARCH.

Fig. 1. M.I.R.A. PROVING GROUND



1 in. high. Over 11 ft. of the width of the road, they are at right angles to the direction of travel, but are inclined at 21 deg. over the remaining five feet of width. This latter provision has been made so that a vehicle can be driven with, say, a nearside wheel on a crest and an offside wheel in a trough or in any intermediate position depending on the lateral position of the vehicle on the road. Like the pavé track, the corrugated road is approximately half a mile long and, since its completion, has been put to good use. In February of this year alone, for example, almost 300 vehicle hours were spent on it.

The noise-generating track, part of which is illustrated in Fig. 2, on the opposite page, has been laid down to provide a surface capable of generating high and reproducible levels of road noise in vehicles. No attempt has been made to reproduce any particular form of road surface but several types were tried before the best surface, which may be described as having a "saw-tooth" formation, was laid down. A stretch of carefully-smoothed asphalt surface has also been laid down to provide a "reference" surface.

The dust tunnel represents an attempt to reproduce the dusty road conditions encountered in undeveloped and tropical countries. It consists of a series of Nissen-hut sections placed end to end to form a continuous tunnel 200 ft. in length and of sufficient cross-sectional area to permit vehicles as large as single-deck buses to be driven through at speed. Varying quantities of a specially-selected dust, corresponding in its essential properties to tropical dusts, are passed on the floor of the tunnel so that a vehicle, on passing through, generates by its motion clouds of dust, probably considerably denser than those produced in normal service overseas. To give safety in dense dust conditions, illuminated guide rails have been fitted along the sides of the tunnel, thereby making it possible for a vehicle to be driven through the dust cloud set up by a preceding vehicle.

As its name suggests, the skid, or steering, pad, consists of a flat smooth circle of concrete, 250 ft. in diameter, on which a vehicle can be driven at various steering angles and different speeds. To obtain measurements of the angle of roll and the attitude of the vehicle, sights are taken on a post located at the centre of the pad. From these, and from other measurements made on the vehicle itself, a detailed study can be made of the stability characteristics of the vehicle, such as under-steer or over-steer at different lateral accelerations. Provision has been made to increase the

diameter to 310 ft. at a later stage should this prove to be necessary.

Other facilities already provided at the proving ground include a shallow water-splash, timing straights, and a cross-country track. The shallow water-splash is 16 ft. wide, approximately 100 ft. long, and up to 3 in. deep. It is filled from a 7,000-gallon storage tank and is used mainly for testing the weatherproofing of cars. It may be noted in this connection that future plans envisage the construction of a much deeper water-splash. The timing straights are situated on the main 2,000-yard runway and each incorporates a timing section. These are arranged so that a vehicle can be accelerated over almost 1,600 yards, timed electronically over either, or both, of two adjacent 50-ft. lengths, and braked over the remaining 400 yards. Two timing straights are provided side by side to enable runs at speed to be made in both directions and so obtain a mean speed. As each vehicle enters and leaves a 50-ft. timing section, it breaks a beam of light arranged to fall on a photo-electric cell, the electrical impulses setting up starting and stopping electronic timing equipment installed in a hut half-way along the straight. This equipment measures the time taken to travel 50 ft. in increments of 0.00001 of a second and is claimed to be accurate within 0.2 per cent. The cross country circuit, which is situated at the north-east corner of the proving ground, is some $1\frac{1}{2}$ miles in length. It consists of farm tracks, bridle paths and rough ground generally and, where necessary, hard-core has been tipped in the softer parts to consolidate the surface so that it is fit for use throughout the year.

A necessary part of the work of the Association is the provision of instruments for co-operative use by members at the proving ground. These are developed mainly at the Brentford laboratories, and to give an idea of the scope of this work, some of them were displayed in the workshops during the open day. Two of these instruments, namely, a brake-pedal load indicator and a steering-torque indicator are illustrated in Fig. 5, on the opposite page. The brake-pedal load indicator has been designed so that it can be clamped to the brake pedal of any vehicle and used to measure the force, up to a maximum of 200 lb. exerted on the pedal under operating conditions. The braking force is transmitted through a cruciform member, each arm of which has two wire-resistance strain gauges, one on the compression side and the other on the tension side. These gauges are connected up as a Wheatstone bridge circuit and the braking force is

VEHICLE-PROVING GROUND AT THE MOTOR INDUSTRY RESEARCH ASSOCIATION.



FIG. 2. NOISE-GENERATING SURFACE.



FIG. 3. CORRUGATED ROAD SURFACE.

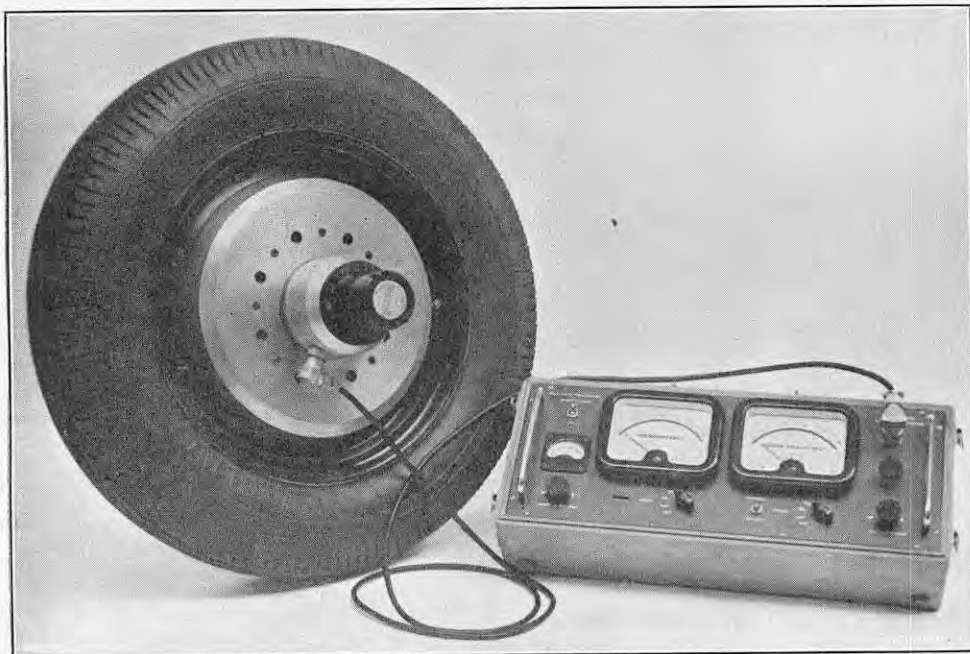


FIG. 4. ROAD-WHEEL TORQUE METER.



FIG. 5. BRAKE-PEDAL LOAD INDICATOR AND STEERING-TORQUE INDICATOR.

read on the dial of a recording milliammeter previously calibrated to read directly in pounds. The steering-torque indicator has been developed to measure the steering effort used by the driver, and consists of a dummy steering wheel which is clamped to the actual steering wheel in such a way that the effort is transmitted from one to the other by two cantilevers pro-

vided with wire-resistance strain gauges. These gauges form the arms of a complete Wheatstone bridge, and, as in the case of the brake-pedal load indicator, the indicating meter is calibrated so that the force can be read directly.

Another interesting piece of apparatus on view was the road-wheel torque meter illustrated in Fig. 4, on

this page. This apparatus replaces the normal wheel of a vehicle and is designed so that any applied torque causes deflection of short but stiff spokes and brings about, therefore, angular displacement of the axle in relation to the wheel rim. This displacement is measured by an electrical inductance method and is recorded on a meter calibrated to read directly in pounds-feet. Eventually, a high-speed pen recorder will be used in place of the meter, so that other relevant data, such as engine speed, road speed, acceleration, etc., can be measured at the same instant.

Other equipment on view included a high-speed camera, a four-channel dynamic-strain recording instrument, a selection of accelerometers, and a magnetic tape recorder; all of these, however, have been referred to in previous articles on the Association's open days. The high-speed camera, in addition to being used in the laboratories in connection with such work as the study of valve-gear motion, has also been adapted for road work and very successful films have been made of the behaviour of an independent front-wheel suspension unit under actual operating conditions. Similarly, records of tyre and wheel behaviour on the pavé road have also been obtained. The dynamic strain recorder, which has been designed and built in the Association's laboratories, is being used for analysing the stresses set up in the components of a vehicle during operation on any part of the proving ground. It operates in conjunction with wire-resistance strain gauges cemented to the components under test, the signals from the gauges being fed through amplifiers to cathode-ray tubes which are continuously photographed on 35-mm. film.

There are, of course, several other instruments in everyday use on the proving ground but those mentioned will, perhaps, serve to show the type of equipment under development. Although there is still much to be done before the proving can be considered as fully comprehensive, a great deal of really useful work has been accomplished in the two years that the airfield has been at the disposal of the Association and already it has become an important part of the industry's research facilities. The number of firms using the ground is rising steadily and it is now commonplace for as many as 20 vehicles, ranging from large commercial vehicles to light cars, to be using the various tracks simultaneously. Development of the ground has been, and will continue to be, concerned primarily with the provision of facilities designed to reproduce the most exacting overseas conditions; the pavé track and dust tunnel are indicative of this policy. New features, extensions and additions are being planned, one of the more important of these being the provision of a high-speed circuit. Such a circuit would prove invaluable, and it is gratifying to learn that the plans for this project are sufficiently well advanced to justify the hope that it may be completed by the end of 1952.

As previously mentioned, the open day was arranged to give members of the Association an opportunity of viewing the progress made during the last two years, and of obtaining an impression of the type of work carried out. To give visitors a more definite idea, many of the member firms co-operated by providing vehicles and test drivers which were available for taking passengers over the different test courses. The arrangements made for visitors were excellent and if they represent a cross section of the Association's methods, the future of the proving ground would appear to be in safe hands.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

INDUSTRIAL EXHIBITION, GLASGOW.—Leading Scottish industrialists have ordered 20,000 tickets for the Exhibition of Industrial Power in Glasgow during the past few days. Sir James Lithgow, managing director of Lithgows, Ltd., who have bought 4,000, said that he was anxious for as many of his workmen as possible to see it. The Scottish Trades Union Congress have promised full support to the exhibition and have bought 1,000 tickets.

LOCOMOTIVE CONSTRUCTION.—The North British Locomotive Company, Glasgow, who recently completed a contract for 52 locomotives for the Nigerian State Railways, have been asked by the same purchasers to supply an additional seven locomotives of the same class. The value of the order is estimated at about 160,000*l.* Work on the 100 YP class locomotives which the company are building for the Indian Government Railways is expected to be completed next year.

ELABORATE GAS PLANTS.—Referring to the control of capital investment, Mr. David Beavis, controller, Edinburgh division of the Scottish Gas Board, addressing the final annual meeting of the Waverley Association of Gas Managers in Edinburgh recently, criticised "the expensive embellishments and excessive trimmings of some of the plants being installed to-day." Too often, he said, the Town and Country Planning Act was operated without regard for economics, but, in industrial development, economics came first.

FACTORY EXTENSION.—Work has begun on a large extension scheme to the Strathleven (Dumbarton) Scottish Industrial Estate clock-making factory of Westelox Ltd., the Scottish subsidiary of the General Time Corporation. Mr. R. Muir Glen, managing director, stated, on June 27, that it was planned to add, by next spring, 40,000 sq. ft. to the present space of 60,000 sq. ft., with a view to raising output by 50 per cent.

TUBULAR HEATING UNITS.—Radiation tubular heating units, mainly for export to the United States, and other countries, are to be manufactured by John Kerr and William Kerr, Ltd., heating engineers, Greenock. Mr. William Kerr, managing director of the firm, announced this on June 26, on his return from the United States, where he had negotiated a contract with a large firm of heating equipment manufacturers in New Jersey. About 2½ miles of tubing are expected to be produced every month.

RUBBER-WORKS EXTENSION.—Victoria Mill, one of the Dunlop Rubber Company's two factories in Dunfermline, is to be extended to increase the production of rayon fabric for tyres, and cotton fabric for colliery-conveyor belting, it was announced on June 29. The extensions will provide employment for an additional 120 persons.

CLEVELAND AND THE NORTHERN COUNTIES.

"CARGO FLEET" PLANT-BUILDING PROGRAMME.—Early next year the Cargo Fleet Iron Co., Ltd., Middlesbrough, expect to have in operation a scheme for making the works entirely self-supporting. The programme includes the erection of a blast furnace which will be the largest on Tees-side, a battery of coke ovens and an up-to-date steel plant. The blast furnace will be capable of increasing the pig iron supply by some 4,000 tons a week and the new steelworks will have a weekly output capacity of 2,000 tons.

CONSTRUCTION OF GOODS WAGONS.—Delays due to the shortage of railway wagons have been the subject of comment in this column on several occasions, and the efforts made by a Tees-side firm to increase the stock of wagons at the disposal of the British Railways are, therefore, of some interest. The Tees Side Bridge and Engineering Works, Ltd., Middlesbrough, are at present producing 16-ton all-welded steel wagons for the British Railways at a rate of 30 a week. In addition, five 42-ton bogie-bolster wagons for the conveyance of long steel plates, rails and sections are being turned out every week.

MINING SUBSIDENCE IN COUNTY DURHAM.—Many acres of farm lands in the north-western and central regions of County Durham are badly affected by mining subsidence and a delegation of representatives of the National Farmers' Union, which made a tour of inspection of the area on June 27, is to place the matter before the Government. It is stated that not only are large areas lost for food production, but many fields are water-logged or are unsafe for cattle.

AFFORESTATION IN CLEVELAND.—Plans for the planting of trees on 75,000 acres of land in Cleveland, during the next 20 years, form part of the national programme of the Forestry Commission. Some 44,000 acres of land are already in the possession of the Commission, and, of this area, upwards of 20,000 acres have been, or are about to be, planted with young trees. The purchase of another 18,000 acres of land is under negotiation.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL POSITION WORSENING.—The reduced production of steel caused by the shortage of melting materials has led to about 600 men of the United Strip and Bar Mills, Sheffield, being put on short time. By using stocks it was possible, for a while, to maintain a 15-shift rate of working, but, now, there has been a fall to a 12-shift basis. The steel shortage is affecting many firms in Sheffield, and elsewhere which use steel in strip and bar form to make a wide variety of essential products. The United Strip and Bar Mills are a branch of the United Steel Companies.

RISING GAS CONSUMPTION.—Doncaster is using between 25 and 30 per cent. more gas than two years ago, largely owing to heavier industrial requirements. Provided the pipes are available, it is intended to lay a new main for conveying gas from the new gasworks at Greasborough, Rotherham, to Doncaster. This would obviate any large-scale extension at Doncaster. The pipeline will be eleven miles in length.

AN AERODROME A NECESSITY.—At a public inquiry at Sheffield into the scheme for an airfield site at Redmires, on the outskirts of Sheffield, it was stated that the absence of an airfield is having a serious effect on the city's trade. Foreign businessmen, it was asserted, by-pass Sheffield because there is a lack of airport facilities. Moreover, the senior vice-president of the Sheffield Chamber of Commerce, Mr. W. G. Ibberson, said the state of the markets made it necessary for Sheffield businessmen to increase their visits to foreign countries to secure orders. The scheme is opposed by hospital authorities on account of the proximity of hospitals to the site.

PIT-HEAD LAUNDRIES.—The Yorkshire miners' leader, Mr. J. A. Hall, who is a member of the National Welfare Commission, states that he intends to press the idea of encouraging miners' wives to send their weekly wash to pit-head laundries. All the facilities are available, namely, fuel, steam and water and to use these facilities to the fullest extent, he contends, would be common-sense economy. The project is being tried out in a small way in counties other than Yorkshire but, so far, it has been confined to clothing which men soil at their work. There is nothing, he states, to prevent welfare authorities from spending money on such schemes.

THE MIDLANDS.

THE LATE MR. F. O. EVERARD.—The death has occurred, at the age of 81, of Mr. F. O. Everard, who was for many years works executive director of Bellis & Moreom, Ltd., Birmingham. Mr. Everard was apprenticed in 1886 to the founder of the firm, G. E. Bellis, and became works executive director in 1915. He retired in 1948, and his old position is now held by his son, Mr. F. Vincent Everard.

INDUSTRY AT WOLVERHAMPTON.—A Committee of the Wolverhampton Chamber of Commerce have been studying the development plan prepared by Wolverhampton Corporation under the Town and Country Planning Act, and have now issued a report on the subject. According to the report, 820 acres in the borough are zoned for industrial purposes. About 100 acres of this industrial zone are undeveloped, but half this land is owned by industrial concerns, and will be needed by them for development. The Committee estimate that industry requires in all about 844 acres, and state that during the next five years requirements for industrial land will have to be met from outside the borough boundaries. The development plan has defined certain zones as residential which contain a few factories, and it is expected that, in due course, these industrial establishments will have to be removed. The Chamber of Commerce has advised firms so situated not to make any alterations in their premises without first seeking the advice of the Borough Engineer.

CO-OPERATION BETWEEN INDUSTRY AND SCHOOLS.—The Wednesbury, Darlaston and District Manufacturers' Association have introduced a scheme to give increased facilities for school masters to obtain information concerning local industries. Arrangements have been made for teachers from Wednesbury, Darlaston, Bilston, Wednesfield and Willenhall to take a special three-day course at local factories. They will spend the first two

days at two different factories, and the last day will be taken up with shorter visits to two more. The factories chosen will be of different types and will give the teachers a broad outline of local industrial processes and methods. It is expected that they will be able, as a result of these visits, to pass on to their pupils first-hand information, and to assist boys about to leave school in the choice of an occupation. The course will be run experimentally this year, but if reports from the factory managements and the teachers are satisfactory, it will probably be extended considerably in 1952.

NEW STORM-WATER CULVERT.—To enable Tipton Council to develop an area of derelict land for housing purposes a new 5-ft. diameter storm-water culvert has been made under the Wolverhampton Level of the Birmingham Canal near Tipton Green. This canal, half a mile of which was drained for the work to be carried out, serves a large industrial area, and the contractors for the drainage scheme undertook to complete the work in ten days, a penalty of 100*l.* a day being imposed for any extension of the time agreed upon. The culvert, the biggest so far made in Tipton, is 342 yards long and is at a depth of 24 ft. below the bed of the canal. The work has been completed as planned, and the canal is now back in service.

PROFIT-SHARING SCHEME.—The Electric Construction Co., Ltd., of Bushbury, Wolverhampton, which introduced a profit sharing scheme in 1950, has announced that employees entitled to participate in the scheme will receive payment at the rate of 1*s.* 8*d.* in the pound on the wages (excluding cost-of-living bonus) which were paid last year.

CHAINMAKERS' WAGES.—The Chainmakers' and Strikers' Association has been negotiating with the manufacturers for a rise in wages. After some discussion, during which both sides put forward proposals, agreement was reached for an increase of 10 per cent. The rise will be national, but as the greatest number of chain works are in the Black Country, the effect will be most noticeable in that area.

SOUTH-WEST ENGLAND AND SOUTH WALES.

OPERATIONS OF THE COAL BOARD SOUTH-WESTERN DIVISION.—The loss sustained in the operation of the collieries in the South-Western Division Coal Board area, in the first quarter of this year, was nearly double the profit made in 1950. The National Coal Board statistics show that, in the first three months of 1951, there was a loss of 402,370*l.*, or 1*s.* 3*d.* on each of the 6,303,637 tons produced. Over the whole of 1950 there was a profit of 217,442*l.*, equivalent to 2*d.* per ton. The Forest of Dean Coalfield made a loss, in the first quarter of 1951, of 6*s.* 9*d.* per ton and the Somerset coalfield one of 19*s.* 3*d.* per ton. The loss, in South Wales and Monmouthshire, was 212,539*l.*, equal to 8*s.* 5*d.* per ton. The chief factor to account for the loss was the increase in wages—the average weekly wage in the Division (including allowances in kind) has risen from 8*l.* 9*s.* 11*d.* in 1950 to 9*l.* 13*s.* 8*d.* this year.

OPEN-CAST COAL OPERATIONS.—According to a Ministry of Fuel and Power statement, more than 7,000,000 tons of good-quality coal, including more than 2,500,000 tons of anthracite, have been produced by open-cast operations in Wales since they were begun in 1943.

SWITCHGEAR MANUFACTURE AT BRIDGWATER.—To cope with the greatly increased volume of orders received, arrangements have been made to transfer the production of Foster switchgear from the Wimbledon factory of Foster Transformers & Switchgear Ltd. (a company in the Lancashire Dynamo Group), to Crypton Equipment Ltd., another factory in the Group. The Crypton factory, at Bridgwater, Somerset, which is newly-built on a seven-acre site, can provide the increased production space that these developments demand and can also offer scope for extensions.

WHITFORD TIN-PLATE WORKS.—Following the decision to close the Whitford tin-plate works at Briton Ferry, which employed 300 men, the Port Talbot town council is to urge a joint approach with other local authorities concerned to secure an alternative industry to absorb the redundant labour.

EMPLOYMENT IN WALES.—Employment in the South Wales ship-repairing industry is now about 1,000 more than in 1939, Sir Percy Thomas, chairman of the Welsh Board for Industry, has told a meeting of the Board. The majority of the men, he said, were engaged on Admiralty work, of which very little was done in the district before the war. There were 679 outstanding vacancies in the engineering, ship-repairing and electrical trades. The total of 22,739 persons unemployed in Wales, at May 21 last, was a record for peacetime.

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.

ROYAL SANITARY INSTITUTE.—*Beverley*: Thursday, July 12, 10 a.m., The Art Gallery, Beverley Library, Beverley. "Human Problems in the Tanning Industry," by Dr. E. H. Thierry.

INCORPORATED PLANT ENGINEERS.—*Newcastle-upon-Tyne Branch*: Thursday, July 12, 7.30 p.m., Roadway House, 8, Oxford-street, Newcastle-upon-Tyne. "Oil in Industry," by Mr. I. A. Howden.

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

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.

Motors for Battery-Operated Road Vehicles and Industrial Trucks.—In view of the increasing use of battery-operated vehicles, the Institution has prepared and published a specification, B.S. No. 1727, covering the motors for such vehicles. It concerns the classification, rating and methods of test for direct-current electric motors forming part of the equipment of battery-operated road vehicles, industrial trucks and tractors, but does not apply to rail vehicles. The specification contains details regarding types of motor, temperature tests, over-speed tests, commutator tests, high-voltage tests, and efficiency, performance and type tests. The appendices include data on the classification of insulating materials, methods of determining efficiency, terminal markings, and recommended limits of temperature in service. [Price 3s., postage included.]

Enamelled Round Copper Wire.—A third revision of B.S. No. 156, covering enamelled round copper wire insulated with oleo-resinous enamels, has been issued. The specification was first published in 1922 and it was revised for the first time in 1932 and for the second time in 1936. A further edition, entitled "Enamelled High-Conductivity Annealed Copper Wire," was published in 1943. The present issue differs from this in that it has been extended to include the full range of wire sizes from 0.001 in. to 0.160 in. diameter inclusive. The specification contains details of wire diameters and resistances, and the thickness of the enamel (including tolerances), together with tests on the enamel insulation. The latter relate to hardness, flexibility and adherence, heat shock, cold test at 0 deg. C., heat ageing and electric strength. [Price 3s., postage included.]

CONTROL OF ALLOCATION OF STEEL, COPPER AND ZINC.—A statement on three measures, decided upon by the Government, for the control of the use of scarce metals was made in the House of Commons on June 28 by the Chancellor of the Exchequer. In the first place, he stated, allocation schemes were being prepared for iron and steel (other than sheet steel and tin-plate, which were already subject to allocation) for introduction as soon as possible, and corresponding measures to regulate the distribution of the more important of the scarce non-ferrous metals would also be worked out. Secondly, since it would take some time to get these schemes introduced and working effectively, a "Defence Order," or "D.O.," symbol would be applied, by Government decision, to orders for specialised defence equipment or work. The quotation of this, with the contract number, would entitle the contractor or sub-contractor to obtain steel and copper, zinc and their alloys. In the third place, various categories of civilian production must be safeguarded and a scheme, for which the symbol "P.T.," indicating "Preferential Treatment" would be used, would enable departments to deal with particularly difficult obstacles to important production.

