ALUMINIUM HANGAR FOR "COMET" AIRCRAFT.

THE flight hangar built to house Comet air-liners for the de Havilland Aircraft Company at Hatfield is an all-aluminium structure with a clear span of 200 ft., a clear height of 45 ft., and a length, which can be extended at a later date, of 330 ft. A view of the nearly completed structure is given in Fig. 1, herewith. On the west flank, the hangar will butt against an annexe building, which will embody a new control tower at the south-west corner; the steel frame for this annexe can also be seen in the illustration. The main structure comprises twelve aluminium-alloy portal frames at 30-ft. centres, spanning 217 ft. between pinned bases and with an overall height of 55 ft. The roof is of north-light construction with an aluminium roof decking covered with bitumen felt and the glazing held by aluminium glazing bars. Corrugated aluminium sheeting, lined with insulating board backed by aluminium-foil, has been used for the cladding on the east side. Both the north and south ends of the hangar are fitted with folding doors which give a clear opening of 200 ft. by 45 ft. The floor level adopted is that of the other workshops and assembly halls of the airport so that the extended hangar can be joined to them without either a step or ramp in the floor.

Aluminium alloy, HE10 (B.S. 1476), was used for all structural sections and the same alloy was also used for all the main gusset plates (B.S. 1477). This alloy is one most widely used in structural work and was chosen on account of its good mechanical-strength properties, its high resistance to atmospheric corrosion and ease of fabrication. The corrugated sheeting is of aluminium alloy NS3 (B.S. 1470). Rivets used in shop-made connections were of $\frac{3}{8}$ in., $\frac{1}{2}$ in., or $\frac{5}{8}$ in. diameter and were of alloys having the designation NES or NEG; they were closed cold, by either squeeze or percussion riveters. The principal site connections were made with turned and fitted bolts of Sherardised steel, and galvanised black steel bolts were used for secondary connections.

For design purposes, the loading conditions were taken to be those stipulated in B.S. 499 (1948). In addition to dead loads of the structure itself, an allowance of 10 lb. per square foot has been made for snow; to allow for the erection of lighting and of a sprinkler system a further 2 lb. per square foot has been assumed over the roof area. The portals have been designed to withstand point loads of 1·5 ton at four points along the lower boom so that light walkways can be added without incurring overstressed members. Wind forces were based on an assumed wind velocity of 65 m.p.h. at an effective height of 50 ft.; this gave a superficial loading of 14 lb. per square foot.

As previously mentioned, the main structure comprises twelve portal frames at 30-ft. centres, spanning 217 ft. between the pinned bases, which are of welded steel, to give a clear span of 200 ft. between the inside of the portal legs. A detail of the welded shoe and baseplate is shown in Fig. 2, herewith. The legs of the portal are rather more than 8 ft. wide and the horizontal girder portions have a constant depth of 10 ft. throughout their span, except at the shoulders, where an extra bracing member has been introduced to take the fixing moment. Under the conditions of severest loading, the clear height below the deflected girders will be 45 ft. $4\frac{3}{4}$ in. Bulb angles, back to back, have been used for all primary and secondary members of the portal frames. In selecting the sections to be employed, some consideration was given to the torsional strength of the members to ensure that a torsional failure would not occur before a flexural failure. Connections have been made with either $\frac{3}{8}$-in. or $\frac{1}{2}$-in. gusset plates. Previously, battened-channel construction has been commonly employed for structures of this type, but experience has shown a considerable saving in man-hours when fabricating double angles; shop work in progress on a girder assembly for one of the portal frames is shown in Fig. 4, on page 98.

The upper and lower booms of the portal girders are stiffened laterally by saw-tooth trusses at 10-ft. centres spanning between the node points of the girders. On the east side of the hangar the portal legs are stiffened by the sheeting rails which are themselves stiffened by angle braces springing from the inside of the portal leg. Horizontal ties along the inside of the portal legs and at the same level as the sheeting rails complete the framing on the east side. On the west side, the large openings required to give access to the annexe building prohibit the use of such a method of stiffening, and the legs of the portals on this side have been stiffened by constructing out-rigger frames to form a lattice-box structure, most clearly seen in Fig. 3, on page 98, which shows the hangar after the erection of the eighth portal. The weight of each portal is 6 tons 7 cwt. Wind bracing has been introduced on both sides of the hangar between the ultimate and penultimate portal frames.

The saw-tooth trusses were designed with particular attention to ease of fabrication. Each consists of a rafter, a horizontal tie, a queen tie and two internal struts. A 4-in. channel, with a stiffened top flange, has been used for the rafter; this permitted the internal members in the majority of the trusses to be riveted to the back of the web without an intermediate gusset plate. Before the roof sheeting was in place, lateral stability was obtained by two ties at rafter level and by one between the truss-ties. The roof sheeting is bolted directly on to the top flange of the rafter. The hip trusses at the ends of each bay of trusses span between the inside leg of one portal and the outside leg of the following portal, and sheeting on the hip slope is supported by purlins which span between the hip truss and the sloping shoulder of the leading portal in each bay. The trailing end of each truss rafter carries a framed stool which supports the

FIG. 1. HANGAR UNDER CONSTRUCTION.