LAUNCHES AND TRIAL TRIPS.

S.S. "BRITISH REALM."—Single-screw oil tanker, with accommodation for twelve passengers, built and engaged by the Fairfield Shipbuilding and Engineering Co., Ltd., Govan, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 610 ft. between perpendiculars by 81 ft. by 44 ft. 6 in.; deadweight capacity, 28,100 tons on a summer draught of 34 ft. Impulse-reaction steam turbines with double-reduction articulated gearing, developing 13,750 s.h.p. at 112 r.p.m., and two Foster Wheeler water-tube boilers. Speed, 15½ knots in service. Launch, June 7.

M.S. "CHARLTON VENUS."—Single-screw oil tanker, built and engaged by William Doxford & Sons, Ltd., Sunderland, for the Charlton Steam Shipping Co., Ltd. (Managers: Chandris (England), Ltd.), London, E.C.3. Main dimensions: 505 ft. by 69 ft. 9 in. by 39 ft.; deadweight capacity, 16,500 tons on a draught of 30 ft. Doxford five-cylinder opposed-piston oil engine developing 6,450 b.h.p. at 117 r.p.m. and a service speed of 14 knots. Launch, June 19.

M.S. "SHANKLIN."—Twin-screw vessel with accommodation for 1,400 passengers in one class, mails and general cargo, built and engaged by Wm. Denny and Brothers, Ltd., Dumbarton, for the Portsmouth/Ryde ferry service of the Southern Region of British Railways. Third vessel of a series of three. Main dimensions: 200 ft. overall by 46 ft. by 10 ft. 6 in. to main deck; draught, 7 ft.; gross tonnage 965. Two Denny-Sulzer eight-cylinder two-stroke trunk-piston Diesel engines, together developing 1,900 b.h.p. at 375 r.p.m. Speed, 14½ knots. Went into service on June 18.

M.S. "JACKY."—Single-screw trawler, built by John Lewis & Sons, Ltd., Aberdeen, for E. Nickerson & Co., Ltd., Grimsby. Second vessel of a series of four. Main dimensions: 120 ft. between perpendiculars by 25 ft. by 12 ft. 6 in.; fishroom capacity, 7,000 cub. ft.; gross tonnage, about 300. Mirreless six-cylinder direct-drive and reversing oil engine, developing 650 b.h.p. at 250 r.p.m., constructed by Mirreless, Bickerton & Day, Ltd., Stockport, Cheshire. Speed in service, 11½ knots. Launch, June 19.

M.S. "ATHELTEMPLE."—Single-screw tanker for carrying molasses in bulk, built by Joseph L. Thompson & Sons, Ltd., Sunderland, for the Athel Line, Ltd., London, W.1. Main dimensions: 465 ft. between perpendiculars by 63 ft. 3½ in. by 35 ft. 10 in.; deadweight capacity, 12,875 tons on a draught of 28 ft. 3 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 4,350 b.h.p. at 112 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 12½ knots. Launch, June 19.

M.S. "BRITISH MAPLE."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for the British Tanker Co., Ltd., London, E.C.2. Second vessel of an order for two. Main dimensions: 463 ft. 5½ in. by 61 ft. 9 in. by 34 ft. 1 in.; deadweight capacity, 12,160 tons on a draught of 27 ft. 7½ in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 3,100 b.h.p. at 105 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Speed, 11½ knots. Launch June 19.

M.S. "STAVIK."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Aktieselskapet Hav and Aktieselskapet Havtank (Managers: Helmer Staubo & Co.), Oslo, Norway. Main dimensions: 465 ft. between perpendiculars by 63 ft. 6 in. by 36 ft. 3 in.; deadweight capacity, 13,575 tons on a draught of 28 ft. 1½ in.; gross tonnage, 8,842; capacity of oil tanks, 623,900 cub. ft. Wallsend-Doxford four-cylinder opposed-piston two-stroke Diesel engine, developing 3,750 b.h.p. at 100 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 12½ knots. Trial trip, June 20.

M.S. "PORT TOWNSVILLE."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Port Line, Ltd., London, E.C.3. Main dimensions: 460 ft. by 64 ft. 6 in. by 41 ft. 6½ in.; deadweight capacity, 10,700 tons on a draught of 28 ft. 8½ in.; gross tonnage, 7,500; cargo space, 312,000 cub.ft. insulated and 295,000 cub. ft. uninsulated. Wallsend-Doxford six-cylinder opposed-piston reversible oil engines, developing 7,500 b.h.p. at 114 r.p.m., constructed by the Wallsend Slipway and Engineering Co. Ltd., Wallsend-on-Tyne. Speed, 15½ knots. Launch, June 21.

S.S. "CAPE BRIER."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for the National Sea Products, Ltd., Halifax, Nova Scotia. Main dimensions: 137 ft. between perpendiculars by 26 ft. 6 in. by 13 ft. 9 in.; gross tonnage, 365. Triple-expansion steam engines, developing 700 i.h.p. at 125 r.p.m., and one oil-burning boiler, constructed by Amos and Smith, Ltd., Hull. Launch, June 21.

PERSONAL.

LORD HYNDLEY, G.B.E., chairman of the National Coal Board, retires on July 15. As from August 1. **SIR HUBERT HOULDSWORTH, K.C.**, D.Sc., chairman of the East Midlands Division of the Board, will be chairman and **MR. W. J. DRUMMOND** and **SIR ERIC COATES**, deputy chairmen. The full-time members are to be **MR. EBBY EDWARDS**, **SIR CHARLES ELLIS, B.A., Ph.D., F.R.S.**, **SIR GEOFFREY VICKERS, V.C.**, and **SIR ANDREW BRYAN, B.Sc., M.I.Min.E., J.P., F.R.S.E.** The part-time members are **MR. J. H. HAMBRO**, **SIR GEOFFREY HEYWORTH**, **MR. GAVIN MARTIN**, **SIR GODFREY MITCHELL** and **ALDERMAN S. JONES**.

SIR CHARLES LILLICRAP, K.C.B., M.B.E., M.I.N.A., Director of Naval Construction, Admiralty, is retiring on September 30. His successor is to be **MR. V. G. SHEPHEARD, M.I.N.A.**, who has been deputy Director of Naval Construction since 1947.

MR. H. G. IVATT, M.I.Mech.E., chief mechanical engineer, London Midland Region, British Railways, retired on June 30 after 47 years of railway service.

MR. W. F. PARKER, M.I.E.E., has been elected national chairman of the Association of Supervising Electrical Engineers, 54, Station-road, New Barnet, Hertfordshire. **MR. L. L. EMMETT** has been elected vice-chairman and **MR. E. J. SUTTON** has been re-elected honorary treasurer.

DR. NICOL GROSS, A.M.I.Mech.E., has been appointed assistant director of research of the British Welding Research Association, 29, Park-crescent, London, W.1, but will remain in charge of the research station at Abingdon. **DR. K. WINTERTON, B.Sc.**, and **MR. H. E. DIXON, M.Sc., A.I.M.**, have been appointed chief metallurgists, the former for ferrous metals and the latter for non-ferrous metals. **MR. C. L. M. COTTRELL, M.Sc.**, and **MR. P. T. HOULDCROFT, B.Sc.**, have been appointed assistant chief metallurgists for ferrous and non-ferrous metals, respectively.

Consequent upon the death of **MR. E. H. W. COOKE**, **MR. LEWIS CHAPMAN**, managing director of William Jessop and Sons, Ltd., Sheffield, has been appointed chairman of the Birtley Co., Ltd., Birtley, Co. Durham.

The board of Drysdale and Co., Ltd., Bon-Accord Works, Yoker, Glasgow, W.4, have appointed three additional directors. **MR. F. J. B. HENDERSON, B.A. (Cantab.)**, is chief of the purchase department and material and supply officer; **MR. C. H. CARSLAW, B.Sc. (Glas.)**, A.M.I.Mech.E., is technical director; and **MR. T. L. MACKIE, A.I.Mar.E.**, is sales director.

The Iron and Steel Corporation of Great Britain announce that **MR. F. SCOPES** has been appointed director and chairman of the Kettering Iron and Coal Co., Ltd., Kettering, in succession to **MR. JAMES GOUGH**, who resigned recently. **MR. Scopes** has also been appointed chairman of the New Cransley Iron and Steel Co., Ltd., Kettering, in succession to **MR. H. J. ELLISON**, who has retired from the positions of chairman and managing director. The latter position has now been taken up by **MR. G. H. JOHNSON**. **MR. EDWARD WITHERINGTON** and **MR. N. W. FISCHER** have retired from the board of **GLYNHUR TIN PLATE CO., LTD.**, Pontardulais, Glamorgan; **MR. W. S. G. REES** has been appointed chairman and **MR. O. J. THOMAS**, **MR. IVOR LEWIS** and **MR. E. ARTHUR WITHERINGTON** have been made directors.

MR. G. W. STEVENSON has been made manager of a new branch office opened by Musgrave and Co., Ltd., St. Ann's Works, Belfast, at 297, Hagley-road, Birmingham, 17.

MR. L. WATSON, secretary and accountant, and **MR. E. C. FARRER, M.C., A.M.I.Mech.E.**, manager of the firm's Northern office, have been appointed to the board of Hydraulic Coupling and Engineering Co., Ltd., Fluidrive Works, Worton-road, Isleworth, Middlesex.

CAPTAIN H. J. CAVILL, O.B.E., general labour superintendent of the Shipping Federation, 52, Leadenhall-street, London, E.C.3, retired at the end of June, on reaching the age of 65.

MR. J. D. MILLNER, formerly of the South London branch of Ferodo Ltd., Chapel-en-le-Frith, Stockport, has been made manager of the North London Depot, at Handel-street, W.C.1, consequent upon the resignation of **MR. L. A. POTTER**. **MR. E. B. KNEE**, of the firm's Bristol branch, is to be the new manager of the South London branch, and the new manager of the Bristol branch is to be **MR. F. E. PERRYMAN**.

DUNLOP COTTON MILLS, LTD., Rochdale, are to establish a factory in Londonderry, Northern Ireland, for the production of rayon cord to be used in the manufacture of rubber tyres of all types.

E. H. JONES (MACHINE TOOLS), LTD., have been appointed agents for Great Britain and Eire for the range of A-I machine tools produced by **Artillerie-Inrichtingen, Ltd.**, Hembrug, Zaandam, Holland.

THE COAL UTILISATION JOINT COUNCIL have removed their offices to 3, Upper Belgrave-street, London, S.W.1. (Telephone: SLOane 9116.)

CARMARTHEN BAY POWER STATION.



FIG. 1. GENERAL VIEW OF SITE.

NEW POWER STATIONS FOR THE B.E.A.: XIX—CARMARTHEN BAY.

THE Carmarthen Bay power station of the British Electricity Authority, an aerial view of which is reproduced in Fig. 1, is situated in the South Wales Division at Burry Port. The necessary excavation and construction work, for which Messrs. Balfour, Beatty and Company, Limited, 66, Queen-street, London, E.C.4, were the contractors, was carried out below the water level table, so that a temporary de-watering system had to be laid down.

Coal will be brought to the station by rail, and after tipping will be taken to the boiler house by two sets of conveyors, each of which will have a capacity of 75 tons per hour. Facilities will also be provided for taking coal to and from a stock pile which has a capacity of nearly 100,000 tons. After pulverising, the coal will be burnt in three boiler houses containing a total of 13 boilers, five of which are at present being installed. Each of these boilers will supply steam at a pressure of 950 lb. per square inch and a temperature of 925 deg. F. The flue gases will be cleaned in Pratt-Daniels dust collectors and Sturtevant precipitators.

The generating plant at present being erected consists of two 52.5-MW Metropolitan-Vickers sets, but three further 60-MW units, with hydrogen-cooled alternators, are to be installed. These sets will generate at 11.8 kV, the voltage being stepped up to 132 kV in 63-MVA transformers, which are being manufactured by Asea Electric Company, Limited, Walthamstow, London, E.17. These transformers will be connected to an adjacent switch-house in which air-blast switch-gear provided by Messrs. Ferguson Pailin, Limited, Manchester, will be erected. Fig. 2 shows the exterior of No. 1 turbine room with the steelwork of the associated boiler house, while the interior of the turbine room is illustrated in Fig. 3.

The condensers will be cooled by sea water drawn from the Burry estuary by Vickers-Armstrongs vertical-spindle axial-flow pumps, each of which will have an output of 53,000 gallons per hour. Three of these pumps are now being installed; one of them will be driven by a constant-speed motor and two by variable speed motors. They are being installed in a deep-level house on the foreshore.

The five-stage feed-heating system will consist of Metropolitan-Vickers equipment and will give a final temperature of 365 deg. F. There will be four feed pumps, three of which will be electrically-driven and one steam driven; the capacity of each will be 550,000 lb. per hour against a pressure of 1,250 lb. per square inch. The electrically-driven pumps are being manufactured by the Harland Engineering Company, Limited, and the steam-driven pump by Messrs. G. and J. Weir.

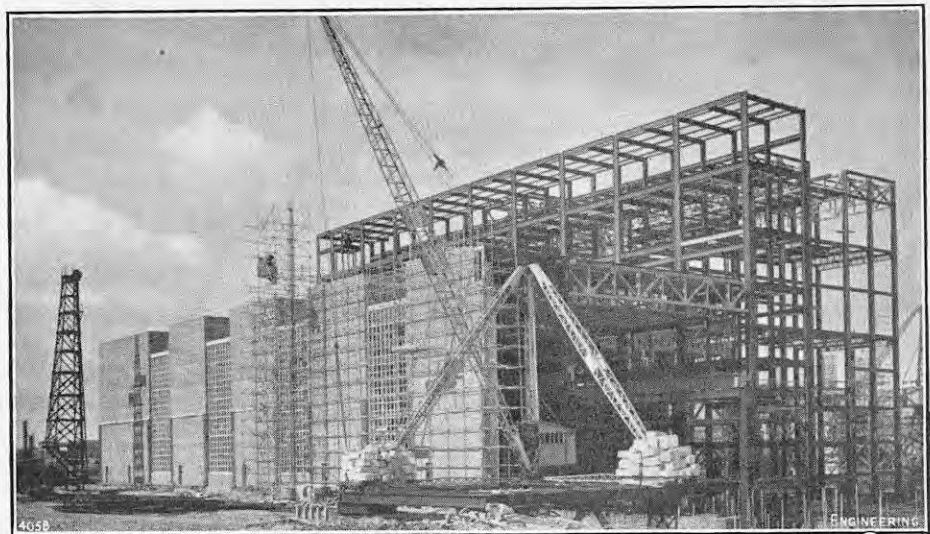


FIG. 2. TURBINE-ROOM AND BOILER-HOUSE FRAMEWORK.

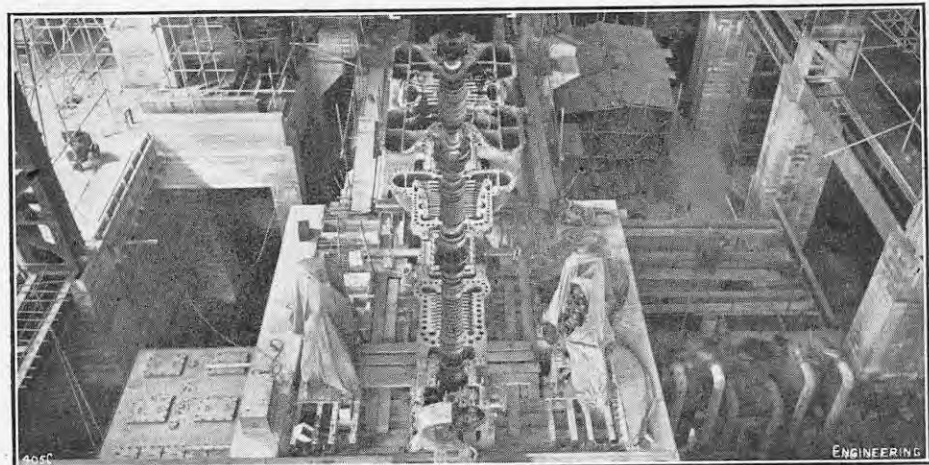


FIG. 3. INTERIOR OF TURBINE ROOM.

ENGINEERING,

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LONDON, W.C.2.

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

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Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30s. per inch. If use is made of a box number the extra charge is 1s. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33½ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

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ENGINEERING

FRIDAY, JULY 6, 1951.

VOL. 172.

No. 4458.

THE NAVAL ARCHITECTS' CONFERENCE.

By the time that this issue of ENGINEERING is in the hands of readers, the International Conference of Naval Architects and Marine Engineers will be nearly over; it concludes in Newcastle-on-Tyne to-day, and to-morrow those members and delegates who are returning to London, where the Conference began on June 25, will be travelling south by a special train, to disperse among the 14 or 15 countries from which they came. It is amply evident that, from both the technical and the social points of view, the Conference has been gratifyingly successful. The papers preserved an excellent balance between the scientific and the descriptive; the various visits, dinners and other functions have reached a commendably high standard of general interest and smooth organisation; the weather has been reasonably kind—an important factor in contributing to the success of any gathering of this sort; and—most important of all—the ties of a common purpose, which have always been notably strong among the fraternity of those whose business is with the construction and operation of ships, have been reinforced in a way that must prove of enduring benefit to all those concerned.

In two respects, the Conference was unfortunate—namely, in the enforced absence, for reasons of health, of Admiral of the Fleet Viscount Cunningham, President of the Institution of Naval Architects, and of Professor Gilbert Cook, President of the Institution of Engineers and Shipbuilders in Scotland. The place of Lord Cunningham—who, we understand, is making satisfactory progress towards recovery—was excellently filled, however, by his successor-elect, Viscount Runciman; and there was equal satisfaction in the news that Professor Cook, who had to undergo a serious

operation with very little warning—had recovered sufficiently to return from hospital to his home in Helensburgh, where he was saluted by the Conference party on their way down the Clyde in the historic steamer King Edward.

All four of the professional societies which collaborated in the organisation of the Conference—the Institution of Naval Architects, the Institute of Marine Engineers, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders—possess an appreciable proportion of members who are domiciled overseas, and it was a happy decision, therefore, to hold these meetings in the Festival year and to show them that, despite economic and other difficulties, the shipbuilding and marine engineering industries in England, Scotland, and Ireland (for a strong contingent paid a visit by air from the Clyde to the Harland and Wolff shipyard at Belfast) are in a commendably flourishing condition. The historical connection with 1851 afforded a good opportunity to review the great contributions that Britain has made to the science and the practice of both ship construction and marine-engine building; some of which are occasionally in some danger of being forgotten, merely because they have been so generally adopted. At the same time, the papers from overseas delegates have come as a timely reminder of how thoroughly other nations have assimilated this knowledge and experience.

The paper which, perhaps, was the most eagerly awaited was that on the resistance experiments carried out with the former Clyde paddle steamer Lucy Ashton. No discussion that could have been compressed into the time available could possibly have done more than provide a sample from the vast field of inquiry that the trials opened up for exploration. The complementary papers which will follow, in due course, the lead set by Sir Maurice Denny will be awaited with an interest no less keen; and the complete series promises to equal in importance the pioneer work of William Froude himself. In this highly original method of testing, Britain undoubtedly has led the world, and great credit is due to Dr. S. Livingston Smith, the Director of the British Shipbuilding Research Association, from whom emanated the original proposal to use jet engines for propulsion, thus avoiding all the uncertainties which have complicated the application of Froude's work in actual design work.

The papers on "Higher Steam Conditions for Ships' Machinery" and "Boiler and Turbine Testing" were usefully complementary, the former showing clearly the factors limiting further advances in steam temperature and pressure, and the progress made in various countries to raise the limits; and the latter paper indicating, as fully as security requirements permit, the amount of research work needed to solve the problems that further advances entail, and the facilities available in this country for that purpose. Incidental details brought out by this paper are the cost of large-scale testing of propelling machinery—something in the region of 100,000*l.* in the case of the destroyer machinery tested at the Pametrada station at Wallsend—and the fact, obvious enough, but not always remembered, that "as machinery advances, the margins in design become less" and the cost of each further improvement, in effort even more than money, progressively greater. The paper on "Marine Fuel Oils" indicated, moreover, the need to seek steadily for means to utilise fuels of something less than optimum quality; particularly, perhaps, the use of oils with relatively high sulphur content.

The paper on "Ship Motions," apart from its merits as a contribution to knowledge of that subject, was a useful reminder that it is still possible to do research that is worth while, without entailing the immense capital expenditure represented by large and super-accurate equipment such as the newer tanks at Teddington, Carderock and elsewhere.

The tank at Newport News is only 56 ft. long and 8 ft. wide, and the models in it are towed by the relatively simple device of a falling weight; but the work described in the paper covered a wide field, and the results obtained are such as to suggest the utility of exploratory small-tank work as a preliminary to more elaborate research in the larger tanks. The next stage, of course, is the comprehensive full-scale testing of ships at sea, and a scheme to carry this a stage beyond anything hitherto attempted was contained in the paper on a "Proposed Design for a Combined Research, Training and Cargo Ship."

The final paper of the eight read in London—that on "Some Aspects of Pre-fabrication in Ship Construction"—brought into discussion a subject that is probably exercising the minds of most shipbuilders of more than minor craft. The fact that some shipyards are finding it advisable to reduce (and even to halve) the number of their berths in order to make full use of welded construction, while others, apparently, have decided that such drastic measures are unnecessary or, at least, are not yet economically justifiable, indicates how varied are local conditions and how numerous the possible combinations of facilities and circumstances. The paper is of particular value as being a record of actual achievement. The same may be said, in a somewhat different connection, of the paper read in Newcastle on "U.S. Fleet Maintenance and Battle-Damage Repairs in the Pacific during World War II." With careful restraint, the author observed that "it is doubtful whether the combined productive capacity of the United States and her Allies" could have provided and maintained enough ships to defeat Japan if they had had to depend on their home shipyards and dockyards. If, unhappily, there should be a World War III, it is tolerably certain that they will not be able to depend on such facilities, but will have to rely on their own efforts and equipment for repairs to an even greater extent. It will be more than ever necessary, in such circumstances, that avoidable injury to propelling machinery shall, in fact, be avoided in the design stage, and some of the ways of doing so were described in the concluding paper, on "Stresses in Propellers and Propeller Shafting under Service Conditions."

In conclusion, some reference should be made to one unfortunate experience in the course of a Conference which, in other respects, has proceeded with a more than ordinary absence of minor *contretemps*. Efficient transport is one of the most important factors contributing to the comfort and pleasure of such an occasion, and it is regrettable, therefore, to record that organisers and members alike were badly "let down" by British Railways. It was an error of somebody's judgment, in the first place, to decide that third-class accommodation would be good enough on the special train which took the members on their tour to Scotland and the North-East Coast, but that does not absolve British Railways from blame for having provided such elderly, dirty and ill-equipped rolling stock. The locomotive was so begrimed that its colour was actually indistinguishable; the lavatory compartments were a disgrace—in some, the water tanks were nearly empty at the start; the train bore no distinctive label except a number on the engine, so that ordinary passengers boarded it at Crewe and had to be induced, with some difficulty, to alight again—at which some, including one who boasted himself "a railway official," were decidedly offensive; and the timing was leisurely in the extreme. Last year's World Power Conference had provided a foretaste of such treatment, but we did not expect it to be repeated this year, in still more objectionable form. It may be that British Railways are anxious to discourage the use of special trains; but, if so, they might at least make an exception in the case of an international conference of such importance.

CAPITAL EXPENDITURE ON BRITISH RAILWAYS.

Two major problems face the railways of this country: the drift of employees to more congenial jobs and the restriction on capital expenditure. Both are symptomatic of the same fact, namely, that the nation is neglecting its railways. A policy of full employment, in which the practical freedom of choice of work is more widespread than it has ever been, is having the effect of denying the railways adequate man-power, since the traditional advantage of security of employment is no longer regarded as peculiar to railways; neither are the pay and conditions and hours of work specially attractive. Moreover, no artificially-created inducement, such as exemption from National Service in the Armed Forces, is operating to redress the balance. This trend in employment is not due to any declared policy but is the natural outcome of the circumstances, whereas the restriction on capital expenditure is a deliberate policy of the Government. It is difficult to see how any action on the part of the Government could satisfactorily solve the man-power problem, though a decision to increase capital expenditure might indirectly have the desired effect since, apart from the scope for greater work, the morale of railwaymen would benefit if they knew that great efforts were being made to raise the efficiency of the undertakings.

Since the Labour Government took office in 1945, the railways have not fared very well in matters of priorities or other special treatments, and it is not surprising that railwaymen, by transferring to other industries, are disproving the once-popular socialist theory that men would be happier in their work in a nationalised industry. A bold policy of capital investment has rightly been pursued in the coal mines, but the British Transport Commission have been fobbed off with cuts and postponements in their plans for rehabilitation and improvement. Immediately after the war, it was a question of planning the work of the nation and achieving a proper balance of trade; now, it is a question of rearmament.

The Government's *Economic Survey for 1950* devoted considerable space to capital investment in the railways of this country, the totals for which were given as 65l. million in 1948, 70l. million in 1949, and 79l. million in 1950, excluding running repairs to rolling stock and permanent-way repairs and maintenance. It was conceded that the effects of restrictions in investment would be severe. A year later, the *Economic Survey for 1951* hardly mentioned railways; there were sections on coal, electricity, steel, building, textiles, agriculture, etc., but not a word about railways except for a line, in a table of gross fixed investment in the United Kingdom, giving 287l. million for 1948, 324l. million for 1949, and 317l. million for 1950, in respect of the whole of transport and communications, "including ships and road goods vehicles, irrespective of the industry or service in which they are employed."

Little comfort was to be found in the annual report of the British Transport Commission for 1949, published in September, 1950: "notwithstanding representations made by the Commission that any further reduction [in capital investment] might have serious consequences upon the efficiency of the railways, the approved level of expenditure in 1950 was reduced to 92l. million"—the difference between that figure and the 79l. million given in the *Economic Survey for 1950* being due to the exclusion, in the latter, of permanent-way repairs, etc. The Commission stated that they could hope to do little more than preserve their undertaking in a reasonable working condition. There was no opportunity of making provision for the modernisation and re-equipment of railway termini and depots, which was clearly essential if inter-working between road

and rail services, in the interests of effective integration, was to be achieved.

Some slight though vague relief in the situation was afforded by the statement the Chancellor of the Exchequer made in the House of Commons on June 21. He explained that, owing to defence needs, there would be no increase in 1951 in the supplies of plant and machinery available for home industry, while in 1952 and 1953 there would have to be a substantial reduction, since more and more of the engineering industry would be producing armaments. He added, however, that investments in coal, electricity, gas, coke ovens, railways, roads and petroleum would be higher than in 1950. The statement was in very general terms, though it expressed a policy of far-reaching implications, but it is clear that experience has taught the Government the un wisdom of publishing a detailed investment programme; no doubt such a programme is worked out, but its implementation depends on other controls, such as allocations of steel and, as Mr. Gaitskell said, there is a great deal of uncertainty in view of the materials position and the impact of the defence programme.

What effect this revision of policy will have on the railways it is impossible to determine. All industries will be affected, of course, but there are strong grounds for the suspicion that the capital investment allowed to the railways is not based on an adequate assessment of the real transport interests of the country. A shortage of a basic commodity such as coal, or a basic measurable service such as electricity, is instantly apparent when it arises and is also largely predictable, but the inadequacy of transport is not so readily defined. Statistics are not a sufficient indication of the efficiency of transport, the true value of which is difficult to assess. It is, however, a major factor in the country's industrial capacity, especially at a time of rearmament, and transport users generally would be happier if it could be shown that the railways are being permitted a level of capital investment proper to the strained circumstances and urgent needs.

That this is the considered view of industry is shown by the fact that, in a memorandum lately addressed to the Ministry of Transport, the Association of British Chambers of Commerce have demanded a long-term plan of capital investment on a substantial scale in British Railways, to replace wartime wastage and enhance general efficiency. As Colonel B. H. Leeson remarked in the discussion on Mr. R. A. Riddles's paper at the Joint Engineering Conference, there is a tendency to say that this country or that could not afford developments in its railways, when it might be more correct to say that it could not afford not to have them. More money must be spent on the permanent way if the number and severity of speed restrictions are to be reduced; stations, termini and depots must be modernised if the efficiency of railway operation is to be raised to the essential level; electrification must be extended, provided it is agreed that no other form of motive power is likely to invalidate its advantages; and London Transport services must be enlarged if the work of a high proportion of the country's population is not to suffer. It is not sufficient to argue that present conditions do not permit these developments: rearmament, no less than unclouded peace, depends on the efficient transport of men and materials. Unfortunately, if there is wrestling in high places over the railways' needs, there is little evidence of it in published statements or reports. The last annual report of the British Transport Commission stated that "in all matters relating to the control of capital investment the closest contact is maintained with the Minister, and the Commission have received every possible assistance from him and his officers within the strict limitations imposed." It is to be hoped that the next annual report, which will be published shortly, will reveal a more pugnacious attitude.

NOTES.

RESEARCH LABORATORIES OF THE SIMON GROUP.

A NOTABLE addition to the research laboratories owned and operated by British industrial organisations was inaugurated on Tuesday of this week when Sir Henry Tizard, G.C.B., A.F.C., F.R.S., Chairman of the Advisory Council on Scientific Policy, opened the new 250,000l. research and development buildings of the Simon Engineering Group, at Cheadle Heath, Stockport. Speaking on the value of research, Sir Henry said it was sometimes thought that only large concerns could afford research. The truth was that no firm could afford not to do research. Those who argued against large-scale research sometimes pointed to Parsons' invention of the steam turbine. Parsons, however, could not have invented the turbine without his sound knowledge of thermodynamics—a science which was fundamental in industry—and his background of engineering experience. Inventions often depended on research done considerably earlier, but new knowledge was always needed and the recent spectacular advances in the gas-turbine field would have been impossible without simultaneous intensive research. Lord Simon of Wythenshawe said that although the Simon Group had undertaken research for many years, it had been recognised that such work must be done on a new scale if the company was to continue to compete successfully in foreign markets. In the past, customers such as Messrs. Imperial Chemical Industries, Limited, had helped by constructive criticism of plants designed for them by the company. He hoped that new customers, such as the National Coal Board and the British Electricity Authority, would do the same. Lord Simon announced that Messrs. Simon-Carves, Limited, had been appointed main contractors for the United Sulphuric Acid Corporation's 3,500,000l. plant at Widnes, to produce sulphuric acid from anhydrite, and were acting in the same capacity for the I.C.I. 1,500,000l. anhydrite scheme at Billingham.

LONDON DEVELOPMENT PLAN.

The Town and Country Planning Act, 1947, required the London County Council to submit a scheme to what is now the Ministry of Local Government and Planning, which would serve as a guide to all the building activities of the Council, local authorities, organisations and private developers for the next 20 years. This task, which is being carried out in consultation with all those concerned, is being performed in seven stages, of which four, covering surveys, the preparation of town maps, consultation with other bodies and reconsideration of the maps in relation to individual subjects, such as density of population, education and housing, have already been completed. The sixth and seventh stages will comprise further consultations with the City Corporation and Metropolitan Borough Councils and the presentation of the plan to the Minister at the end of the present year. Meanwhile, a report covering the fifth stage of the plan was presented by the Town Planning Committee to a meeting of the London County Council on Tuesday, July 3. It comprises four main documents: a town map, illustrating the proposals for the use of land; a programme map, which gives a broad indication of the work which it is expected will be substantially completed during the first five and following 15 years; and two statements containing factual descriptive information and an analysis which is intended to serve as a basis for discussion on the problems which have arisen. According to the report submitted on Tuesday, it is proposed in the first five years to provide dwellings for 233,000 people, which will involve the re-housing of some 70,300 people. Over 20 years, the needs of education will require the displacement and re-housing of 89,000 people, while, in addition, the provision of 480 acres of open space in the first five years and 590 acres eventually will mean the displacement of about 5,400 and 45,000 people, respectively. The plan also includes proposals for building six fly-over intersections, 37 roundabouts, 10½ miles of new principal roads, 7 miles of major widenings of existing routes and two miles of new tunnel.

These works will require the re-housing of about 23,000 people.

SOCIETY OF CHEMICAL INDUSTRY.

The 70th annual meeting of the Society of Chemical Industry will be held from Monday, July 9, until Friday, July 13, at the Royal College of Science, Imperial Institute-road, South Kensington, London, S.W.7. The meeting opens at 8 p.m., on the first day, with a reception at the Geological and Science Museums, South Kensington. The annual general meeting will be held on Tuesday, at 10 a.m., and after a luncheon at the May Fair Hotel, visits will be paid to the Anglo-Iranian Oil Company's research station at Sunbury-on-Thames; the Mullard Radio Valve Company, Limited, Mitcham; Kodak, Limited, Harrow; the Metropolitan Water Board's Laboratories, and other works and establishments. On Wednesday, July 11, at 10 a.m., the Society's Medal will be presented to Professor E. C. Dodds, M.V.O., F.R.S., at the Royal Institution, Albemarle-street, W.1. Later in the morning, lectures on "Water in Industry," which is to be the theme of the lectures at the meeting, will be delivered by Mr. H. W. Cremer, C.B.E., and Professor P. G. H. Boswell, D.Sc., F.R.S. Further visits to several works and establishments will be paid in the afternoon. At 7.30 for 8 p.m., the annual dinner of the Society will be held at the Dorchester Hotel, Park-lane. On the morning of Thursday, July 12, further lectures on various phases of "Water in Industry" will be delivered by Dr. E. W. Russell, Dr. M. A. H. Tinker, Professor H. S. Taylor, Dr. E. I. Akeroyd, Mr. J. Leicester, Dr. U. R. Evans, F.R.S., and Dr. T. Thornhill. In the afternoon more visits will be paid to works, etc., and on Friday morning, the final lectures on "Water in Industry" will be delivered by Dr. J. H. Oliver, Mr. E. L. Streatfield, Mr. P. Hamer, Dr. F. W. Mohlman and Dr. B. A. Southgate. Additional visits have been arranged for Friday afternoon and the meeting closes with a reception by the chairman and directors of Imperial Chemical Industries, Limited, to be held at 8.30 p.m., at the Connaught Rooms.

THE MINISTRY OF MATERIALS.

The Rt. Hon. R. R. Stokes, P.C., M.P., Lord Privy Seal, speaking at a luncheon at the Park Lane Hotel, London, on Monday, July 2, referred to the task he was about to undertake as the first Minister of Materials. The luncheon was organised by the journal, *The Manager*, and the chair was taken by Sir Archibald Forbes, finance director of Spillers, Limited, and President of the Federation of British Industries. Mr. Stokes said that greater efforts must be made towards joint consultation of the right kind, namely, in the shops; not the board room. It was not always realised that full employment entailed a duty to give a full day's work; voluntary absenteeism, if tackled in the right way, could be reduced to less than 0.3 per cent. Some alleviation of the fuel situation could be achieved if the heat insulation of workshop buildings was not so criminally neglected. With regard to the length of the working week, it was a fallacy to assume that because it was desirable to reduce hours in heavy industry it was also desirable throughout other industries. The fact must also be faced that the gap between the pay of skilled men and unskilled men had become so narrow that it was no longer worthwhile to become skilled. Mr. Stokes said that shortages of materials had been aggravated by the defence programme, but were not wholly due to it. In his view, the problem facing the world, after the materialists of the East had been dealt with, was to raise the standard of living of the millions of the world. With regard to the work of the new Ministry, the staff would be largely recruited from the Board of Trade and the Ministry of Supply. The "pipeline" of industry must be kept full; it was his job to see that materials were available, and he hoped to tackle the question of exorbitant commodity prices. As far as possible, industry would be dealing with the same people as before. He did not think a Minister of Production was necessary. He had had a very good reception at Washington; there were political difficulties, but responsible Americans appreciated the needs and the problems.

LETTERS TO THE EDITOR.

SOME UNSOLVED PROBLEMS IN CIVIL ENGINEERING.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest your reprint of Mr. G. A. Maunsell's James Forrest lecture to the Institution of Civil Engineers (published in the issues of June 8, 15 and 22). Mr. Maunsell states (page 769, June 22): "Parsons, the inventor of the steam turbine, broke right away from established steam-engine practice, with which he could scarcely have been fully conversant." I believe it is true, but I cannot give a reference, that Sir Charles, when still a pupil at Armstrongs, of Elswick, obtained permission to build a radial steam engine of his own design. As an old Parsons man, I would be glad to know if anyone can tell me whether this engine worked.

My father, the late Emeritus Professor W. M. Thornton, who co-operated with Sir Charles some 45 years ago on experiments on cavitation of ships' propellers, once told me that Sir Charles had remarked to him that "mathematics are of very little help." Dr. Gerald Stoney, his famous assistant, has also stated that Sir Charles was "rarely, if ever, known to make use of formal mathematical reasoning for the solution of any problem." This is in spite of the fact that he was 11th Wrangler in the Mathematical Tripos at Cambridge. These remarks surely support Mr. Maunsell's observation, "It may quite possibly be that many or all works of genius and all genuine advances of the human mind . . . owe their origin rather to an intuitive perception of truth on the part of the founder than by intellectual reasoning."

Yours faithfully,

B. M. THORNTON.

Winnington Hall Club,
Northwich,
Cheshire.
July 2, 1951.

JOINT ENGINEERING CONFERENCE, LONDON.

TO THE EDITOR OF ENGINEERING.

SIR,—In your report of the paper on "Electric Signalling," on page 747 of your issue of June 22, it is stated that "Power signalling was first introduced at Crewe in 1900." While it is true that this installation was the first on the London and North Western Railway, the first installation of power signalling anywhere in Great Britain was at Granary Junction, Bishopsgate, on the Great Eastern Railway, in 1898, where the Westinghouse electro-pneumatic system was installed. It is of interest that, while the Crewe installation has now been replaced by a modern all-electric interlocking system, the original installation at Granary Junction is still in service.

Yours faithfully,

O. S. NOCK.

20, Sion-hill, Bath.
June 27, 1951.

BRITISH ELECTRICITY AUTHORITY.—The graduate training scheme for technical engineering staff, by which the British Electricity Authority provides training courses for men and women engineering graduates, has been modified to include a period of up to 6 months basic mechanical workshop training. The period of training may now be 2 or 2½ years and the rates of pay have been increased to 330l. for the first year and 345l. per annum for the remaining period, with an addition of 25l. per annum in the London area.

CABLE TRUNKING WITH FUSED TAP-OFF UNITS.—A cable trunking system has been designed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, for use in factories where the total current does not exceed 100 amperes per phase. Where vulcanised rubber cables are employed, a terminal block, which enables the main cable to be tapped without cutting, is fitted inside the trunking and to it a fused tap-off unit is fitted and wired. Connection is then made by cable to the machine. All the drilling and fixing can be carried out on site after the position of the machine has been chosen.

OBITUARY.

MR. R. F. MCKAY.

WE regret to learn of the death, on June 14, at the age of 67, of Mr. Robert Ferrier McKay, M.Sc., A.M.I.C.E., who achieved some distinction as an author, lecturer and examiner and for his work on naval machinery and protection devices. He had retired last year as manager of the inventions and patents department of the Dunlop Rubber Company.

Mr. McKay was born in Edinburgh on August 19, 1883. His general education was gained at the Henry Smith School, Hartlepool, and after three years at the University of Durham, Newcastle-upon-Tyne, he graduated B.Sc. in 1903. A further three years was then spent under Sir Alfred Yarrow, followed by five years as a junior draughtsman. In 1906, Mr. McKay turned to academic work as a demonstrator at the City and Guilds Engineering College, London, under Professor W. E. Dalby, and in 1911 he was made senior lecturer, specialising in the theory of machines and machine drawing and design. During the summer vacation of 1915 he kept in touch with naval matters as an assistant to the works manager of Messrs. Yarrow and Company, Limited; he took part in the erection of machinery, and in the trials and preparation for sea of torpedo-boat destroyers. In 1916 he returned to Yarrow's as senior draughtsman.

In 1917, Mr. McKay joined Messrs. Vickers Limited, under Mr. T. G. Owens-Thurston (later Sir George Thurston), and for the two years he was there he was engaged on the protection of shipping against mines and submarines, being associated with the design of the Mk. III "Otter," an anti-mine device for the protection of merchant vessels, and in 1919 he read a paper on the paravane to the British Association. In 1920 he was appointed a technical officer (engineering) in the Department of Scientific and Industrial Research, where he acted as secretary to several committees. He joined the Dunlop Rubber Company in 1926 as engineer in a department formed for the development of the technique of electrically depositing natural rubber latex, and he was later made manager of the department from which he retired last year.

While working under Professor Dalby, Mr. McKay wrote *The Theory of Machines*, first published in 1914, and he was also the author of *The Principles of Machine Design*. For some years he served as examiner for the B.Sc. (Eng.) degrees of London and Benares universities, and for the examinations of the Institution of Civil Engineers. He joined that Institution as a student in 1904, was made an associate member in 1919, and received the Bayliss Prize. He was also a member of the Institution of Mechanical Engineers.

MR. G. GEOFFREY SMITH, M.B.E.

WE also note with regret the death, on Friday, June 29, at the age of 66, of Mr. Geoffrey Smith, M.B.E., a director of Associated Iliffe Press, Limited. He was well known in connection with the motoring and allied journals of that publishing house, and, as a technical journalist, he earned merit by his advocacy of gas turbines at a time when the subject was a closed book to all but a few.

George Geoffrey Smith was born at Newark, Nottinghamshire, on March 4, 1885. After an apprenticeship with Messrs. Ransomes and Marles, Limited, he joined the editorial staff of *The Motor Cycle* in 1904 and, eight years later, was appointed editor. He was made an M.B.E. for his service during the first part of the 1914-18 war, subsequently joining the Royal Flying Corps. Between the wars he assumed the direction of an increasing number of Iliffe journals; in 1923 he was made a director of Iliffe and Sons, Limited, and in subsequent years, of a number of their subsidiary companies. Mr. Smith's best known book was undoubtedly *Gas Turbines and Jet Propulsion* (first published in December, 1942), a work on a modest technical level, but he was also the author of *The Modern Diesel*. He was a Freeman of the City of London, and a liveryman of the Worshipful Company of Coachmakers and Coach Harness Makers.

THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

THE Royal Agricultural Society's annual show, which opened at Cambridge on Tuesday, July 3, and closes this evening, is the fourth to be held in that neighbourhood. When it was held at Cambridge for the first time in 1840, it occupied about five acres of Parker's Piece, then the County and University cricket ground, and the livestock and implement entries totalled 337 and 115, respectively. This year, the show covers 150 acres and approximately 5,000 head of livestock will compete for prizes having a total value of 20,000*l.* This is probably the greatest collection of farm livestock ever gathered in one place and well illustrates how the diversity of the country's soil and climate has led to the development of a wide variety of breeds to meet local conditions. There are, for example, over 20 breeds of cattle, 32 of sheep and over a dozen breeds of pigs. Although tractors are rapidly replacing horses on the farm, there are still occasions when horses are invaluable for certain types of work and there were many occasions during last winter when they were able to carry on in mud which bogged down tractors. It is gratifying to record, therefore, that the entries of horses totalled 928 against 843 at last year's show, this year's entries ranging from heavy shires to diminutive Shetland ponies.

Wool, of course, was the foundation of this country's wealth, but the difficulties of shepherding to-day, not least of which is the havoc caused by dogs to flocks kept near large centres of population, has caused a decline in the number of flocks during the last few years, particularly in the lowland counties of England. Even so, over 800 entries of sheep, representing 27 breeds, are being shown, and for the first time since 1947, there are classes for the cheviot breed. The largest entries from one breed come from the Suffolks, which have spread from their native East Anglia to nearly every country in the world. Cattle entries exceed 1,800 head, and all, with the exception of some Highland breeds, are from attested herds. Two championship trophies are being awarded for the first time this year, one for beef cattle and one for dairy and dual-purpose cattle. Entries for pigs were so large that many had to be refused; nevertheless, space has been found for approximately 1,000 pigs, the most popular breed being the large whites. There are nine classes for goats but, owing to the prevalence of fowl pest earlier in the year, it has not proved possible to form a poultry section and no birds are on show. The machinery and implement section covers 70 acres, nearly half the showground; it is next to impossible to assess the total number of exhibits, as they range from large crawler tractors to small hand tools, but it would appear that there is a drop on the figures for last year, probably due to the rearmament drive and the consequent shortage of raw materials.

An attractive feature of the Royal Show is the way all facets of farming are covered, the exhibits ranging from large experimental plots to small handicrafts sections. The dominant theme of the Ministry of Agriculture's exhibit, for example, is the need to give both crops and livestock a good start for greater output. The complete display covers more than an acre and outdoor plots demonstrate: the manuring of a typical sequence of crops of four predominant soil types in East Anglia; seed dressing and control of weeds in cereals; labour-saving methods of sugar-beet growing; planting dates and fertiliser placement with potatoes; weed control on carrots; and the establishment of good grazing leys in East-Anglian conditions. Indoors, groups of shorthorn cattle show the results of rearing cattle on four different levels of nutrition, while litters of pigs are used to demonstrate the importance of high-weaning weights in piglets. For the horticulturist, there is information on better strawberry production and other exhibits cover labour-saving piggeries, inexpensive fencing, examples of farm roads made from local materials, and demonstrations on making concrete roads. The Ministry of Agriculture exhibit, incidentally, affords a good example of the foresight needed in

planning the Royal Show as the calves for the beef exhibit were bought eighteen months ago and preliminary work started on the outdoor plots nine months ago.

Adjoining the site of the Ministry of Agriculture, is the exhibit of the National Institute of Agricultural Botany, where plant-breeding and seed-testing methods are explained. The importance of quality in marketing agricultural products, is demonstrated by the Northern Ireland Ministry of Agriculture, and an exhibit staged jointly by the Ministries of Food and Agriculture shows a complete egg-candling grading and packing station at work. Countryside crafts and activities are represented at numerous stands. The Rural Industries Bureau, for example, are demonstrating the work of the rural craftsmen, while agricultural engineers and woodworkers are showing what can be produced in a modern workshop.

It was only to be expected that this year many of the exhibits have an historical bent and, accordingly, the Milk Marketing Board are displaying the scientific and technical developments in the handling, transporting, manufacturing and distributive aspects of milk production which have occurred during the last century. The Royal Agricultural Society's exhibit also is historical, consisting of farm implements and machines about 100 years old, some of which are still in use. The display includes an early portable steam engine which was hauled by horses, a two-horse wooden-framed mower and a winnower built in 1853, which recently was converted to engine drive and, after the show, will be returned for further use. Another interesting exhibit in this section is a farm cart originally shown at Crystal Palace in 1851, and still in everyday use on a Northamptonshire farm. To show the contrast between new and old, a seed drill is being displayed beside a seedlip and dibbler and a wooden plough beside an iron plough.

In the implement section, practically every conceivable aspect of mechanised farming is covered. The tractor, as was to be expected, takes pride of place and, in common with previous shows, a parade of the latest machines of this type is taking place each day in the Grand Ring. Formerly, the parade was confined to tractors of British origin but this year the scope has been widened and is open to all tractors regardless of whether they are of British or foreign manufacture. Further interest has been added to the parade this year by including one of the earliest farm tractors to be driven by an internal-combustion engine, namely, the Ivel agricultural motor which was exhibited at the 1903 Royal Show. It is a three-wheel machine which, instead of the usual engine-cooling radiator, is provided with a 30-gallon cooling tank. A simple, but exceptionally heavy, cone clutch is arranged to give one forward and one reverse speed and the control lever, which is locked in forward and neutral gear, is designed so that when in reverse it has to be held in engagement by hand as a safety factor.