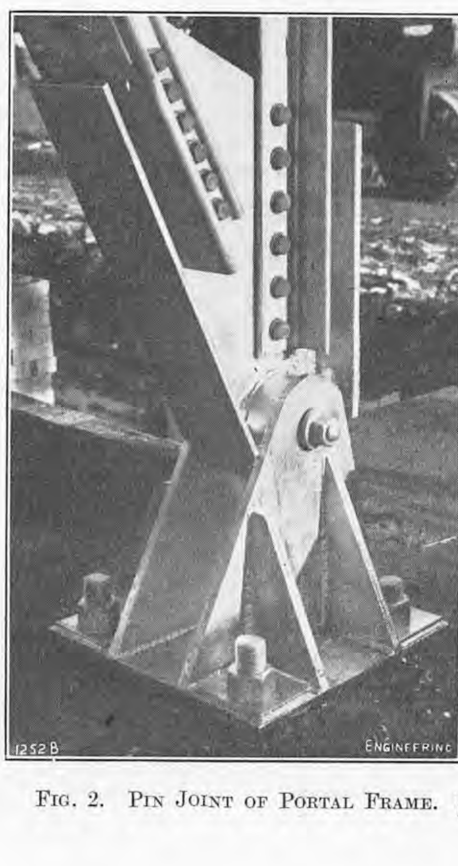


FIG. 2. PIN JOINT OF PORTAL FRAME.

ALUMINIUM HANGAR FOR "COMET" AIRCRAFT.

STRUCTURAL AND MECHANICAL DEVELOPMENT ENGINEERS, LIMITED, SLOUGH.

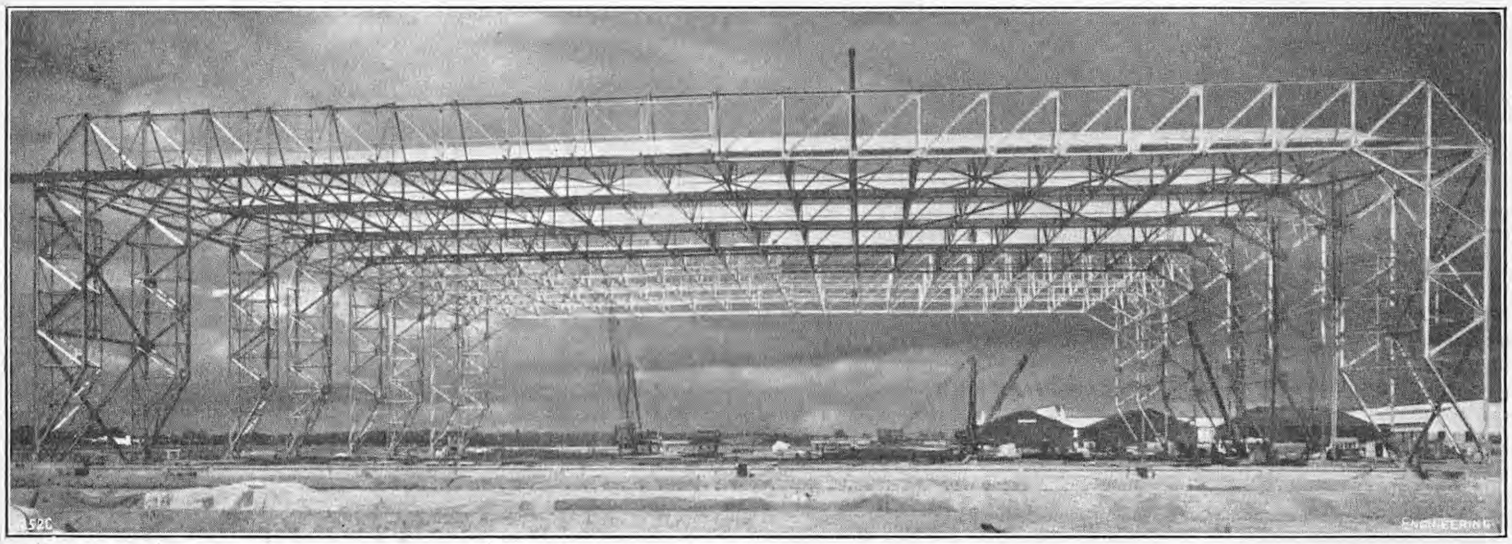


FIG. 3. FRAMEWORK DURING CONSTRUCTION, FROM THE NORTH.