Tractors, of course, are the very backbone of mechanised farming, so it is only logical to commence our review of the exhibits in the implement section by referring to a new machine of this type, namely, the Ferguson Diesel tractor which is being shown by the manufacturers, Harry Ferguson Limited, Coventry. This machine is illustrated in Fig. 1, opposite, from which it will be seen that it bears a close resemblance to the standard Ferguson tractor. It is fitted with a four-cylinder engine having a bore and stroke of 3½ in. and 4 in., respectively, and developing 25 h.p. at 2,000 r.p.m. The Freeman-Sanders patented form of combustion chamber is used and the manufacturers claim that this gives exceptionally quiet and smooth running with but little Diesel "knock." C.A.V. fuel-injection equipment is fitted, the rate of injection being controlled by a pneumatic governor.

The unit is of straightforward construction, the combined crankcase and cylinder block being fitted with renewable dry-type liners and the cylinder head being provided with overhead valves operated in the usual manner from the camshaft through push rods and rocking levers. Aluminium-alloy pistons are used and these are fitted with fully-floating gudgeon pins located by Circlips. The crankshaft is static-

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, CAMBRIDGE.

(For Description, see Page 20.)



FIG. 3. TRACTOR-MOUNTED POTATO PLANTER; MESSRS. HARRY FERGUSON, LIMITED.



FIG. 4. COMBINED SEED DRILL AND FERTILISER DISTRIBUTOR; MESSRS. HARRY FERGUSON, LIMITED.



FIG. 5. TRACTOR-MOUNTED REVERSIBLE PLOUGH; MESSRS. HARRY FERGUSON, LIMITED.



FIG. 6. PRECISION SEEDER; MESSRS. HARRY FERGUSON, LIMITED.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, CAMBRIDGE.

(For Description, see Page 20.)



FIG. 7. TRACTOR-MOUNTED ELEVATOR DIGGER; MESSRS. JOHNSON'S (ENGINEERING), LIMITED.



FIG. 8. BANTAM "ROTAVATOR" FITTED WITH TOOLBAR; ROTARY HOES, LIMITED.



FIG. 9. POTATO HAULM PULVERISER; ROTARY HOES, LIMITED.



FIG. 10. HOWARD "ROTAVATOR" FOR FERGUSON TRACTOR; ROTARY HOES, LIMITED.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.



FIG. 1. DIESEL-ENGINED TRACTOR; MESSRS. HARRY FERGUSON LIMITED.

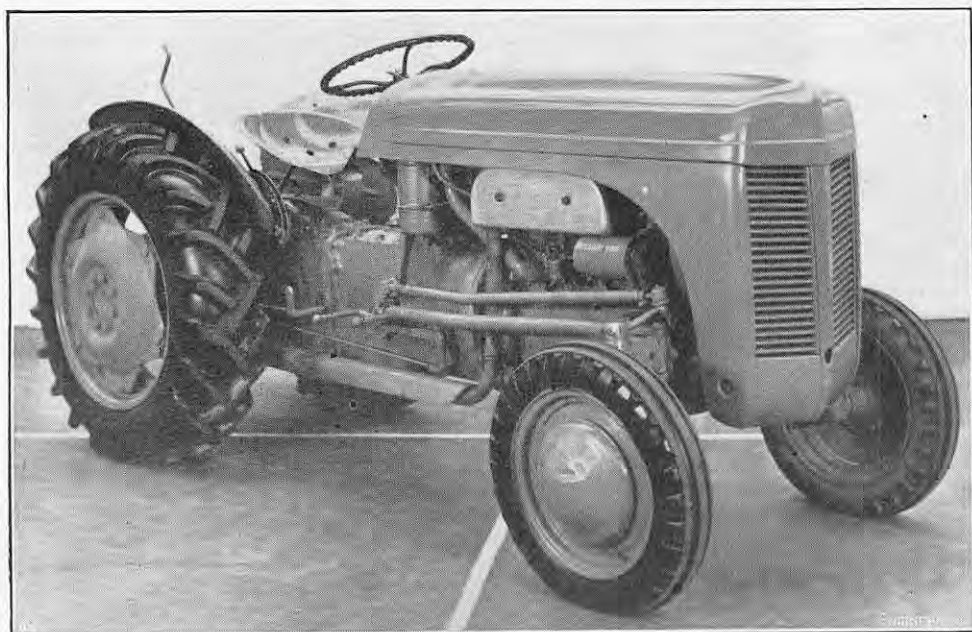


FIG. 2. NARROW-WIDTH TRACTOR; MESSRS. HARRY FERGUSON LIMITED.

ally and dynamically balanced and is supported by three large main bearings of the lead-bronze indium-plated type. The camshaft also is supported by three bearings and is driven from the crankshaft through a duplex roller chain. To assist in starting in cold weather, a Kigas heater is installed; this comprises a small special fuel tank fitted with a hand-operated pump and an atomising nozzle in the manifold for spraying the fuel on to an electrically-heated glow plug. Other equipment installed on the engine includes an oil cleaner of the replaceable-cartridge type, a water-circulating pump for engine cooling, twin fuel filters, and de-compression gear. Electrical equipment is fitted as standard and consists of a 12-volt battery, together with an auxiliary dynamo of the non-ventilated type and a starter motor. The starter motor is operated from the sixth position of the gear lever and a special interlocking device ensures that the unit cannot be engaged accidentally when the tractor is running. As with other Ferguson models, the new Diesel engine is being manufactured by the Standard Motor Company, Limited, at their Banner-lane factory, Coventry.

Messrs. Harry Ferguson Limited are also showing their new extra-narrow tractor. This machine,

which is illustrated in Fig. 2, on this page, has been developed for use in vineyards, sugar plantations and similar locations not generally accessible to their standard machine. It is 20 in. narrower than the standard tractor and although similar in layout, basic changes had to be made to the rear and front axles. The front central axle beam has been shortened and set to a different angle, and both the right- and left-hand axle assemblies have been modified so that the steering geometry is unaffected; new radius rods and drag-link assemblies also have been provided.

As will be seen from the illustration, the bonnet is considerably longer than on the standard machine; this has been brought about by having to move the radiator forward to give the necessary clearance for the cross swinging of the front axle. New smaller wheels are fitted to the front and rear axles, thereby lowering the tractor by 2 in. and ensuring that the stability is still satisfactory despite the narrower track; should long overhung implements be used, however, extra weights are provided for fitting to the front wheels. The controls, seat position, mudguards, etc., have, of course, been modified and the hydraulic-lift shaft arms have been altered to allow for the very narrow track. The

lower hydraulic-system lift arms, however, are standard fittings placed in the reversed position so that, when the wheel track is opened out, to 44 in. or more, it is only necessary to reverse them and carry out a few more minor modifications such as the removal of special stabilisers, the fitting of standard check chains and the re-location of the mudguards, to enable the tractor to be used in conjunction with all standard implements. The front track width is adjustable by increments of 4 in. between the limits of 37 in. and 50 in. and the rear track by the same increments between the limits of 32 in. and 56 in., and by reversing the front wheels on their hubs, the maximum front-track width can be increased to 58 in. The overall width at the front of the tractor with the wheels set at the minimum track is 46 in. and the corresponding dimension at the rear of the tractor 44 in.

Mr. Harry Ferguson was, of course, the pioneer of tractor-mounted implements and it was only to be expected that special efforts would be made during this Festival year to improve on, and increase the number and wide range of implements already available. Many new implements are, in fact, being shown and these include a tractor-mounted potato planter, a combined seed drill and fertiliser distributor, a mounted reversible or "one-way" plough and precision seeding machine, to mention but a few. The tractor-mounted potato planter, which is illustrated in Fig. 3, on Plate I, is really an attachment for use with the Ferguson ridger; it is designed so that two operators can be carried in a convenient position for feeding the seed potatoes by hand down the planting chutes. Two types are available, one for planting ordinary seed, in which case a steel hopper is used, and the other for planting chitted seed, the latter type being shown in the illustration. The trays are carried by steel-frame attachments which replace the hopper and, when not in use, the complete frame can be dismantled and stored as lengths of angle iron. Six trays may be carried, two in front and two at the side of each operator, the side trays being supported by extensions to the main frame which are bolted in position, the bolts passing through holes normally used for securing the marker to the ridger. When used as a potato-planter, the central ridging body is moved back almost into line with the two outer bodies and correct spacing is ensured by a marker bell operated by a small land wheel. Row width can be varied from 24 in. to 30 in. and the spacing from 8 in. to 16 in., while the depth of planting may be from 1½ in. to 5 in. above ridge-bottom level.

The combined seed drill and fertiliser distributor is illustrated in Fig. 4, on Plate I. On several machines of this type the fertiliser distributor forms an integral part of the implement and cannot be detached. This has the disadvantage that a separate fertiliser distributor has to be used for crops other than cereals. The Ferguson distributor is designed, therefore, so that it can form an attachment to their universal seed drill, thereby making it a combined drill; or it may be used separately as a broadcast distributor, being fitted to the tractor rear linkage in the latter case. When used with the seed drill, the fertiliser is fed down separate tubes and placed immediately behind the seed, the drive being taken through the seed-drill gearing. Application up to a maximum of 4 cwt. an acre can be obtained by this method, whereas for broadcast distribution up to 25 cwt., an acre can be applied, the rate being controlled by single ratchet wheel arranged to operate a variable-speed gear enclosed in an oil bath. An agitator operates throughout the breadth of the machine and the fertiliser falls through fixed apertures on to short conveyor belts which deliver the predetermined quantities of fertiliser to the ground. The width of distribution is 7 ft. and the hopper, which is lined with stainless steel, has a capacity of 7½ cub. ft.

The introduction of the Ferguson reversible plough, or one-way plough as it is often called, is particularly welcome as this form of plough can prove particularly useful, especially on hilly ground. It is illustrated in Fig. 5, on Plate I, from which it will be seen that it is a single-furrow implement of exceptionally neat design. Both the right- and left-hand bodies are mounted, together with their

PRODUCTION OF BLACKSTONE VERTICAL OIL ENGINES.

(For Description, see Opposite Page.)

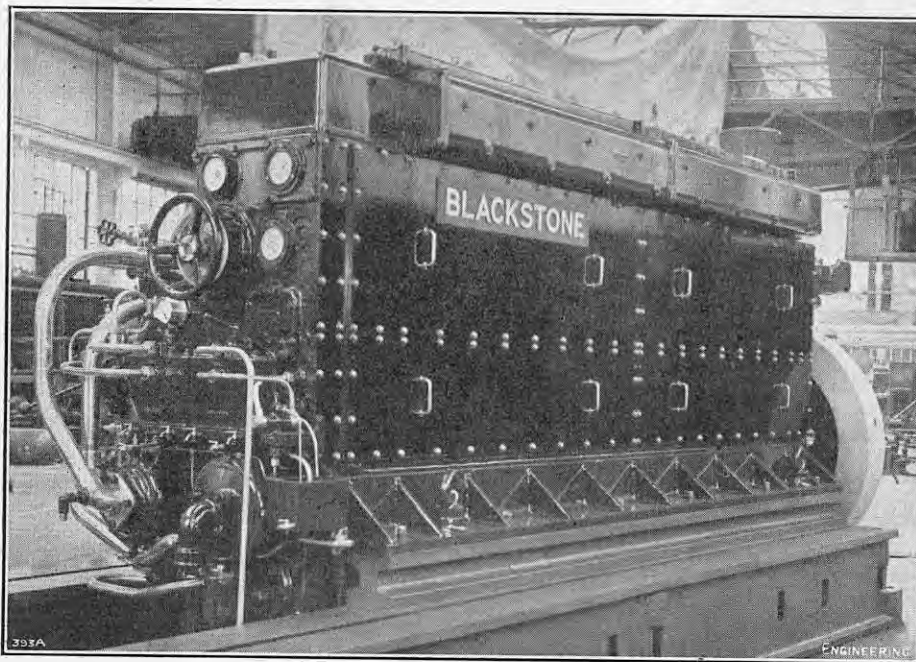


FIG. 1. EIGHT-CYLINDER 360-H.P. DIESEL ENGINE.

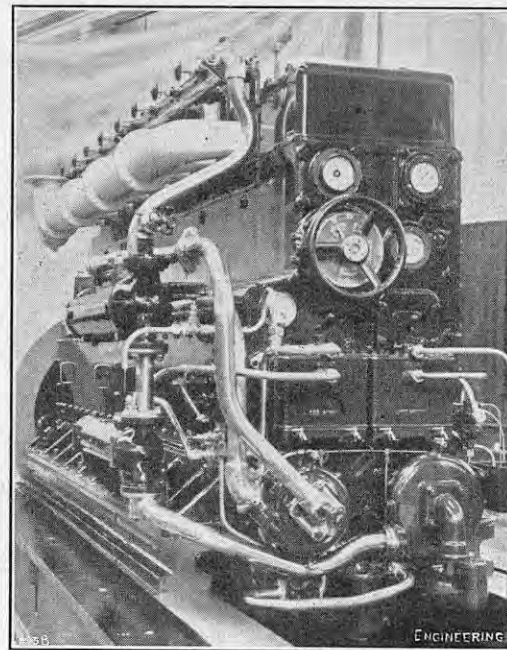


FIG. 2. CONTROL GEAR FOR 360-H.P. DIESEL ENGINE.

disc coulters, on a central beam at an angle of approximately 80 deg. to each other. The central beam, in turn, is supported by a tubular structure provided with two horizontal arms and a vertical strut for attachment to the three-point linkage of the tractor. A latch plate is fitted to the forward end of the central beam which operates in conjunction with a latch mounted on the tubular structure to lock the plough in the working position. The latch is depressed by a plunger in an indexing arm which pivots at the front of the central beam, the position of the indexing arm being controlled by a cam mechanism and over-centre spring mounted on the latch plate. The indexing arm is operated by a chain assembly fixed to a bracket at the rear of tractor and indexing takes place automatically when the plough is lifted into the transport position, the movement of the plough relative to the tractor causing the chain to tighten and depress the latch. The indexing arm is then pulled over until it engages a shoulder on the latch plate; this, in turn, is also pulled round until the plough reaches the transport position when the latch engages a slot in the latch plate to lock the complete assembly in position. The plough is, of course, controlled for depth and lifted for transport by the hydraulically-operated implement lift fitted to the rear of the tractor.

The Ferguson precision seeder is illustrated in Fig. 6, on Plate I. Basically, it consists of two cylindrical hoppers fitted to a steel frame of the row-crop type situated close to the ground. Serrated-plate seeding mechanisms are located in the bases of the hoppers and these are driven independently by chains from the press-covering wheels visible in the illustration. Depth of sowing can be adjusted to a maximum of 5 in. below the surface and disc markers are provided to ensure accuracy of row spacing, the markers being designed so that they are raised and lowered automatically with the seeder. Seed spacing within each row can be adjusted from 1 in. to approximately 3 ft. and provision is made for sowing clusters of seeds, alteration of seed spacing being obtained by changing the seed plates and drive sprockets. Row spacings can be adjusted from 18 in. to 52 in. but this can be increased still further by removing the markers. Individual fertiliser hoppers having a capacity of 2 cwt. can be fitted; these are shown in position in Fig. 6. The fertiliser-distributor mechanisms are made from corrosion-resistant materials and the fertiliser placement in relation to the seed rows can be adjusted up to 2 in. to either side and 4 in.

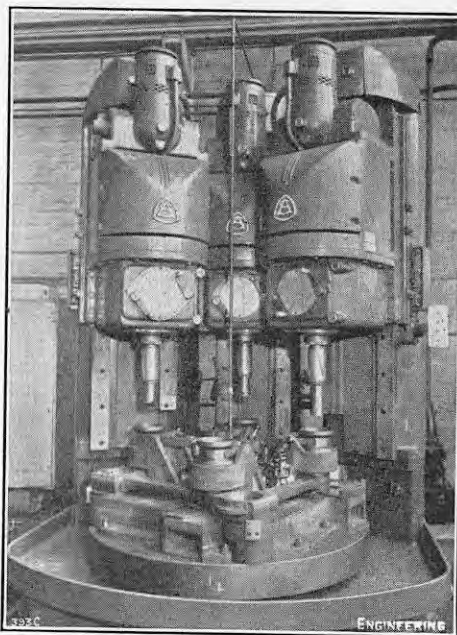


FIG. 3. MACHINE FOR MULTIPLE BORING OF CONNECTING RODS.

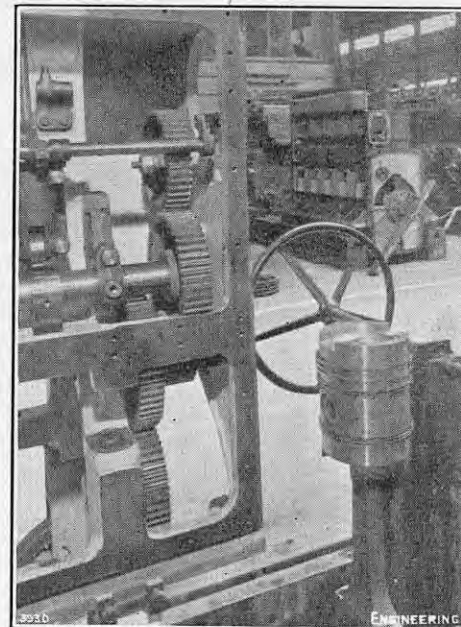


FIG. 4. PISTON-ASSEMBLING FIXTURE.

below the surface. By changing the drive sprockets, the rate of fertiliser application can be varied from 75 lb. per acre up to a maximum of approximately 5 cwt. per acre, the actual figure depending, of course, on the row width.

The production of mounted implements for use behind tractors, however, is by no means confined to tractor manufacturers as many specialist firms have produced special implements, or modified their existing range, to fulfil this purpose. A good example is furnished by the tractor-mounted elevator-digger illustrated in Fig. 7, on Plate II, which has been produced by Messrs. Johnson's (Engineering), Limited, March, Cambridgeshire, for the continuous lifting of such crops as potatoes, carrots, etc. It can be used behind any tractor fitted with a three-point implement linkage and rear power take-off and is exceptionally easy to manipulate. As will be seen from the illustration, it consists of the usual digging shares which lift the roots on to a shaker-elevator arranged to deliver to one side. It is designed for coupling directly to the tractor rear linkage and can, therefore, be lifted into and

out of the work at will. The elevating gear is driven by an extension shaft from the tractor rear power take-off and all shafts, etc., are fitted with either ball or taper-roller bearings to reduce maintenance work to a minimum. The driving gears are made from hardened steel and to prevent the mechanism from being damaged, adjustable safety clutches are incorporated in the drive. Its introduction satisfies a long-felt need as it is a fast-working implement particularly suitable for use on smaller farms that do not warrant the capital outlay involved in a full-size machine of this class.

In our reports of previous Royal Shows, it has been pointed out that the design of horticultural equipment has reached an advanced stage and that machines have been developed which, by a simple system of interchanging parts, can be adapted to perform several different tasks. A good example of such a machine is furnished by the "Bantam" rotary cultivator, a machine manufactured by Rotary Hoes, Limited, East Horndon, Essex, and designed basically for rotary cultivation, but which can also be fitted with a range of implements such

PRODUCTION OF BLACKSTONE VERTICAL OIL ENGINES.

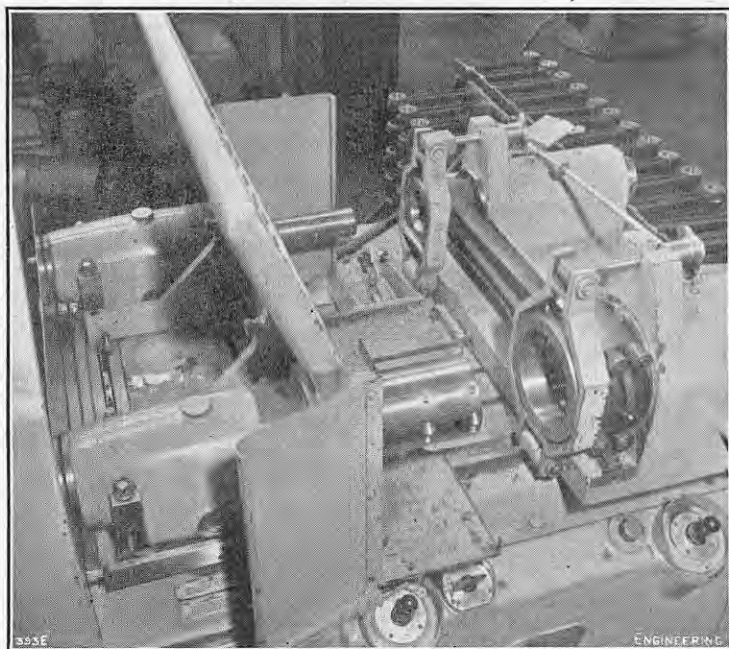


FIG. 5. FINAL MACHINING OF CONNECTING-ROD BORES.

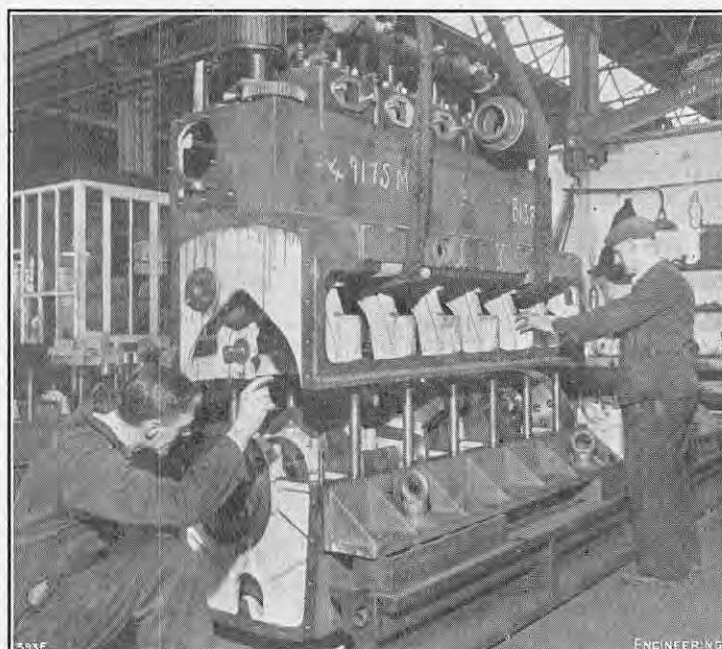


FIG. 6. ASSEMBLING CYLINDER HOUSING AND CRANKCASE BASE.

as a cylindrical mower, a reciprocating-cutter bar, hedge clipper and a rigid tine cultivator. It is illustrated in Fig. 8, on Plate II, where it is shown arranged for ordinary cultivating work, the rotary hoe having been replaced by a rigid tool frame. The machine is driven by a single-cylinder air-cooled petrol engine which may be either of the two-stroke or four-stroke type. As will be seen from the illustration, the engine is set across the frame of the machine and the drive is transmitted to the "propeller" shaft by a pair of stepped pulleys and a V-belt. The land wheels have a diameter of 14 in. and are fitted to a drum, an arrangement which gives good stability but simplifies the construction. It is controlled in the normal manner by extended steering arms and, in view of its light weight, approximately 135 lb., is exceptionally easy to handle.

Rotary Hoes, Limited, are also showing their new potato-haulm pulveriser and their range of rotary cultivators designed for use behind the leading makes of tractor. The potato-haulm pulveriser, which is illustrated in Fig. 9, on Plate II, has been designed to disperse all weeds and haulms from the ridge before the tubers are lifted and is suitable for use behind Ferguson, Fordson Major and Cropmaster tractors. Its general design is similar to that of the cultivators, but the blades are arranged at angles to follow the contour of the land baulk. The implement is operated with the blades about 1 in. or 2 in. above the ground, and the controls include a dog clutch for putting the rotor into operation and an adjustment for height of working. It is lifted by the ordinary hydraulic mechanism of the tractor and is driven through suitable gearing and a cross shaft from the tractor rear power take-off.

The range of Howard "Rotavator" rotary cultivators being shown by Rotary Hoes, Limited, includes their new machine designed for use behind the Ferguson tractor. It is illustrated in Fig. 10, on Plate II, from which it will be seen that the general design follows closely that for previous machines of this class. It is driven from the rear power take-off through an extension shaft, an intermediate jack shaft, connected to the extension shaft by bevel gears, and a chain, which connects the jack shaft to the rotor spindle. The complete unit is mounted centrally behind the tractor and its working width is 50 in., so that when the tractor wheels are set in at their closest, it eliminates the wheel tracks. Provision is made for disconnecting the rotor drive and the depth of working is controlled by the adjustable land-wheel visible in the illustration.

(To be continued.)

BLACKSTONE VERTICAL OIL ENGINES.

ALTHOUGH Messrs. Blackstone and Company, Limited, Stamford, had been making horizontal oil engines for a number of years, it became apparent before the outbreak of the second world war that, in the higher-powered ranges, the demand for vertical high-speed engines would soon outstrip that for horizontal engines, despite the continued popularity of the latter type overseas. Accordingly, the firm's technical staff studied the possibility of developing a vertical engine that would give greater output per cylinder without involving a commensurate increase in specific fuel consumption, be no heavier than existing engines and yet be competitive in price. It was decided at the outset that the engine should be capable of operating as a normally-aspirated or a turbo-charged unit and be equally suitable for use on land or for marine propulsion. Designs were completed in a comparatively short time and a prototype engine of the turbo-charged type was soon put into operation. The war, naturally, impeded development, but the design has now been settled and engines are already being produced in large numbers and in a variety of sizes.

The new range of engines has been designated the EV series, a typical unit being illustrated in Figs. 1 and 2, opposite. This is an eight-cylinder unit fitted with a normal induction system and capable of developing a maximum of 360 h.p. at 600 r.p.m.; when fitted with a turbo-charger, however, the output is increased to a maximum of 480 h.p. Normally-aspirated engines ranging from two-cylinder units to the eight-cylinder unit just referred to are available, but the turbo-charged engines are available only in four-, six- and eight-cylinder sizes. The bore and stroke for all engines remain constant at 8½ in. and 11½ in., respectively, and the design of the complete range is similar in the main essentials. The bedplate is an iron casting, of box section, designed to carry the crank in steel-backed white-metal lined main bearings of the precision type. A single-piece casting forms the cylinder housing for each size of engine, it having been decided that the use of a separate casting in each case is preferable to a unit built up from standard castings as it is lighter and saves machining the joint faces. The crankshaft is machined from a solid forging of nickel steel, heat treated to give a tensile strength of between 40 and 50 tons per square inch. In accordance with usual practice, passages are drilled through the webs to feed the oil to the main and big-end bearings and the whole shaft, which is built to Lloyd's survey regardless of whether the engine is for land or marine use, is balanced. All crankpins and journals are ground and the flywheel end of the shaft is flanged to form a half-coupling to which the flywheel is bolted.

Close-grained cast-iron pistons are used and each is provided with three compression rings and two oil-control rings, the latter being situated one above and one below the gudgeon pin. The gudgeon pins are of the fully-floating type retained in position by Circlips and a cover plate is fitted inside each piston dome to

prevent oil spray coming into contact with the heated underside of the crown. Separate heads are fitted to each cylinder and each is fitted with overhead valves operated in the usual manner by push rods and rocking levers. Wet-type cylinder liners are employed and these are treated by the Listard process of chromium hardening to give a hard-wearing internal surface. They are sealed at the top by copper gaskets and at the bottom by rubber rings, the top locating shoulders being ground on to their mating surfaces. The connecting rods are machined from H-section heat-treated steel stampings and are fitted with steel-backed white-metal lined big-end bearings and chill-cast phosphor-bronze small-end bushes. Four fitted bolts retain each bearing cap in position and the rods are drilled for lubrication of the small-end bushes. The camshaft is driven through gearing at the flywheel-end of the engine and the complete camshaft assembly can be removed laterally from the engine after dismantling the side covers and tappet blocks, a useful feature for marine applications.

C.A.V. fuel-injection equipment is fitted as standard, individual pumping elements being provided for each cylinder. The fuel injectors are arranged between the inlet and exhaust valves and spray into toroidal combustion chambers formed in the piston crowns. A governor is driven from the camshaft and it is claimed that this keeps the engine speed constant within $\pm 2\frac{1}{2}$ per cent. Forced lubrication is, of course, employed throughout, the wet-sump system being used on land engines and the dry-sump system on marine engines. Cooling is effected by a heat exchanger, water in both the primary and secondary circuits being circulated by gear-driven centrifugal pumps. An oil cooler is also installed and the manufacturers state that the lubricating-oil consumption is 0.0036 pint per brake horse-power hour for the normally-aspirated engines and 0.0027 pint per brake horse-power hour on the turbo-charged units. Fuel consumption varies, of course, with the load, but for normally-aspirated engines, it is given as 0.372 lb. per brake horse-power hour at full load and 0.366 lb. at three-quarter load, the corresponding figures for turbo-charged engines being 0.365 lb. and 0.352 lb., respectively. As previously mentioned, a turbo-charger is available for four-, six- and eight-cylinder units; this is driven by the exhaust gases and is manufactured by Messrs. D. Napier and Sons, Limited.

The engines are well fitted out and, as will be seen from Fig. 2, the controls are all grouped at the forward end. Standard equipment supplied with each engine includes an air filter, air-starting to all cylinders, starting-air reservoir, lubricating-oil priming pump, tachometer and all the usual gauges, thermometers, etc. Turbo-charged models are fitted with a divided exhaust manifold and the turbo-charger is mounted on a bracket at the flywheel end of the machine, a special intake air filter being provided in place of the usual Micro-vee unit. The overall dimensions vary, of course, with the type of engine, but for the eight-cylinder unit illustrated, the length, including turbo-charger, when fitted, is 162½ in., the height 84 in., and

the maximum width 48½ in. The height measured from the centre line of the crankshaft is 64 in. and the distance to the base of the sump, measured from the same datum, is 20½ in.

The complete range of engines is being produced at the Stamford factory of Messrs. Blackstone, a self-contained works having its own power house, pattern shop, foundry and the usual machine shops, erecting shops, etc. The foundry has an output of some 35 tons a day and is capable of fulfilling all the internal factory requirements. Considerable thought has been given to production problems and to ensure a good rate of output, many new machine tools have been installed. The cylinder blocks, for example, are machined on a large triple-head plano-miller in three passes, the last pass comprising a finishing cut on the top surface of the cylinders for which purpose a 24-in. cutter is used. Another interesting machine is the three-spindle vertical borer illustrated in Fig. 3, on page 22, which has been installed for boring the connecting rods and tappet blocks. There are four stations, three of which are used for rough boring, semi-finish boring and finish boring, respectively, while the fourth station is used for loading, thereby reducing idle time to a minimum. It was manufactured to the requirements of Messrs. Blackstone by Messrs. Adcock and Shipley Company, Limited, and is believed to be the only machine of its type in existence. To ensure accuracy in the finished connecting rod, particularly between the centres of the top and bottom ends, a final cut is taken in a dual-head fine-point boring machine; this machine, which is illustrated in Fig. 5, on page 23, is exceptionally accurate and is capable of maintaining very close limits. Considerable use is made of jigs in the machine shop. The flanges of the various types of turbo-charger pipes, for example, are drilled in a universal jig which can be adapted to take all such pipes, while the engine end-cover plate is bored in an air-operated fixture designed to ensure that the centres of the gear-driven water-circulating pumps and lubricating-oil pumps are maintained at the correct relationship.

Much ingenuity has been used also in the assembly shop. Here each cylinder block is assembled complete with cylinder heads, pistons, connecting rods, valve gear, injectors, etc., before it is fitted to the baseplate, a system which is probably unique. The blocks are built up progressively, each passing down an assembly line on a special trolley. At the first station, the cylinder liners are installed, the top locating shoulders, as previously mentioned, being ground to their mating surfaces. Next the cylinder heads, which have been fitted previously with their valves and associated springs, are placed in position followed by the valve gear, the tappet blocks for which are installed as a complete sub-assembly. These sub-assemblies, such as the cylinder heads and tappet blocks, are put together on what might be termed subsidiary assembly lines arranged at right angles to the main assembly line and equipped with special machines designed to accelerate each operation. The camshaft, for example, has the flats for locating the cams machined on it by a special vertical-head milling machine designed and constructed by Messrs. Blackstone. Designing this machine was not a simple matter as due allowance had to be made for the different timings of normally aspirated and turbo-charged engines.

As previously mentioned, the block has the pistons fitted before it is bolted to its associated bedplate. These are, of course, inserted in the bores complete with connecting rods, which are assembled, together with the piston rings, in one of the sub-assembly areas. As the heads are already in position, they are inserted from below the block and to simplify this procedure the special rig illustrated in Fig. 4, on page 22, has been evolved. In operation, the base of the piston is placed on a small platform, which subsequently is raised towards the cylinder, the necessary motion being obtained by means of a chain and sprocket mechanism operated by a handwheel. During this operation, the rings are held within their grooves by a special clamp, which drops clear as the piston enters the cylinder. The operation is surprisingly simple and saves a considerable amount of time over the more usual method. When each block is completely assembled, it is transferred by an overhead crane to the opposite side of the assembly shop, where it is lowered on to its associated bedplate previously fitted with the main bearings, crankshaft, etc. This operation is illustrated in Fig. 6, on page 23, correct alignment of the block and bedplate being ensured by dowels inserted at each corner of the crankcase. The engine is then completed prior to dispatch to the test house.

UNITED KINGDOM EXPORTS OF BICYCLES AND MOTOR CYCLES.—Exports of bicycles and motor cycles during May were valued at 2,840,317l. or 1,000,000l. more than was the case in May 1950. The increase for bicycles was 666,095l., and for motor cycles 356,711l.

LABOUR NOTES.

At least 800,000 insured workpeople were absent from their employment every day of the year, owing to illness or injury of one sort or another, according to a statement made by Mr. Alfred Robens, the Minister of Labour and National Service, at the opening of the "People at Work" Conference at Keble College, Oxford, on Saturday last. The number of reported accidents in factories which occurred during the last year for which statistics were available amounted to very nearly 200,000, and it had to be remembered that not all industrial accidents were required to be reported. Each of these accidents resulted in a loss of working time and it had been estimated by a competent authority that, taking industry as a whole, and ignoring losses due to permanent disablement or death by accident, the less serious accidents represented a loss to the nation's man-power strength of the equivalent of over 25,000 operatives a year. Although much had been done to fight the dangers of industrial diseases and accidents, there was still much, Mr. Robens stated, that remained to be accomplished. The problem would largely be solved, however, if managements and workpeople alike could be educated in the use of safe practices.

A four-day strike of operatives at the works of the Austin Motor Company, Limited, Birmingham, which arose owing to a dispute over questions of redundancy, came to an end on June 26. At the same firm, shop stewards recently advanced wage claims for an all-round wage increase of 11s. a week for all employees, other than those in administrative and office grades. In an announcement issued by the Company on June 29, it was stated that about 3,000 of its 17,000 employees were to receive wage increases. In the case of commercial and works staff, the increases would amount to 5 per cent. on existing basic pay, while the lower-paid employees would receive increases varying from 5s. to 10s. a week. All these increases would be retrospective for nearly three months. Negotiations are in progress between the Engineering and Allied Employers' Federation and the various unions concerned regarding demands for wage increases by other sections of the firm's employees.

As was to be expected, the constantly increasing cost of living and the measures best suited to limit the impact of rising prices on the lowest-paid wage earners will provide the principal subjects for discussion at the biennial conference of the Transport and General Workers' Union, which will open at Whitley Bay on Monday next and continue until the following Friday. Altogether some hundreds of motions will be submitted to the conference on a large variety of industrial, economic and trade-union subjects. Among them will be proposals for the reduction of purchase tax on essential articles, the reintroduction of price controls on a large scale, further increases in the tax on distributed profits, reductions in the costs of wholesale and retail distribution, longer holidays with pay, and wage increases. One suggestion is that subsidies shall be paid to the nationalised industries out of the moneys provided as compensation to the former owners of those industries.

A number of branches of the T.G.W.U. have put forward motions asking for wage improvements, in one form or another, but only one branch has suggested that there should be a definite all-round wage increase of a fixed sum. This motion is too long to quote here but it appears to be intended to provide for employees generally to receive an extra 20s. a week. A proposal less frequently encountered at these conferences is one that certain changes shall be made in the manner of compiling the index of retail prices. About eighty branches have sponsored motions requesting that prompt action shall be taken to halt, or reverse, the upward trend in the cost of living, and those appealed to in this connection include the Union itself, the Government, the Trade Union Congress, and various combinations of these three.

Some 816,000 workpeople in the United Kingdom received increases in their full-time weekly wages during May and these were estimated to amount to a total of 213,000l. net, or an average of over 5s. a head. The Ministry of Labour Gazette for June records that, among the principal groups of workpeople who benefited from the increases, were the manipulative grades in the Post Office, employees in the iron and steel industry, persons engaged in civil-engineering construction in certain districts, operatives employed in the paper-making industry and those engaged in the manufacture of wooden boxes and packing cases in England and Wales. In the iron and steel industry there were small increases owing to the operation, in that industry, of sliding-scale arrangements based on the interim index of retail prices. The highest pro-

vincial-grade rate of wages was adopted in the civil-engineering construction industry for all areas in Great Britain outside the London district and this regrading resulted in the granting of increases ½d., 1d. or 1½d. an hour, according to area, for those affected.

During the first five months of the present year, a total of 6,395,500 persons received net increases in their full-time weekly wages amounting in all to approximately 2,463,300l. a week. The significance of these figures becomes apparent when they are compared with those for the corresponding months, January to May, of 1950, when a total of 2,268,000 workpeople received net increases in their wages aggregating only 374,000l. a week. In the course of the first five months of the present year, 1,102,000 persons in the building and contracting industries received increases amounting to 562,500l. a week, some 1,111,500 persons employed in the transport and communications industries benefited by a total of 447,500l., and 103,500 operatives in the printing and paper industries obtained advances totalling 38,100l. During the same period, personnel in the engineering, ship-building and electrical-goods industries numbering 182,000 received net increases amounting to 80,900l. a week, while, in the metal-manufacturing industry, 194,000 workpeople received net additions to their wages aggregating 45,900l. a week.

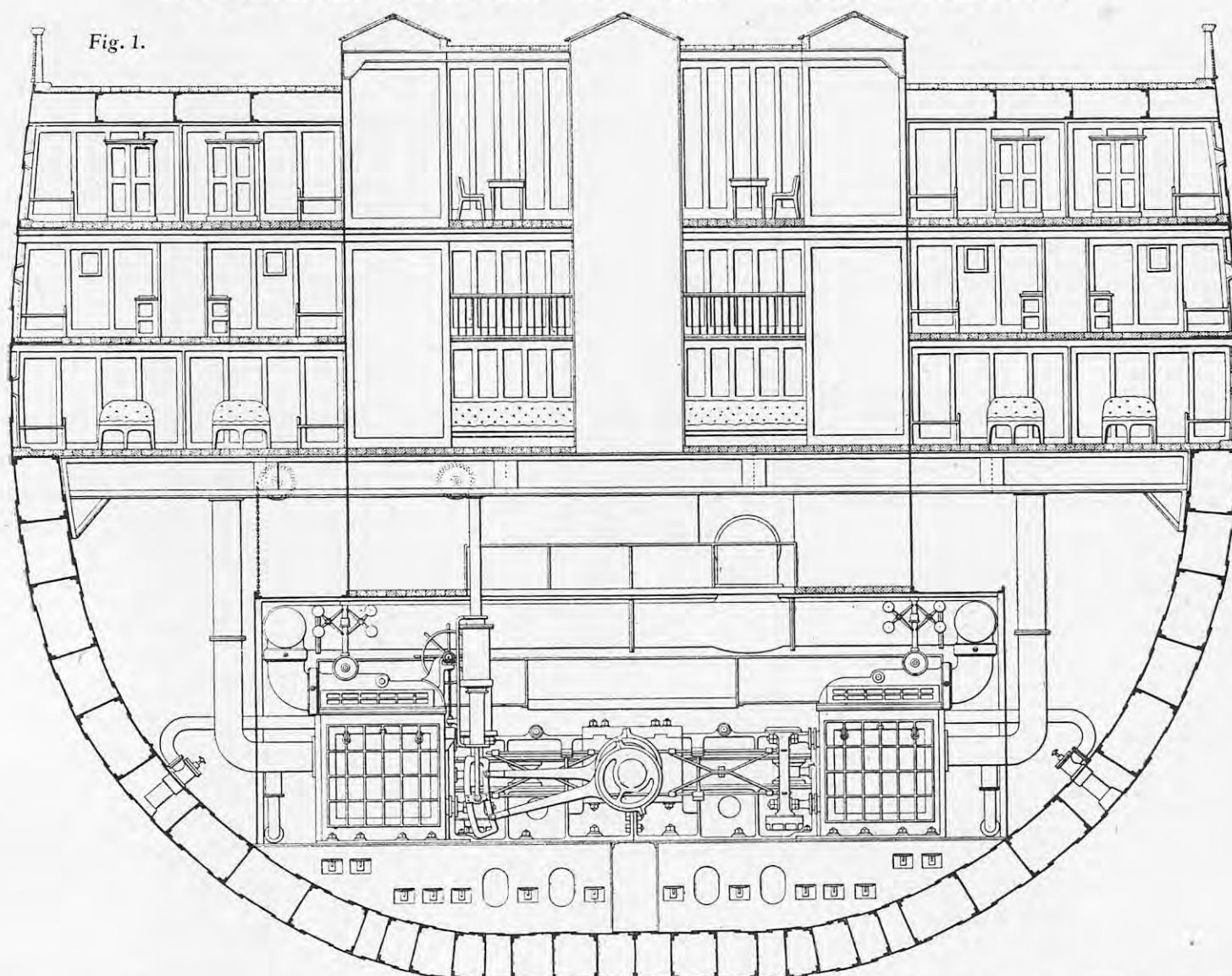
Stoppages of work in the United Kingdom, due to industrial causes, were slightly fewer in number during May last, but were of rather more serious a character. Altogether, there were 189 disputes in progress during the month, and, in them, some 57,700 persons were involved and about 190,000 working days were lost; while, during April, the number of disputes in progress was 192, but, in these, only 46,100 workpeople took part and the number of days lost was rather less than 152,000. During May, 1950, the total number of disputes in progress was 133, with 22,300 persons involved and 51,000 days lost. Strikes occurring during the first five months of the present year aggregated 736, against 636 during the corresponding months of 1950. In the case of the former, 180,800 workpeople took part and 904,000 working days were lost.

Two outstanding improvements in the working conditions of British coal miners were announced at the annual conference of the National Union of Mineworkers, which opened at Blackpool on Monday last. One of these improvements will provide two weeks' annual holiday with pay for all miners and will come into force from the beginning of next year. The present period of annual holiday with pay is one week and there has been considerable agitation, for some time past, that this should be extended to a fortnight. The other concession by the National Coal Board is the institution of a supplementary pension scheme for the industry. It is hoped that this scheme also will come into operation on January 1 next. A special delegate conference of the N.U.M. will be held in London on September 20 to discuss the details of the scheme and to make the final decision as to its acceptance.

The terms of the proposed pension scheme, as announced to the delegates at the annual conference, will provide for retirement pensions varying from 10s. to 30s. a week for miners aged 65 and over, in addition to the pensions under the National Insurance Acts. The proposals, as they stand, are expected to cost the National Coal Board a total of about 150l. million during the next thirty years, or an average cost of between 5½d. and 6d. per ton of coal produced. It was stated that the Board would borrow some 40l. million, of the 150l. million which it must provide, in order to meet the cost of that proportion of pension due to miners aged 47 and over, when the scheme comes into operation, in respect of their past services, and for which they have paid no contribution. The repayment of this loan will be spread over a number of years and the interest will amount to about 20l. million. The remainder of the total sum will be paid out at the rate of 3l. million a year in respect of the Board's share of the weekly contributions to the pension fund.

The Board's contributions will amount to 2s. a week each for underground miners and 1s. 8d. a week each for surface employees. The men will pay 1s. 6d. a week when employed underground and 1s. 3d. a week when engaged on surface work. The amount of pension drawn will vary according to length of service, with a minimum of 16 years for those employed underground and of 19 years for surface men. The attendance record of the individual and the extent to which he has been employed on surface or underground work will be taken into consideration. Provision will be made for cases of early retirement for reasons of ill health.

TRANSVERSE SECTION OF THE "GREAT EASTERN."



SHIPS' STRUCTURES: A CENTURY OF PROGRESS.*

By R. B. SHEPHEARD, C.B.E., B.Sc.

ONE hundred years ago, with the repeal of the Navigation Acts and the opening of sea-borne trade with this country to ships of all nationalities, British shipping was entering on a period of vigorous expansion. While, in 1851, steam packets were well established on the services of the General Steam Navigation, Cunard, Royal Mail, and Pacific Companies, only 4 per cent. of British tonnage was steam-driven, and the bulk of trade was carried in wood sailing-ships. Yet during the following 20 years the total British-owned tonnage was doubled, and had reached a figure of nearly 8½ million tons. Of the tonnage of new ships built in 1870, 66 per cent. were steam-driven, and 80 per cent. constructed of iron.

Structural arrangements of early iron ships followed all too closely those of the wood ship, though advantage was soon taken of the improved strength to increase dimensions. In 1853, the *Himalaya*, 339 ft. in length, the largest steamship then afloat, went into service. The 1863 Rules of Lloyd's Register for Iron Ships contain sketches of design commonly adopted at that period. It was natural that the great civil engineers of that time should apply their minds, unfettered by the traditions of wood shipbuilding, to the use of iron. Fairbairn, I. K. Brunel and J. Scott Russell designed or built iron ships, with particular attention to their efficiency as stressed floating girders. Fairbairn, who built about 100 iron ships on the Thames, realised the comparative weakness at the deck in ships of that period; and, in the *I.N.A. Transactions* of 1860, gave calculations of hull longitudinal strength on the beam theory, assuming the hull to be poised—rather unnaturally—on rocks. From his experience with tubular bridges, he suggested strengthening the decks by fitting

cellular boxes under the gunwale and abreast the hatchways.

Brunel, chief engineer of the Great Western Railway, early turned his fertile mind to ship design. His *Great Britain*, 296 ft. in length, built of iron in 1843, was transversely framed and arranged with two longitudinal bulkheads of full depth and five transverse bulkheads. She survived serious stranding on the North-East Coast of Ireland, which amply proved the strength of the structure.

Brunel will always be remembered in association with Scott Russell for the design and building of the *Great Eastern*, on the Thames between 1854 and 1858. She was 680 ft. in length, with cellular construction in the bottom, extending up to some 10 ft. above the load water-line, and with similar construction at the strength deck. Ten transverse bulkheads were fitted (Fig. 1, herewith). She was dogged by financial misfortune, but her structure was revolutionary and proved entirely successful. Scott Russell in 1862 presented a paper to the Institution of Naval Architects on his longitudinal system. Fig. 2, on page 26, reproduced from this paper, shows one of his ships so framed, the clipper *Annette* of 1861. The shell plating was supported by equally-spaced deep fore-and-aft girders with transverse frames and several bulkheads, the fully plated iron deck also being longitudinally stiffened. Nevertheless, the scientific thinking of these great pioneers had little effect on the trend of general development. The longitudinal system was not accepted, and progress towards increased structural efficiency by a better distribution of longitudinal material and elimination of redundant internal stiffening was long delayed.

There remained one final glorious period of wood and sail. The China tea clippers reached their zenith between 1860 and 1870. They were built on a composite system of wood planking on iron framing.

Two of the many famous ships in this service may be singled out—the *Thermopylae*, designed in 1868 by Bernard Waymouth, Principal Surveyor to Lloyd's Register, and the *Cutty Sark*, ordered from Scott and Linton and completed by William Denny and Brothers a year later, which now lies in the River Thames at

Rotherhithe. The opening of the Suez Canal in 1870 sounded the death-knell of the China clipper.

Wrought-iron plates were necessarily limited in size, and rarely exceeded 500 lb. in weight. By the nature of their manufacture, methodical testing was impracticable. Many complaints were voiced of the inconsistent and poor quality of the material, and, in some instances, of excessive corrosion. Crucible steel, with high tensile strength, was available, but unreliable, brittle, and very costly. Henry Bessemer took out his early patents in 1855, and Siemens some ten years later. By the early '70s, great progress had been made in the manufacture of ductile steel by the converter and open-hearth processes. Mild steel was used in France in 1873 in the building of warships, and in 1875 Nathaniel Barnaby appealed to British steel-makers to produce reliable mild steel on a commercial basis. "We want a perfectly coherent bloom or ingot of which the rolls have only to alter the form, and we look to manufacturers for it."

Steelworks rapidly grew up in this country and, as a result of special investigations, Lloyd's Register in 1881 established the system of tensile, ductility and bend tests, under supervision of their surveyors at the works, which has since remained essentially unchanged. This availability of reliable material of higher tensile strength than wrought iron, in conjunction with a permitted reduction of 20 per cent. in scantlings (steel thicknesses being conveniently expressed in twentieths of an inch in place of the equivalent sixteenths for iron) led to rapid progress in the size of ships, reduction of hull weight and valuable economies in building through the use of larger individual plates. It did not, however, herald any immediate advances in structural design.

The third great invention in steelmaking was due to Sidney Gilchrist Thomas, who in 1879 took out patents for the removal of phosphorus in the steelmaking processes by the use of "basic" materials; cheaper high-phosphorus ores could thus be used. Basic open-hearth steel soon became, and still remains, the chief source of supply for shipbuilding steel. The change over from iron to steel in shipbuilding was rapid.

* Paper presented at the International Conference of Naval Architects and Marine Engineers, London, on June 26, 1951. Abridged.

Whereas, in 1878, steel was used in only 8 per cent. of new construction, the proportion was completely reversed by 1890.

In the iron cargo ships of the '60s, the shell plating was gradually reduced in thickness from the heavy keel and bottom to the lower edge of the sheerstrake, which usually had the same thickness as the bilge plating. A limited reduction in the side shell plating only was permitted towards the end of the ship. Light stringers and tieplates were fitted below the wood decks. As the length of ships later increased, iron decks became more common, but in the awning and shade deck types, this uppermost deck was of lighter scantlings than the "main" deck. Fairbairn remarked in 1860 that "a ship should be constructed with the same proportion of strength upon her upper deck as at her keel"; yet this sound objective, and the implications of William John's 1874 paper on "The Strength of Iron Ships,"* had little practical effect until many years later.

Built-in bottom ballast tanks were first introduced in the Tyne steam colliers in 1852, for the purpose of eliminating wasteful loading and discharge of solid ballast on the service to the Thames. The most popular early design was the McIntyre tank, introduced about 1860, constructed with comparatively shallow fore and aft girders laid on top of the normal open floors, and most awkward for access and maintenance. The McIntyre tank gave place early in the present century to the transversely-framed double bottom, with full-depth plate floors, later modified with skeleton floors.

Typical early iron ships were fitted with several decks or tiers of beams; and the holds were further obstructed by large bilge and side keelsons and closely spaced pillars. Hatchways were small, and the holds were consequently much restricted and extremely awkward for loading. In the course of time, tiers of beams were replaced by deep webs and stringers in the cargo spaces, but were long retained in the forward panting area. In place of the built frame with reverse angle, rolled Z bars and bulb angles were developed, but the associated side stringers remained for many years. Close-spaced rows of pillars were replaced at the turn of the century by wide-spaced pillars supporting deep fore and aft girders, and by centre-line bulkheads acting as grain divisions. The earlier practice of fitting shallow horizontal and vertical stiffening to transverse bulkheads was superseded by vertical stiffening with deep horizontal girders. The experimental work of the 1914 Bulkhead Committee established scantlings for riveted bulkheads on a sound practical basis.

The process of clearing away ineffective material was greatly accelerated some fifty years ago through the application of "determinate" methods for assessing framing and similar scantlings, and particularly by the work of Foster King, Bruhn, and Isherwood. Foster King, in a paper to the British Association in 1925,† traced these developments with characteristic pungency. The story has also been concisely summed up by Bruhn‡: "Moment of resistance methods have gradually led to very considerable improvements in the distribution of material. It is only necessary to mention the transferring of material to the upper part of the structure, the regulation of the scantlings of frames and beams according to the length of unsupported span, the abolition of side stringers and of horizontal stiffeners on bulkheads, and the practical abolition of the fitting of hold beams and web frames for general strength purposes. In tank ships the moment of resistance methods have perhaps had even more effect in removing redundant material than in ordinary ships."

Internal structure in its simple functional form, and on the transverse system, finally emerged before the first world war, and this system of framing is still predominant. The Isherwood longitudinal system found no lasting favour in cargo ships, largely due to the loss of stowage through the deep side transverses. This rearrangement of material resulted in progressive and substantial savings in weight. A minor setback, however, occurred about 1900, when additional strengthening of bottom forward was found necessary from experience in ballast voyages with the fuller forms then fashionable.

Reliable estimates of the improvement in structural efficiency and carrying capacity over the years are complicated by changes in ships' characteristics at different periods, and the following illustrations should therefore be treated with reserve. The trend in

* *Trans. I.N.A.*, vol. 15, page 74; and *ENGINEERING*, vol. 17, page 276 (1874).

† "Scantling Developments in Iron and Steel Merchant Ships," by J. Foster King, *Brit. Assn.*, 1925; also *ENGINEERING*, vol. 120, page 305 (1925).

‡ "Efficiency in Ship Construction from the Strength Point of View," *Trans. I.E.S.S.*, vol. 67, page 560 (1923-24).

SHIPS' STRUCTURES.

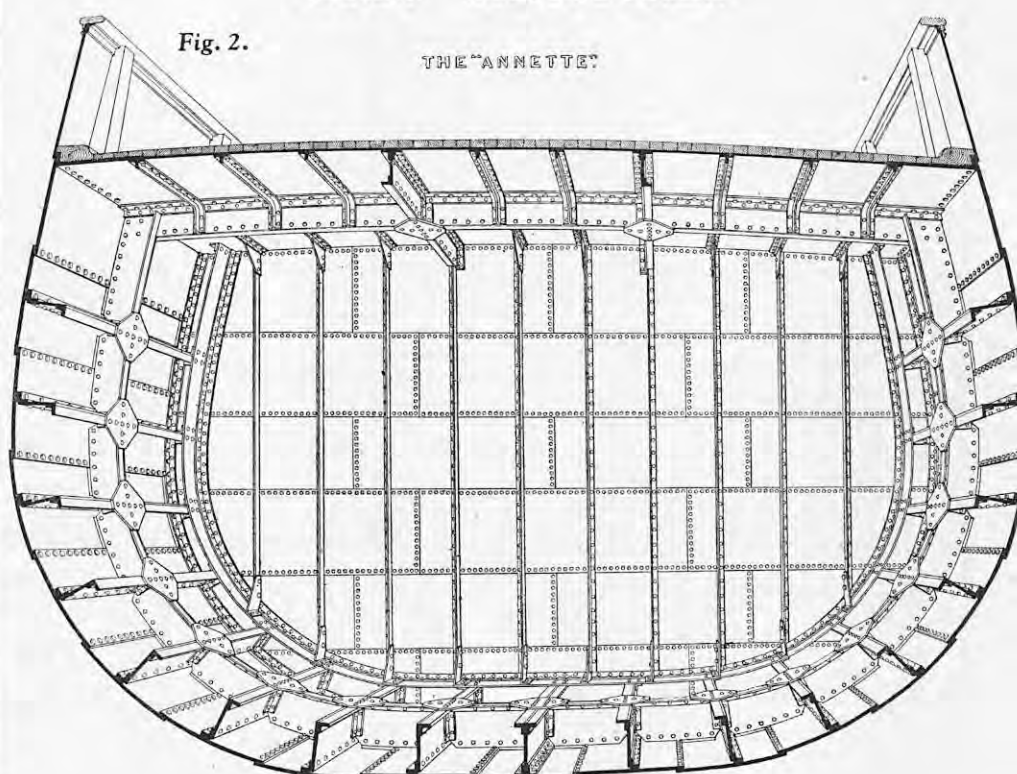
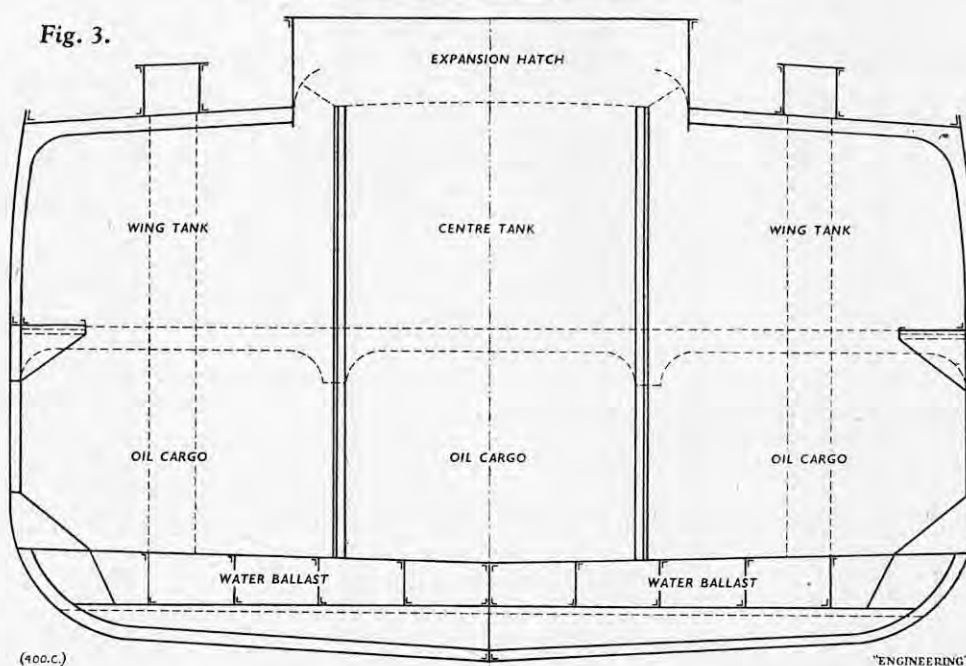


Fig. 3.



"girder" efficiency is indicated by the following table, which compares the midship section modulus ÷ area of two-deck steel riveted ships, 380 ft. by 50 ft. by 36 ft./28 ft. of spar-deck or open shelter-deck type, built to Lloyd's Rules of various dates. The 50-ft beam, however, does not represent modern practice; if this is increased to 53 ft., the figures are modified as shown in brackets.

Year.	Midship Section Modulus ÷ Area.
1880	Spar deck, 7.75
1909	Shelter deck, 8.25
1922	Shelter deck, 8.80 (9.4)
1948	Shelter deck, 9.00 (9.9)

An analysis has been made of the ratio of dead-weight/displacement for a number of representative riveted three-island and open shelter-deckers about 400 ft. long, and corrected, for comparison, to a common block co-efficient of 0.76. This reveals that a ratio of about 0.66 in 1880 has improved to 0.73 in 1920-25, with little change since that period. An examination of individual ships shows that the reduction in machinery weight at constant speed is largely offset by an increase in wood and outfit.

Compared with the earlier years, there remains little scope for reduction in the structural weight of

ships, except by the most effective use of welded design; and, pending the development of means to inhibit corrosion wastage, or of alternative structural materials. Classification Rules have been freed from restrictive or arbitrary limits, and now represent standards—which should be kept constantly under review—against which any individual proposal can be assessed. The 1930 Load Line Convention, which recognised these standards and established international agreement on freeboards and conditions of assignment, has proved a most effective instrument. Safety at sea, based on life and of property, has improved to a degree which might well have seemed unattainable in the days of Samuel Plimsoll and Benjamin Martell.

The design of ships for carrying bulk oil cargoes, and conforming in essentials to modern ideas, dates from 1886, when three memorable tankers were built on the North-East Coast. These were the Gluckauf, Bakuin and Loutsch, from the yards of Armstrong Mitchell, William Gray, and Hawthorn Leslie. The Loutsch, renamed Chaumian, still appears in Lloyd's Register Book, registered at Odessa.

The Loutsch, the structural arrangements of which are shown in Figs. 3 and 4, on this and the opposite pages, had two longitudinal bulkheads with tanks about 26 ft. in length, and expansion trunks, but with a ventilated McIntyre double bottom for ballast only. A cofferdam separated the tanks from the coal bunker, and the cargo pumps were fitted in a space forward.

SHIPS' STRUCTURES.

Fig. 4.

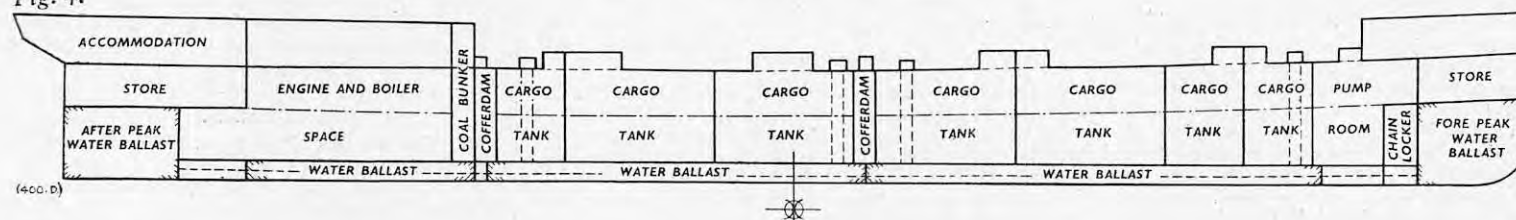


Fig. 5.

BENDING MOMENT FACTORS IN LOADED & BALLAST CONDITIONS FOR REPRESENTATIVE DRY CARGO SHIPS OF VARIOUS DATES OF BUILD & FOR CARGO LINERS

	LENGTH BEAM AND DEPTH	YEAR OF BUILD	TYPE	LOAD DRAUGHT, FEET	C _B	TYPE OF MACH ^y	FUEL, TONS		DEEP TANK, TONS	DISPLACEMENT, TONS		B.M. FACTOR			WEIGHT DISTRIBUTION DIAGRAMS	
							COAL	OIL		LOAD	BALLAST	LOAD HOG	BALLAST		LOAD	BALLAST
													SAG	HOG		
A	328 × 35.0 × 26.7	1874	3 DECK	20.0	0.74	STEAM	480	—	NO	4,950	2,720	31.8	30.0	—		
B	336 × 48.25 × 24.75	1925	POOP BRIDGE AND FORECASTLE	20.98	0.77	STEAM	1,205	—	NO	7,550	4,450	40.0	23.6	—		
C	335 × 47.83 × 32.67	1945	SHELTER DECK	22.08	0.69	STEAM	890	—	NO	6,980	3,950	35.3	30.0	—		
D	313 × 46.25 × 27.75	1947	SHELTER DECK	19.37	0.70	DIESEL	—	500	NO	5,600	3,120	33.0	39.0	36.5		
E	392 × 48.5 × 29.75	1901	POOP BRIDGE AND FORECASTLE	23.83	0.77	STEAM	1,390	—	700	10,010	6,770	40.0	25.0	—		
F	400 × 53.0 × 29.58	1917	POOP BRIDGE AND FORECASTLE	24.08	0.78	STEAM	1,080	—	870	11,380	6,395	40.7	22.1	—		
G	410 × 57.25 × 38.0	1943	CLOSED SHELTER DECK	27.5	0.75	DIESEL	—	1,240	430A 1,250 240F	13,915	7,350	34.8	30.2	—		
H	420 × 57.29 × 38.5	1946	SHELTER DECK	25.5	0.74	STEAM	1,360	—	NO	13,040	6,655	32.8	25.0	—		
I	416 × 56.87 × 37.33	1943	CLOSED SHELTER DECK	27.7	0.76	STEAM	—	1,820	660 648F	14,250	5,750	34.6	32.3	28.0		
J	416 × 56.87 × 37.33	1943	CLOSED SHELTER DECK	26.83	0.76	STEAM	2,550	—	715	13,770	8,270	31.3	23.5	—		
K	455 × 62.5 × 40.75	1944	SHELTER DECK	27.29	0.68	DIESEL	—	1,407	NO	15,175	7,685	34.0	35.0	31.0		
L	465 × 64.0 × 42.67	1944	CLOSED SHELTER DECK	29.81	0.67	STEAM	—	1,770	665	17,150	8,615	36.5	41.5	31.0		

(400.E)

Fig. 6.

BENDING MOMENT FACTORS IN LOADED CONDITION FOR REPRESENTATIVE TANKERS OF VARIOUS DATES OF BUILD

	LENGTH, BEAM AND DEPTH	YEAR OF BUILD	TYPE	LOAD DRAUGHT, FEET	C _B	PER CENT. LENGTH TANK SPACE EXCLUDING END COFFERDAMS	TYPE OF MACH ^y	FUEL, TONS		LOAD DISPLACEMENT, TONS	B.M. FACTOR SAG	WEIGHT DISTRIBUTION DIAGRAM
								COAL	OIL			
M	410 x 52-0 x 33-75	1898	EXPANSION TRUNKS CARGO 'TWEEN-DECK AND CENTRE-LINE BULKHEAD	25-5	0-795	53-4	STEAM	689	—	12,375	32-3	
N	395 x 51-5 x 30-75	1911	SUMMER TANKS AND CENTRE-LINE BULKHEAD	24-75	0-775	53-2	STEAM	—	820	11,170	34-2	
O	460 x 59-0 x 34-0	1935	TWO LONGITUDINAL BULKHEADS	27-5	0-785	66-6	DIESEL	—	786	16,800	45-5	
P	610 x 80-5 x 45-0	1950	TWO LONGITUDINAL BULKHEADS	34-00	0-785	64-8	STEAM	—	2,200	37,500	37-8	

(400.F)

"ENGINEERING"

Shell rivets were countersunk in way of the cargo tanks, and the seams double-riveted. Plans for this ship were submitted to Lloyd's Register at the end of June; she was launched in October and completed in December—a remarkable achievement.

Design in these early days was exploratory, and by no means standardised. In some cases, light shade decks were fitted over the main tank deck, and these apparently safely sustained the severe sagging stresses resulting from short tank spaces in relation to ship's length; the arrangement was followed in the later shelter-deck type. Gradually the single-deck design with centre-line bulkhead, expansion trunks and wing summer tanks became the accepted standard. The size of ships increased and deadweights of 10,000 tons were being carried in the early years of the century. Framing was arranged transversely, with numerous webs and stringers at the shell and bulkheads.

A venture of unusual interest was initiated in 1908 by the building of the *Iroquois*, a powerful twin-screw tanker of over 11,000 tons deadweight, designed for the ocean towage of the *Navajo*, 450 ft. B.P., which carried about 9,000 tons deadweight of oil but had no propelling machinery, and was rigged as a six-masted schooner. The pair, familiarly known as the "Horse and Cart," traded for many years on the North Atlantic, their success being largely due to expert seamanship and the special towing gear fitted. The partnership was finally broken in 1930, when the *Navajo* became a fuelling station; the *Iroquois* carried on alone till 1947.

Isherwood, in his historic 1908 paper to this Institution* described the first tanker built on his longitudinal system by R. Craggs and Sons, of Middlesbrough, the *Paul Paix*. The Isherwood system transformed the whole picture of tanker development. Determinate methods were applied in the design of a simplified structure, providing increased longitudinal strength and support to plating against secondary failure by buckling, with ample transverse strength and considerable saving in steel weight. The earlier erection difficulties with longitudinal construction were overcome in Isherwood's design, which made full use of hydraulic riveting, and permitted the erection of bulkheads and other internal structure in units limited only by the available berth lifting capacity.

The new system made rapid headway, but much attention was still given to improvements in transversely framed tankers, which retained popularity with many builders and owners. The great advantage of longitudinal framing at the bottom and deck has led in recent years to the universal adoption of this system in all ocean-going tankers. The summer-tank design, particularly susceptible to heavy corrosion, was superseded some 20 years ago by the single-deck type with two longitudinal bulkheads. This latter arrangement is well adapted to the "combination" system, in which the side shell only is framed vertically (and the longitudinal bulkheads also, where these are plane and not corrugated). Both the all-longitudinal and "combination" systems have fully proved their efficiency, though for the very largest tankers, the longitudinal is perhaps better suited.

Prior to 1908 the length of individual cargo tanks averaged 25 ft. 6 in. Lloyd's standard length of 30 ft. in 1924 has been increased recently to 40 ft., but tanks exceeding this length are now not uncommon. Tank length has been largely governed by experience of structural damage and leakage in heavy weather. Immunity from damage with the greatly increased tank capacities of the present time is due to improvements in internal design and connections, and especially through the proper use of welding.

The ratio of total tank space to length of ship has an important influence on longitudinal bending stresses. As Fig. 6, page 27, shows, this ratio has tended to increase, with beneficial reductions in the critical sagging moments. A figure of 0.65 is generally attained in modern large tankers.

Size and speed have grown during recent years. The 12-knot 12,000-tonner is being replaced by larger and faster ships, and many of 28,000 to 30,000 tons deadweight have been built since the war. Further growth seems likely to be determined more by restrictions on draught and docking facilities than by structural problems. The modern large tanker has capacity ample for a full deadweight of light spirit, permitting much flexibility when carrying heavier cargoes or in ballast. Excessive bending moments may consequently be imposed unless careful attention is paid to distribution of loading, especially on ballast voyages. This control becomes increasingly important in very large tankers.

In 1874, William John, then Assistant Chief Surveyor to Lloyd's Register, read his classic paper before this Institution on the strength of iron ships, to which reference has been made. He emphasised the "absence

of data on the margin of strains to which ships are subjected when floating among waves," and developed the method of assessing longitudinal bending moments which has remained the accepted basis of comparison to the present day. He expressed the results of his calculations for various types of warships and merchantmen by the familiar factor

$$\frac{\text{Displacement} \times \text{Length}}{\text{Bending Moment}}$$

which was originally due to W. J. MacQuorn Rankine.

John described the labour involved in these calculations as "enormous." Many simplifications have been developed by naval architects, such as the Biles "coffin" for approximate distribution of hull weight, and the use of "influence lines" in correcting basic computations for differences in loading. In recent years, attention has been focused on the separation of still water from the "standard" wave bending moments, and rapid and reliable methods for determining these components have been developed by J. Foster King* and J. M. Murray,† obviating the processes of double integration. Such methods are in constant use by Lloyd's Register, and have proved of great value in assessing the effects on bending moments of variations in design and in loading.

Longitudinal bending moments in loaded and ballast conditions for two series of representative cargo ships, about 330 ft. and 400 ft. in length, and of different dates of build, have been computed. The results, together with similar calculations for two modern cargo liners, are tabulated in Fig. 5, on page 27. The bending moments have been calculated on the usual assumptions that the ships are poised on a trochoidal wave having a height equal to one-twentieth of the length, the length being equal to that of the ship. The Smith correction has not been applied, since the results are given for comparison only.

The moments expressed by the factor Displacement $\times$ Length/B.M. have been computed for the conditions of the ship loaded with homogeneous cargo and with coal or oil fuel half burnt out, and in ballast departure condition, with all permanent and reserve bunkers and water-ballast tanks filled.

Notes on the individual ships are below.

A broad review of the two groups of cargo ships shows that, over the past 50 years, bending moments in the loaded condition have tended to increase. Factors which have influenced this trend include the change in type from three-island to shelter-deck, and increased speed. In ballast, the coal burner is subject to severe sagging moments; this condition is improved in the oil burner. In cargo ships of modern design, therefore, the more critical condition is hogging loaded, whereas in earlier coal burners this was sagging in ballast. For the cargo liners considered, it will be noted that the ships are hogging in the ballast condition.

In Fig. 6, on page 27, are shown similar comparative results for a series of tankers, with machinery aft, representative of various dates of build. Bending moments have been calculated on the same basis as for the dry-cargo ships, but for homogeneous loading only, and with one-quarter of the fuel burnt out; it being assumed that bunkers are filled at the loading port. The ballast condition has not been included.

Notes on the individual ships are as follows.

DRY CARGO SHIPS.

A.—Similar to that considered by John in his 1874 I.N.A. paper; the calculations are, in effect, a reconstruction of his results. John assumed a 12 ft. height of wave; the present calculations have been made for the conventional 16.4 ft. height. Making allowance for this difference, there is substantial agreement between the two sets of calculations.

B.—In this three-island coal burner, the ballast factor is severe.

C and D.—Modern shelter-deckers of the type now common in the Mediterranean and similar trades. The favourable ballast factors for D—a Diesel-driven ship—are due to the small capacity of the oil-fuel bunkers amidships.

E.—Typical of the large three-island tramp built at the beginning of the century. The deep tank amidships affects the severity of the ballast condition.

F.—A typical three-islander of the period; here again the ballast factor is influenced by the deep tank in addition to the coal concentrated amidships.

G.—A Diesel-driven closed shelter-decker, with about 1,000 tons oil fuel carried in the double bottom, and 270 tons only in the midship bunkers. Ballast tanks fitted in the wings at the after end of No. 1 hold and at the tunnel sides—an arrangement adopted in a number of war-built ships—also ease the balance factor.

H.—A modern shelter-decker, unusual in that she is a coal burner.

I.—A "Liberty" ship. In making the computation for the ballast condition, the deep tanks in No. 1

hold have been assumed empty. If these tanks are filled, the hogging moment is substantially increased.

J.—In this "Ocean" ship, the influence of the large amount of coal is reflected in both the load and ballast factors. She is typical of a number of war-built ships, many of which have since been converted to oil burning.

K.—A Diesel-engined cargo liner; the ballast condition is relatively favourable.

L.—A turbine-engined "standard" cargo liner.

TANKERS.

M.—The two-deck arrangement with expansion trunks common at the time.

N.—This type, with summer tanks and centre-line bulkhead, was popular for many years.

O.—A size of ship, with two longitudinal bulkheads, which has been widely adopted.

P.—Representative of the large modern tanker.

Buckling of deck plating has attracted attention since the earliest days of iron and steel shipbuilding. William John, in 1877,* emphasised the importance of regulating scantlings to withstand compression as well as tension. He examined the case of a 210-ft. iron paddle steamer which, when steaming slowly across a long easy swell, suddenly broke off at the fore end of the engine space and went to the bottom. He showed the sagging to be the critical bending moment, and that, on the assumptions made, the compressive stress in the deck exceeded the crippling strength of the plating determined by Rankine's formula.

In the early years of the present century, the practice of making ballast voyages with a concentration of weight in coal bunkers and deep tanks amidships became increasingly common, and cases of buckling of decks were reported. The ships affected were generally of the awning-deck type, having beams on alternate frames at the strength deck. As a result of these failures, the requirement was introduced that beams should be fitted at every frame on all unsheathed strength decks.

During the first quarter of the Twentieth Century, concentration of loading in ballast voyages grew in severity, and the minimum thicknesses of unsheathed deck plating were increased. The subject was closely investigated by Montgomerie, who carried out experiments on samples of deck plating under compression. The results were then related to experience of ships in service, and a suitable criterion for the necessary thickness of plating and strength of beams to resist buckling was thus derived.† The experience of Lloyd's Register since that time has confirmed the validity of these conclusions. Additional data on actual crippling stresses were contributed by W. Thomson, who showed‡ from an analysis of the stresses in ships which had stranded and failed through buckling of the decks, that Montgomerie's basic curve held good for these static conditions.

It has been shown that the hogging moments in dry-cargo ships have tended to increase. While this trend, coupled with the progressive increase in plating thicknesses, has reduced the liability of compressive failure at strength decks, it has resulted in a decided increase in the possibility of deflection of bottom shell plating. Evidence of undue compressive stress in bottom plating has been observed primarily in welded transversely framed ships which have been in service for several years. Instability of plating under compression seems to have been enhanced in these ships through the initial deflection of the shell plating between the floors, caused by thermal contraction at the fillet welding. This deflection, in some cases, has been sufficient to lead to progressive increase in unfairness, during which plastic flow takes place. The gradualness of the process provides a safeguard, but the efficiency of the plating is impaired.

This problem, which has only in recent years become acute, is being attacked in three directions: by a systematic analysis of the loading of ships in service, from theoretical investigations of the efficiency of deflected panels of plating, and by experimental work. Compression tests on full-scale specimens of double-bottom structure, both riveted and welded, are now being made by the British Shipbuilding Research Association, in association with Lloyd's Register, to determine more completely the mechanism of behaviour of plating panels and the effects of variation in their thickness and arrangement of the supporting framework. Increased strength and economy of weight from the longitudinal system at the bottom and deck have long been realised in tanker design; traditional practice must be held largely responsible for retarding a similar development in the dry-cargo ship.

(To be continued.)

* "The Strains of Iron Ships," *Trans. I.N.A.*, vol. 18, page 98 (1877).

† *ENGINEERING*, vol. 137, page 553 (1934).

‡ "Some Cases of Failure of Deck Plating Under Compressive Stresses Due to Stranding," *Trans. I.N.A.*, vol. 87, page 71 (1945); and *ENGINEERING*, vol. 159, page 518 (1945).

* "A New System of Ship Construction," by J. W. Isherwood. *Trans. I.N.A.*, vol. 50, page 115; and *ENGINEERING*, vol. 85, page 505 (1908).

* "Longitudinal Bending Moments," *Trans. I.N.A.*, vol. 86, page 214 (1944).

† "Longitudinal Bending Moments," *Trans. I.E.S.S.* (1947).

NOTES ON NEW BOOKS.

Geology of the District North and East of Leeds.

By WILFRID EDWARDS, M.A., G. H. MITCHELL, D.Sc., and T. H. WHITEHEAD, M.Sc., A.R.C.S. Department of Scientific and Industrial Research, Memoirs of the Geological Survey of Great Britain. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 7s. 6d. net.]

THIS typical memoir of the Geological Survey of Great Britain describes the area covered by the Leeds Sheet No. 70 of the new series of one-inch to the mile geological maps, i.e., the north end of the Yorkshire, Derbyshire and Nottinghamshire coalfield. A brief account of the area was given in a small memoir on Leeds and Tadcaster, published in 1870, and the carboniferous rocks were more fully treated in the *Geology of the Yorkshire Coalfield* in 1878. As a result of the re-survey carried out between 1931 and 1938, considerable advances have been made in the study of the stratigraphy of the Millstone Grit, the coal measures and the Permian series of rocks. Detailed mapping of the Pleistocene drifts has revealed several features of interest, and has resulted in substantial progress towards a fuller understanding of the glacial history of north-eastern England. The industrial part of the area involved lies almost entirely in the south-west, within the boundary of Leeds, and, although situated on coal measures, the area derives most of its fuel from the more productive parts lying farther south. The thick seams of the area are now largely exhausted and only one large colliery is at present raising coal within the sheet-boundary, though others have pushed their workings across the southern edge. The few feet of ironstone-bearing mudstone, which form the roof of the Black Bed coal, have been worked extensively in the past on the east side of Leeds. Ironstones of similar nature occur at various horizons in the carboniferous rocks of the district, but these have not been worked since very early times. Besides coal and ironstone, the carboniferous rocks have provided building stone, brick-clay and fireclay, and contain coarse-grained sandstones, suitable for crushing to sand and concrete-aggregate. The Permian rocks, formerly a source of building stone, yield lime and contain gypsum. Copious references are appended to each of the nine descriptive chapters covering the general and economic geology of the area, and the general presentation of this 93-page memoir is of the usual high standard.

The Steam Locomotive of To-day: Its Construction, Operation and Upkeep.

By M. P. SELLS, O.B.E. The Locomotive Publishing Company, Limited, 88, Horseferry-road, London, S.W.1. [Price 10s.]

THERE may be too many general and popular books on locomotives, but, surprisingly, there are not many good up-to-date books for engineers. Though steam-locomotive design is well along the asymptotic curve of development, changes in details, especially proprietary parts, create a demand for the revision of existing books or the publication of a new book. Major Sells's work is a substantial revision of a book published in 1936 under the title *How the Locomotive Works and Why*, part of which was originally prepared for the African locomotive running staff of the Nigerian Government Railways. As one-time chief mechanical engineer of that system and of the Rhodesian Railways, he is versed in the difficulties of training the engineers of overseas railways, and a reasonable proportion of his book is devoted to practical running matters. There are also some notes on workshop practice dealing with, for example, tolerances and allowances, scrapping sizes, metal mixtures, the maintenance of superheater parts, and the electric welding of frames, steel fireboxes, tubes, patch plates, cracks, etc. These notes, as the author is careful to point out, are based on his experience and do not necessarily conform with practice on other railways. On page 2 the author seems to be unaware that the initial letters of the elements carbon, hydrogen, oxygen, nitrogen and sulphur are used as the chemical symbols; Fahrenheit and Centigrade are temperature scales, not types of thermometers (*vide* page 6); and (on page 73) a 3-ft. wheel makes twice, not three times, the revolutions of a 6-ft. wheel at the same track speed. The book is provided with ample illustrations, including several folding plates, and is well worth the 10s. of a driver, fireman or cleaner; or, indeed, of a pupil or apprentice who is determined to study locomotive practice as well as theory.

WOOLWICH POWER STATION.—Consent to the extension of Woolwich power station has been received from the Minister of Fuel and Power by the British Electricity Authority. The extension comprises one 30,000-kW turbo-alternator and two boilers each of an evaporative capacity of 180,000 lb. an hour, which will bring the total installed capacity of the station up to 133,250 kW.

PROPERTIES OF MATERIALS AND ENGINEERING USES OF CAST METALS.*

By R. W. BAILEY, D.Sc. (Eng.), Wh.Sc., M.I.Mech.E., F.R.S.

THE choice of a material for any purpose whatever must, of course, be dependent in some measure upon the material's properties, including cost as a property, but for engineering uses the term properties has generally a restricted range, and usually refers to such qualities as strength, elasticity, ductility, ability to withstand repeated loading and shock, which would ensure reliability under operating conditions of loading and temperature. In addition, there are such physical properties as density, thermal expansion, thermal conductivity, electrical resistance and magnetic properties, any one of which may be of high, and in some circumstances of dominating, importance. Since most engineering structures have to be designed to transmit loads, strength would generally be given priority in importance, with ductility as a partner, but one of quite uncertain significance concerning the over-ruling requirement of reliability, and one which, in my view, is frequently over-valued as a property as distinct from the indication it may give of an abnormal and unsatisfactory condition. In view of the importance attached by engineers to strength and ductility attention is given first to these properties.

The high importance attached to strength (usually tensile strength is understood, since strength in compression would always be greater than in tension) is because more than any other property it determines the cross-sectional area of a part, whether the loading is static or variable. This is so when it is variable because the fatigue resistance bears a ratio to the tensile strength, termed the endurance ratio, commonly 0.4 to 0.5 for a wide range of metals. It is unusual, however, to base design directly upon fatigue-test data since failure in practice would depend so much upon other factors, such as the character of the disturbing forces, and the effects of notches and the surface condition. Consequently, experience with a particular kind of part in service is of much greater importance in determining permissible nominal variable stress. Hence, strength remains the dominant property. Despite the information yielded by failures of parts in service, where frequently ductility has clearly played little or no part, most engineers have a feeling that ductility confers greater security. Therefore, before considering the engineering possibilities of cast metals from the standpoint of strength, it will be as well to inquire what measure of assured ductility is really useful in practice.

That the essential ductility must be quite small for most engineering uses is evident if one considers the case of hardened gears in, say, motor vehicles, which are subject to high loading of a repeated kind and heavy shocks at times, with stress concentration present. Here a tensile test would show not more than 1 per cent. extension including the elastic strain, which would constitute the greater part. A virtue assigned to ductility, or plastic strain, is that it accommodates stress concentrations and thus prevents the high stress values which would occur without plastic strain. But a stress of, say, 40 tons per square inch, and a stress concentration factor of 3, bringing the unrelieved stress to 120 tons per square inch, could have the difference between, say, 80 and 120 tons per square inch accommodated by an extension of $(40 \div 13,500) \times 100$, or by slightly under 0.3 per cent. It will be clear from this example that an assured ductility of 1 per cent. extension is likely to be adequate for safety in most engineering uses, but, of course, commonly more would be welcome, and would be essential in special cases, as, for example, lifting chains and gear. There is, however, a considerable difference between small essential magnitudes, and those generally specified for wrought materials, which, understandably, tend to create a scale in the minds of engineers when considering castings.

Leaving out brass and bronze castings, often chosen for properties other than strength, the serious entry of castings, as an alternative to wrought parts, occurred with the production of steel castings. The choice was between the same, or very similar materials, in the cast and wrought forms. In this connection the question naturally arises, what is the influence of forging? The answer from experience is that, given clean and sound material, there is frequently little or no influence. The improvement often found with forging arises from its action in rendering a defective condition less harmful, though the condition may be in nowise an abnormal or remediable one. This may be exemplified by the case of a large rotor forging, where the

reduction, by forging, on the body is 2.5:1 on the cross-sectional area, and at each shaft end 20:1. The physical properties by tensile test, are given in Table I, the positions of the test pieces being shown in Fig. 1, on page 30. It will be seen that the properties at the axial position of the body, and at the shaft, are equally good for the end near the bottom of the original ingot. That a steel casting can give the properties of a high-class forging when the metal is clean, and segregation is negligible, is shown by the results of tests upon a large flywheel, cast in the usual sand mould. The results of tests are shown in Table II,

TABLE I. Properties of Forging Test-pieces.

Test Piece.	Ultimate Tensile Strength, Tons per sq. in.	Yield Point, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.
TL	45.6	25.5	20.0	39.2
TR	45.0	25.0	17.0	30.6
TX	45.8	26.0	18.0	24.6
BL	42.5	24.0	23.0	41.9
TC	47.5	25.5	18.0	36.4
MC	47.8	26.0	8.0	10.0
MC2	41.5	23.5	6.0	11.7
BC	39.6	21.5	28.0	41.9

TABLE II.—Physical Test Figures for High-Quality Cast-Steel Flywheel.

Test Piece.	Ultimate Tensile Strength, Tons per sq. in.	Yield Point, Tons per sq. in.	Elongation, Per cent. on 2 in.	Reduction of Area, Per cent.	Bend Test.
A	37	22	27	45	180 deg. unbroken.
B	36.5	22	27	46	180 deg. unbroken.
C	37	22	25	36.4	180 deg. unbroken.
D	36.5	22	29	48.8	180 deg. unbroken.
E	37	23	27	50	60 deg. broken.
F	37	23	26.5	50	180 deg. unbroken.
G	37.25	23	28	50	180 deg. unbroken.
H	37	22	17.5	30.8	180 deg. unbroken.

and the positions of the test pieces are shown in Fig. 2, on page 30. Experience in both cases shows that ductility is reduced by segregation, and that, in the case of a forging, ductility may be improved by a sufficient degree of reduction by forging. As an example of a high-duty non-ferrous metal casting, a high-tensile manganese-aluminium brass retaining ring for a single-phase turbo-alternator may be cited. The dimensions of the ring are shown in Fig. 3, on page 30, and the percentage chemical composition is as follows: copper, 64.4; zinc, 26.5; iron, 1.5; manganese, 1.8; and aluminium 5.3. The yield point of the material was 32.8 tons per square inch; the ultimate tensile strength 44.5 tons per square inch; the elongation on $4\sqrt{A}$, 9 per cent., and reduction of area 13 per cent.

Such rings have been superseded by non-magnetic steel forgings, "warm worked" to a tensile strength of 60 tons per square inch. The few cases of failure in service of these non-ferrous castings were not due to any casting defects, but to intergranular cracking of the "season cracking" type, the most serious in the lecturer's experience having been traced to the presence of ammonia in the atmosphere at the power station concerned, due to the proximity of a manure and fertiliser works. In Fig. 4, on page 30, is seen a microphotograph showing a typical crack in this case. These examples will suffice to show that engineers have confidence in castings operating under severe conditions, provided the material has the requisite strength, cleanliness and assured ductility.

So far, working temperature has not been mentioned, and as tests are commonly made at atmospheric temperature, it is usual to think of material properties at this temperature. But, of course, there is a considerable field of usefulness for castings at elevated, and indeed, quite high temperatures, where, if they possess the necessary strength and reliability, they may not only offer an alternative to wrought material, but in some cases they may be constructionally and economically superior. The ability of metals to withstand loading in service at elevated temperatures is dependent upon the extent to which they undergo permanent deformation or creep, under load, and a very extensive field of special testing, as you will know, has come into existence during the last thirty years to determine the behaviour of metals in this respect. The phenomenon is not in itself very new, and foundrymen have long been aware of one aspect of it in the distortion of castings and the use of a seasoning period or treatment to minimise its ill effects. Indeed

* Edward Williams Lecture delivered before the Institute of British Foundrymen on Wednesday, June 13, 1951, during the Institute's 48th Annual Conference at Newcastle-upon-Tyne. Abridged.

ENGINEERING USES OF CAST METALS.

Fig. 1.

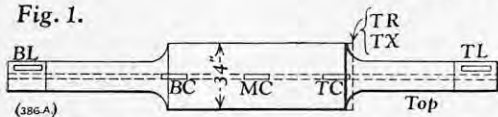


Fig. 2.

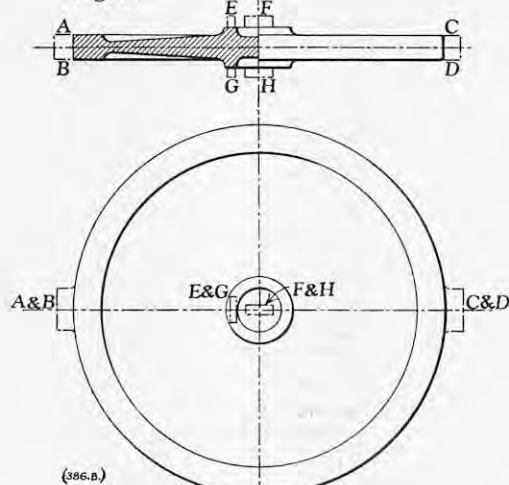
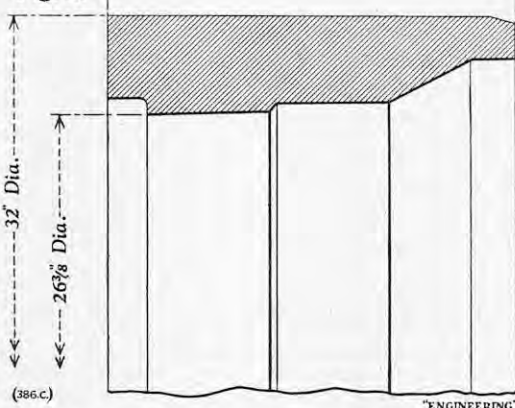


Fig. 3.



one of the great early pioneers in testing the properties of cast iron, E. Hodgkinson, who was responsible, as you will know, for a well-known formula for the strength of cast-iron columns, and who also settled the cross-section proportions of cast-iron beams, must have been one of the first, perhaps the very first, to make creep tests. He measured the progressive shortening of a series of cast-iron columns under different loads, and their life to failure. The results of his tests were reported in the year 1840, and Fig. 6, opposite, reproduced from Hodgkinson's Royal Society Paper, illustrates his tests. Now, vast numbers of tensile creep-testing machines are in use and are being added to all over the world, to meet high-temperature needs, but they are mainly applied to the testing of steels and heat-resisting alloys. Nevertheless, Hodgkinson's work on cast-iron pillars is historic and I would quote his words. "In all the previous experiments, the pillars were broken without any regard to time, and an experiment seldom lasted longer than one to three hours. There might, therefore, be considerable doubt upon the minds of many persons whether the results obtained would be consistent with those which would arise from long-continued pressure. At my suggestion, therefore, Mr. Fairbairn had the apparatus erected, by which pillars might be permanently loaded."

Two circumstances in our times which should have created a rational perspective regarding the significance of strength, microstructure and ductility of cast *vis-a-vis* wrought metals, are the behaviour of metals at elevated temperatures, and the advent and wide use of electric-arc welding. Both these developments violate earlier ideas of what appeared desirable, and what should be approved or disapproved. Together, they provide a reasonable background against which properties and the engineering uses of cast metals may rationally be judged. Let us first notice the behaviour of metals at elevated temperatures. At temperatures where creep operates, short-time tensile tests may show good strength with unimpaired ductility at fracture, but at lower stresses, failure in a long time may occur at much reduced ductility. This is particularly so in the case of materials of high resistance to creep, which would, therefore, be chosen for parts employed for

strength at high temperatures. Low ductility in this case results from inter-crystalline cracking which supervenes before large deformation has developed. Commonly, the long-time ductility of the material used for high-temperature plant would not be more than a few per cent. extension. Safety against failure has to be provided by the margin this ductility has over that which takes place, and which, by design, is limited by the working stress. Fig. 5, herewith, shows characteristic intergranular cracking of a high creep-resistant 0.5 per cent. molybdenum steel under tension. Thus, wrought materials possessing high ductility as shown by the usual short-time tests, may really operate under conditions causing the ductility at failure to be low and the normal ductility by short-time test to have little or no practical significance when operation is considered. The position of cast metals for high-temperature service should, therefore, be judged from this more favourable standpoint.

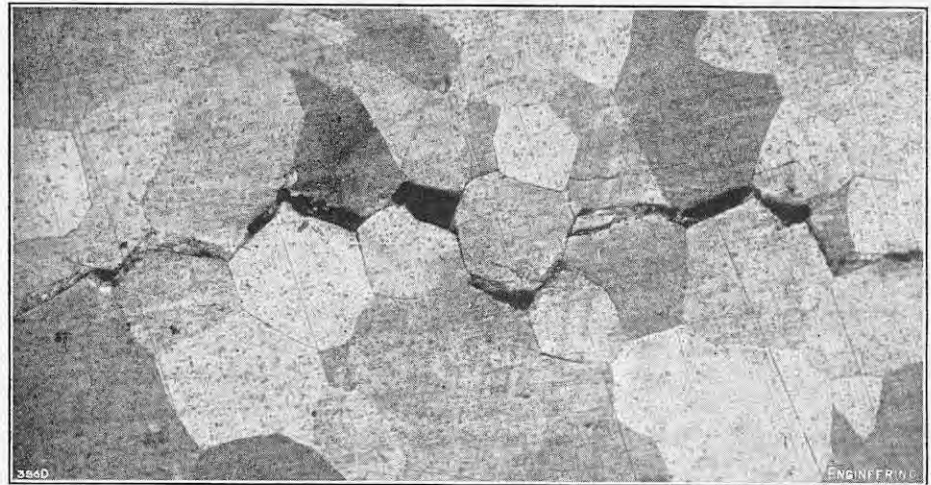
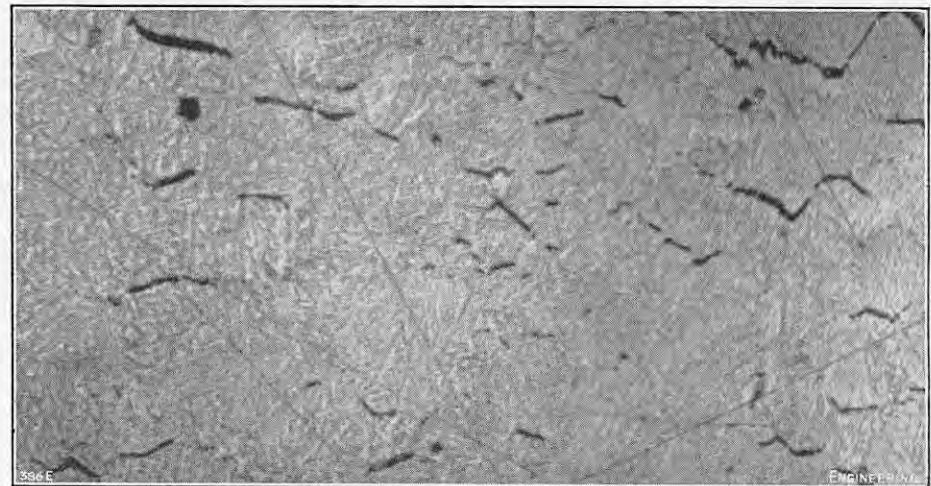
A corresponding modification of views is to be expected from the widespread adoption of welded structures. Electric-arc welding has brought with it a wide range of microstructure and often residual stresses which have now to be accepted, although many metallurgists of, say, two decades or so ago, would have been greatly disturbed by their presence in structures of wrought materials. This must have compelled the conclusion, in practical minds, that microstructure, provided it does not reveal a dangerous feature, is in many cases of small importance in itself, that it is upon effective physical properties that the suitability of a metal part rationally depends, and that it should be judged upon this basis. Hence the high importance of properties of materials in assessing engineering uses of cast metals. An outstanding example showing a full appreciation of the importance of material properties in influencing the engineering use of a cast metal is furnished by the work done to improve the strength and ductility of cast iron, and particularly in investigating the use of cast iron for crankshafts of internal-combustion engines.

Crankshafts have rightly been regarded as a most vital component of engines, subject as they are to high loading of a repeated or cyclical character producing torsional and bending stresses, associated frequently

with forced and sometimes synchronous vibration of both kinds. The essential form of the part involves regions of high local stress which can only be mitigated but not removed by skilful design and generous fillets. Moreover, good resistance to wear at journals is important. Material properties of a high order, such as strength, ductility, surface hardness, notch-bar value, notch insensitivity and fatigue resistance were looked for in forged-steel shafts, and by many engineers they were regarded as essential. Clearly, however, the successful operation of cast-iron crankshafts has assisted in creating a more reliable perspective regarding the significance of these properties, and this has been made more precise by the extensive investigation of the materials used.

Next to strength and ductility, or, more widely, the ability of a material to deform safely in service, the ability of a part to withstand repeated, fluctuating, and reversing stresses is a property of great practical value. It is covered generally by the term fatigue, and a vast amount of fatigue testing of metals has been carried out over the years, of which only a small part can be said to have had much influence upon the choice and use of materials. This is because test pieces frequently are not strictly representative of actual parts in material, surface condition and scale. They are employed, however, to measure or investigate a material property which has usefulness for comparative purposes, but is rarely a basic factor in design. Nevertheless, it may influence practice in manufacture, as may be seen, for example, in the adoption of a surface treatment to increase resistance to fatigue failure. Parts should not normally fail by fatigue, but they do at times, and most frequently the cause is stress arising from vibration at a critical or natural frequency, faulty design producing high stress concentration, or the presence of a defect or defective surface condition. A case may be cited where fatigue failure of a steel shaft resulted from an electric welder touching the shaft with his live electrode. Change in design is usually the only satisfactory remedy, and as this is generally possible it is the course commonly followed.

In connection with fatigue, the subject of the internal damping capacity of a material or its property of

FIG. 4. INTERGRANULAR CRACK IN CAST MANGANESE-ALUMINIUM BRASS. $\times 25$.FIG. 5. INTERGRANULAR CRACKING IN MOLYBDENUM STEEL. $\times 100$.

ENGINEERING USES OF CAST METALS.

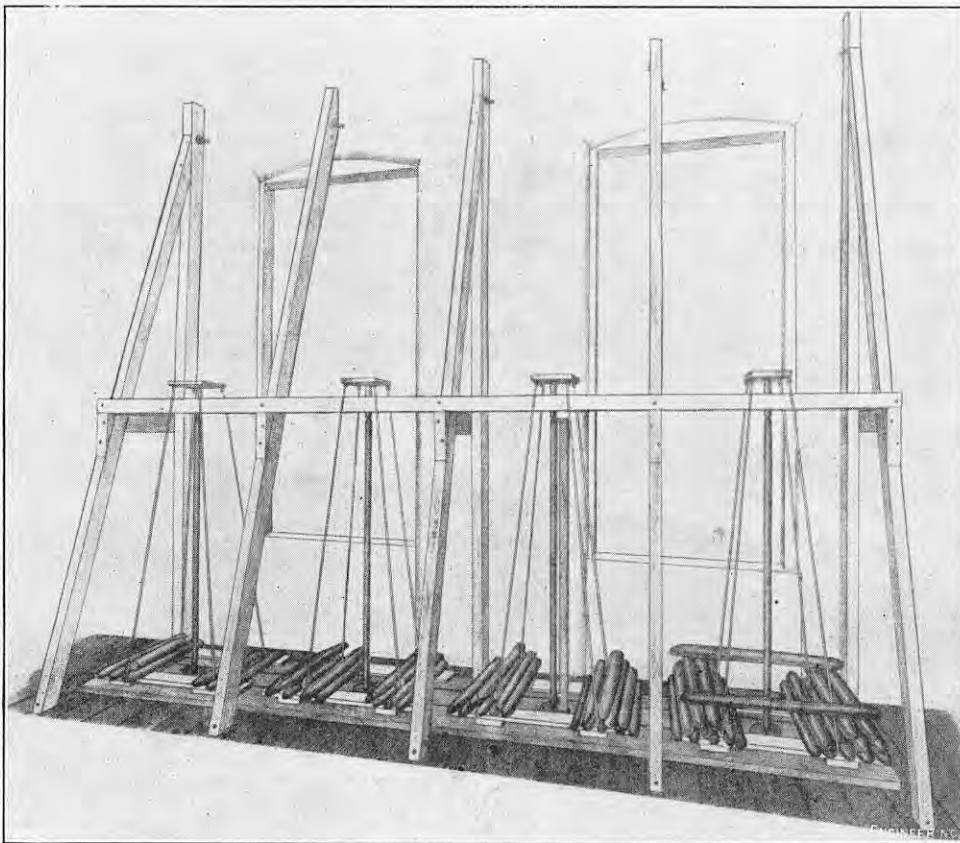


FIG. 6. APPARATUS FOR TESTING CAST-IRON COLUMNS IN 1840.

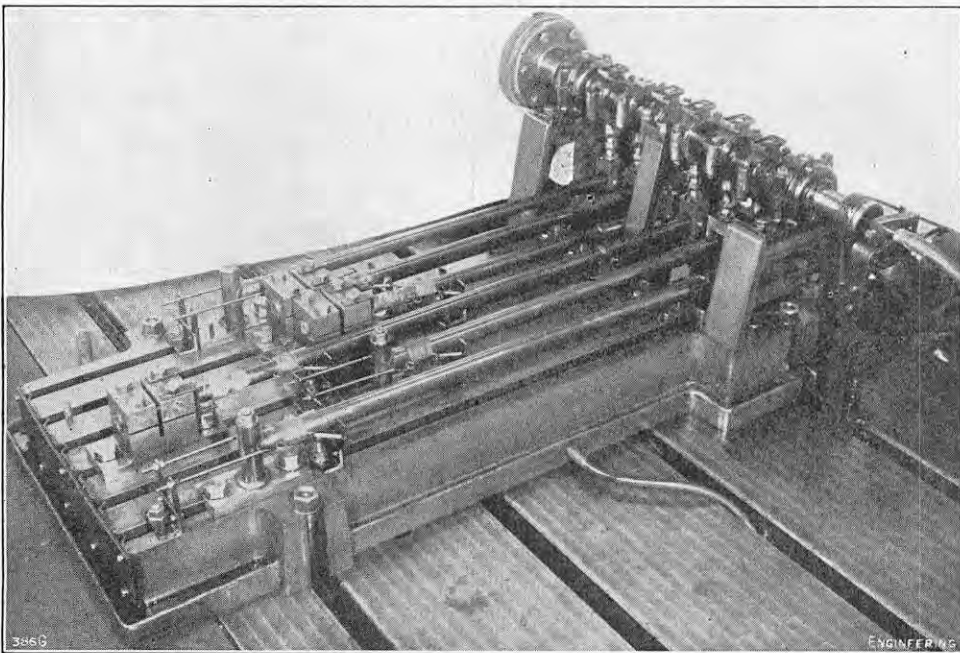


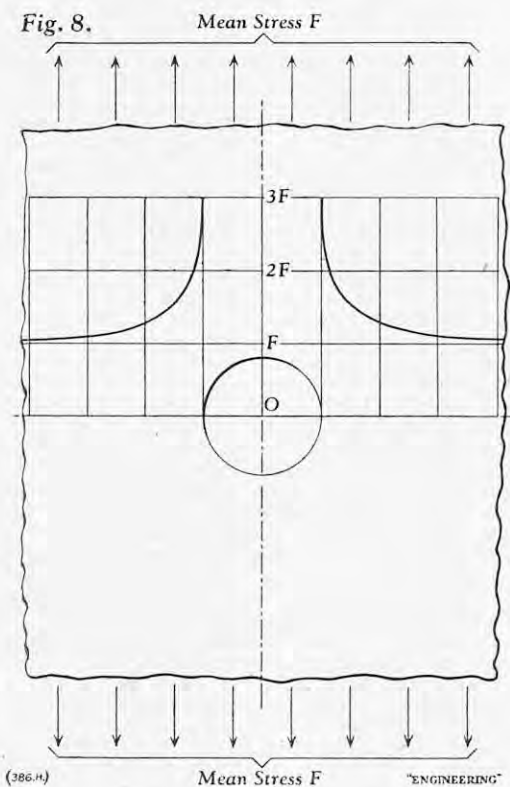
FIG. 7. SIX-UNIT REPEATED-STRAIN TESTING MACHINE.

absorbing energy—as by internal friction—under cyclic stress, is continually cropping up. Damping capacity has considerable scientific interest and value in the physics of metals, but because its amount is usually small compared with that contributed by constructional and operational features of machines and machine parts, it has very little influence in engineering practice, and none in my experience in determining the choice of a material for a particular part.

It should not be assumed from the above remarks upon the fatigue resistance of a material, that fatigue is a property of little importance. Fatigue testing becomes of very considerable practical importance when it is applied to actual parts, and therefore when it makes an approach to the conditions which occur in engineering practice. Here the factors of material, surface condition, design, and perhaps the character of the loading, are present, and the test becomes an endurance test under the special conditions determined by these factors in association. Strain-gauge technique

may in some cases be utilised to enable actual stresses to be measured, but usually the intensity of the loading can be represented by a nominal calculated stress, which can be utilised for design.

An extremely useful type of fatigue-testing machine is one in which a movement of controllable amount can be imposed upon the part under test, to determine the loading. A valuable feature of this type is that it imposes a specific strain, as distinct from a specific load or stress. Frequently such machines are simple and readily constructed. A good example of this type of machine has been applied by the Motor Industry Research Association for investigating cast-iron crankshafts. In this, a single-throw crank of standard form is tested stationary. One side is held firmly by a clamp, and the shaft at the opposite side has an extension the end of which is displaced up and down, thus subjecting the crank webs and pin to bending. The movement is applied by a vertical rod and is derived from an adjustable eccentric mounted on the



driving shaft below the crankshaft. Fig. 7, herewith, shows a battery of six cantilever mechanically-operated repeated-strain testing units, installed by the Metropolitan-Vickers Electrical Company, in which the displacement and loading applied by each machine are derived from an eccentric of fixed eccentricity. The load and displacement are varied by altering the length and flexibility of the cantilever, and thereby the strain and bending moment it transmits to the part or material under test are determined.

Reference has been made to the applied-strain type of machine because cast materials can often best be judged in comparison with wrought metal for engineering parts by tests of this kind when fatigue or repeated strain is the criterion. This is because frequently failure, if it occurs, will take place where there is a gradient of stress and strain, as at a fillet or hole, and the strain which may lead to failure is likely to be partly plastic and partly elastic. The accompanying stress will be determined by the stress-strain characteristics of the material, which will be different with different materials. A shaft rotating in three bearings with a specific misalignment would be a case of applied strain. Many parts which appear to fail by fatigue, do so not under millions of applications of stress, as in the common fatigue test, but under a comparatively small number of applications of excessive strain. It is the large pot holes and heavy bumps which most damage a road vehicle spring. The ordinary fatigue test and fatigue-test results throw little useful light on the important property of a material to withstand repeated heavy strain without developing a crack. This property is best investigated by the applied-strain type of machine. A cast material having good behaviour in this respect would have substantial claims for use as an engineering material. A measure of ductility is clearly needed, but it should be ductility which allows a large number of cycles of strain to be withstood safely—a descriptive but inelegant word for this property would be “concertina” ductility.

The recent improvements of cast irons resulting in a measure of ductility and much improved strength, notably by causing the graphite to be spheroidal, may also have conferred the property of withstanding repeated high strain. If so, this would be an important gain and would increase the engineering value of the material. Another direction in which one may expect cast iron having spheroidal graphite to offer interesting possibilities is in applications to parts operating at high temperatures under stress, as in steam power plant. Hitherto the use of flake-graphite cast iron has been restricted in steam power plant to medium temperatures, rarely over 350 deg. C. (662 deg. F.), even for the most satisfactory compositions, because of growth trouble experienced some years ago. This should be very greatly reduced by the new irons, and if growth does not become of significance at temperatures of 450 deg. to 550 deg. C. (842 deg. to 1,022 deg. F.), where the material would be subject to creep, important further

possibilities are open to it for investigation and application in high-temperature plant.

Engineers have lived so long with stress and strain dominated by elastic theory, that vision may be handicapped by the limitations this theory imposes, and which, in fact, may largely be removed by plastic strain effects occurring as creep at high temperatures. One of these limitations is stress concentration. It is well known that a hole in a plate, small in diameter compared with the width of the plate, results in tensile stress at the sides of the hole three times the mean stress in the plate when the plate is under tension. This is indicated in Fig. 8, on page 31. This, at first thoughts, might raise doubts about the influence of the roughly spherical cavities in spheroidal-graphite cast iron. Creep, however, would substantially remove the tensile-stress concentration and, in my view, it is probable that cracking, which would be intergranular and determined by tensile stress would not be appreciably hastened by the small graphite-filled cavities. Indeed, as cracking of creep-test specimens seems always to be initiated at the surface, and we believe involves to some extent an effect of the atmosphere, it is possible that the graphite might operate advantageously. At any rate investigation by creep tests would provide the answer, and it should be undertaken—perhaps interested individuals are doing this or may have done so. However this may be, operating temperatures have now reached a level such that the long operating life expected of steam power plant has made graphitisation of wrought steels a possibility, and apparently a certainty at the heat-affected zone of an electric weld.

The sudden failure in an American power station of an electrically-welded steam pipe,* due to graphitisation, directed a great deal of attention there to the possibility of this phenomenon occurring in service, especially as operating temperatures have continued to increase. The use in steelmaking in America of substantial aluminium additions for the deoxidation of the steel weld was a predisposing cause not present in British practice, and although this has now been corrected in steam-pipe manufacture, there is no doubt that with the higher operating temperatures coming into use, graphitisation must be regarded as a possibility. Experience in America has shown that, at the heat-affected zone of an electric weld, graphitisation may take two forms, a dangerous one descriptively referred to as "eyebrow" or chain graphite, and the common normal granular or random form which may occur in parts not influenced by welding. The presence of this is not regarded as serious in itself. If this is a correct assessment, the graphite form in spheroidal-graphite cast iron, on account of its rounded character, should be even less of a risk. There seems to be good grounds for the hope, from recent developments, that the range of usefulness of cast iron for high-temperature steam plant may be increased.

For very high operating temperatures, which gas-turbine development has necessitated, it is recognised that superior alloys may be impracticable in wrought form or may present production difficulties which would be avoided by castings. It is because of this possibility that particular interest has been taken in the lost-wax process of precision casting, and it accounts largely for its most common application to the production of gas-turbine blades. Cast blades have proved satisfactory for the stationary guide vanes but the need has not yet arisen for their use as moving blades, where operating stress is more severe. Experience has shown that stationary blades of jet-aircraft gas turbines are liable to cracking as a result of unequal heating at combustion hot spots, particularly when starting, and that the character of the cracking is usually inter-granular. Materials are tested for resistance to this tendency, and in this property cast materials show good performance.

Either by inference, or directly, I have endeavoured in this lecture to convey the view that, for engineering uses, castings where they may offer an alternative to wrought metals have as wide a field of use as their physical properties justify and their competitive position allows. Given high quality both in materials and product, castings in most cases need not be at a disadvantage in physical properties compared with wrought metals. In any case their promise and prospects for engineering uses, apart from considerations of cost, may be assessed from the results of mechanical tests and metallurgical examination interpreted with intelligence.

THE OLD CENTRALIANS.—Dr. W. Abbott will speak on "Engineering Potentialities and Opportunities in Afghanistan" at the next luncheon of the Old Centralians (the old students' association of the City and Guilds College). The luncheon is to be held at the Chez Auguste Restaurant, 47, Frith-street, London, W.1, at 12.55 p.m. on Friday, July 13.

* See "Symposium on Graphitisation of Steel Piping," A.S.M.E. Annual Meeting, New York, December, 1944.

CONCRETE VIBRATORS.

Two new concrete vibrators have been introduced recently by Messrs. Compactors Engineering, Limited, 1A, Brailsford-road, London, S.W.2. Fig. 1 shows an internal vibrator which is driven by a small electric motor operating on either a 110-volt single-phase 50-cycle supply or a 110-volt direct-current supply; alternatively, it can be supplied for a 220-240-volt alternating- or direct-current supply. The motor is protected against moisture and is cooled by forced ventilation. It is provided with a carrying handle, a short length of three-core cable with plug and socket, and a 20-ampere switch. The motor, which operates at 9,500 to 10,000 r.p.m. under load, is coupled directly to a flexible shaft 12 ft. or 18 ft. long, which rotates within a semi-flexible non-stretching casing. The vibrating head incorporates an out-of-balance weight assembly running in high-speed bearings with oil-bath lubrication, and enclosed in a casing of heat-treated steel. The tip of the vibrating head can be supplied in heat-treated steel or wear-resisting rubber, the latter

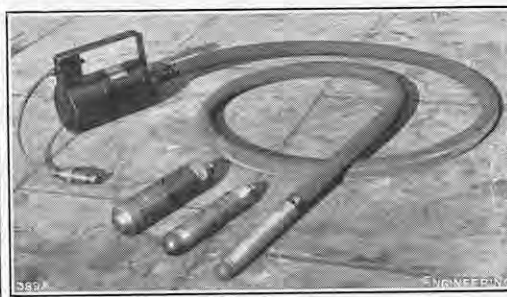


FIG. 1. ELECTRIC VIBRATORS.

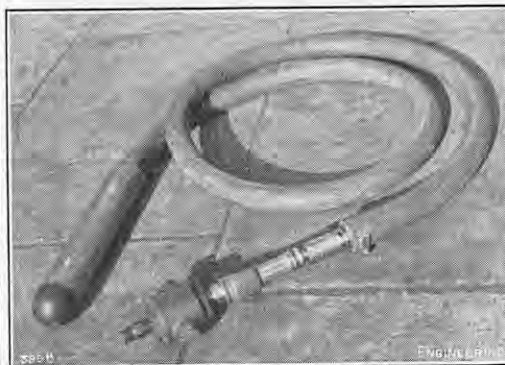


FIG. 2. PNEUMATIC VIBRATOR.

having the advantage of preventing damage to the form work. Three sizes of interchangeable vibrating head are available—1½ in. diameter by 10½ in. long, 2½ in. diameter by 10½ in. long, and 3 in. diameter by 12 in. long. The capacity of the vibrator is 8 to 16 cubic yards of consolidated concrete per hour; and the total weight, with the 12-ft. shaft, is 63 lb.

The pneumatic internal vibrator, shown in Fig. 2, is designed on conventional lines and is intended for use on dry and harsh concrete; apart from oiling, it is designed to operate for long periods without servicing. The vibrating head comprises a heat-treated wear-resisting steel cylinder and toe-piece, housing an eccentric running in high-speed bearings and driven by a four-vane air motor fitted with a speed regulator and running on ball bearings. The motor operates on air at a pressure of 75 to 100 lb. per square inch, with a consumption of approximately 30 cub. ft. per minute at 90 lb. per square inch; the air flow is controlled by a throttle handle fitted with a ½-in. connector. A 1-oz. capacity lubricator is fitted. Pressure and exhaust hoses 10 ft. in length are supplied. The capacity of the vibrator is up to 16 cub. yards of concrete per hour. The speed of rotation is approximately 9,000 r.p.m., and the overall weight of the complete unit is 34 lb.

ULTRASONIC SOLDERING BATH.—An ultrasonic soldering bath, recently introduced by Mullard Limited, Century House, Shaftesbury-avenue, London, W.C.2, enables small articles of aluminium and aluminium alloy of complex shape to be dealt with. The bath, which is ½ in. in diameter and ¾ in. deep, is first heated by a resistance winding until the solder in it becomes molten when it is agitated by a magnetostriction transducer. This transducer is composed of a stack of iron-alloy laminations and is operated at a frequency between 19.5 and 21 kilocycles. In this way, the refractory oxide films which form on the metal are broken up without the use of flux.

BOOKS RECEIVED.

Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory. 1951. The Astronomer Royal, Royal Observatory, Greenwich, London, S.E.10.

Fifty Years of British Standards. 1901-1951. British Standards Institution, 24-28, Victoria-street, London, S.W.1. [Gratis.]

Housing Manual. 1949. *Technical Appendices.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. net.]

Ministry of Health and Scottish Office. Inland Water Survey Committee. Fifth Annual Report. 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9d. net.] (See page 791, issue of June 29.)

Illinois State Water Survey. Bulletin No. 39. Ground-water in the Peoria Region. Part 1. Geology. By LELAND HORBERG. Part 2. *Hydrology.* By MAX SUTER. Part 3. *Chemistry.* By T. E. LARSON. State of Illinois, Division of the State Water Survey, Urbana, Illinois, U.S.A.

Osram Valve Manual. Part 1. Receiving Types of Valves, Cathode Ray Tubes, Electronic Devices. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. [Price 5s.]

Reports on Progress in Physics. Volume XIV (1951). Edited by A. C. STRICKLAND. The Physical Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. [Price 27s. 6d. net to Fellows of the Society; 50s. net to non-Fellows.]

The College of Aeronautics, Cranfield. Report No. 46. The Use of a Potential Flow Tank for Testing Axisymmetric Contraction Shapes Suitable for Wind Tunnels. By A. W. BABISTER and others. No. 47. *Vibrations of a Swept Box.* By J. M. RADOK. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire.

U.S. Army Corps of Engineers. Stages and Discharges. Mississippi River and its Outlets and Tributaries. 1949. The President, Mississippi River Commission, Vicksburg, Mississippi, U.S.A. [Price 1 dol.]

The Oxide-Coated Cathode. By DR. S. WAGENER. Volume One. *Manufacture.* Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 21s. net.]

Thermodynamics. By PROFESSOR GEORGE A. HAWKINS. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 52s. net.]

The Behavior of Engineering Metals. By DR. H. W. GILLET. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 52s. net.]

Survey of Marine Machinery and Boilers. By P. T. BROWN. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 12s. 6d. net.]

Investment in Empire. British Railway and Steam Shipping Enterprise in India, 1825-1849. By DANIEL THORNER. University of Pennsylvania Press, Philadelphia, Pennsylvania, U.S.A. [Price 3.75 dols.] Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 30s. net.]

The Edison Group. Societa Edison, Foro Buonaparte 31, Milan, Italy.

TRADE PUBLICATIONS.

Overhead Travelling Crane.—Appleby-Frodingham cast-iron beams have been used in an overhead travelling crane recently built by Vaughan Lift & Engineering, Ltd., 5, Crompton-way, Crawley, Sussex. The use of this type of beam, for this purpose as for others, gives a greater strength-weight ratio.

Taps, Drills and Cutters.—A catalogue issued by the Aldridge Tool & Engineering Co., Ltd., Aldridge, Nr. Walsall, Staffs., illustrates various types of standard and special form-cutters and hobs, reamers, drills, ground-thread taps, die-sinking cutters, flat and circular form tools, end mills, tools for the cycle trade, etc. It also gives useful technical information on allied matters.

Maintenance of Conveyor Belts.—The British Tyre & Rubber Co., Ltd., Herga House, Vincent-square, London, S.W.1, have prepared a booklet on the maintenance of conveyor belts. It gives notes on the repair of belts and the mobile service which the firm provide for making vulcanised joints in customers' belts.

Machine Tools and Small Tools.—A wide range of British, American and European machine tools for which Burton, Griffiths & Co., Ltd., Mackadown-lane, Marston-green, Birmingham, are the sole agents or distributors are listed in a catalogue published by them. The Small Tools Division of the same firm, at Montgomery-street, Birmingham, 11, have issued a similar catalogue of small tools and accessories.