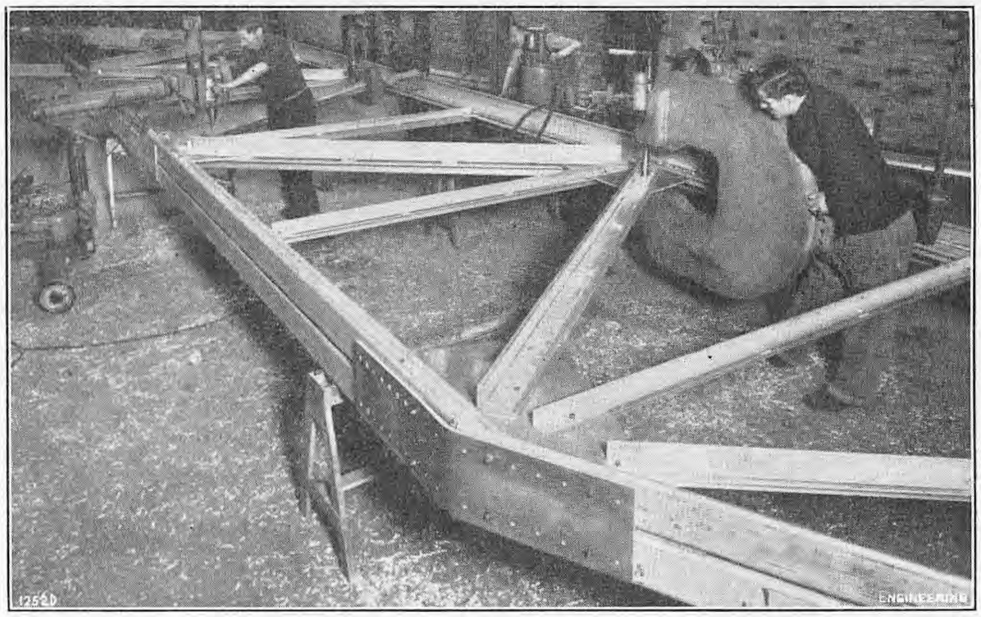


FIG. 4. SHOP WORK ON A PORTAL FRAME.

inside of the valley gutter and lower glazing rail. At 2-ft. centres, and spanning between this lower rail and cleats on the top boom of the portal frame, are the glazing astragals. The framed stools with the lower glazing rail in position can be seen in Fig. 5, opposite. Wind bracing for the roof has been introduced in the plane of the lower boom of the portal girders in the two bays at the southern end of the hangar. There are 23 trusses to each bay, making 253 in all. Each truss weighs 175 lb.

Canopy frames have been fitted to both the north and south portals. Incorporated in the canopy frames are the upper guide channels for the sliding and folding doors; these channels are supported at 10 ft. centres by wind-bracing members that cantilever beyond the line of the end portals. The underside of each canopy is sheeted with 16-s.w.g. aluminium-alloy sheeting, level with the toes of the guide channels, so forming a flat surface for the rubber draught excluder which has been fitted along the upper edge of the doors.

Movements along the 330-ft. length of the hangar due to changes in temperature have been taken care of by introducing expansion joints at all structural connections on one side of the sixth portal frame from the north end. The truss shoes at this section have been connected to the portal girder by short links which are free to swing to take up any movement; this has necessitated special shoes in cast aluminium on each truss in this particular bay, in place of the gusset plates used elsewhere. All the sheeting rails and the ties along the east side of the hangar have slotted holes at this section, and the connections for the rail stays have been formed so as to allow freedom for expansion but to ensure that the stays act as stiffeners to both the rails and the portal legs. Expansion in the width of the building is absorbed by distortion of the portal frames.

The roof is of north-light construction with eleven valleys. The daylight requirements have been achieved by twelve continuous runs of glazing, 9 ft. 3 in. deep by nearly the full width of the hangar, using aluminium-alloy glazing bars and ¼-in.-thick wired cast glass in 2-ft.-wide panes; the glazing sub-contractors were Helliwell and Company, Limited, 68, Victoria-street, London, S.W.1. Corrugated aluminium roof decking, supplied by William Briggs and Sons, Limited, East Camperdown-street, Dundee, has been used to cover the south-facing slopes of the roof. Above the decking, and bonded to it by hot-oxidised bitumen, are ½-in. thick insulation boards; the whole is waterproofed by two layers of bitumen roofing felt with a mineral finish to the capping sheet. The hip slopes are covered in a similar fashion. Eastwood Specialists, Limited, Eastwood House, 158-160, City-road, London, E.C.1, were the sub-contractors for the supply of the insulating board.

Drainage from the valley gutters spills over the hip slopes into boundary wall gutters, 2 ft. wide and of robust construction, which run the full length of the sides of the hangar, widening at each corner to form platforms, 10 ft. wide by 12 ft. long: the gutters then run across the width of the hangar at each end. So that they may be used as walkways, aluminium hand-rails have been fitted along the gutter run; the parapet above the gutter, and the hand-rails, can be seen in Fig. 1, on the previous page. The gutters are drained by six aluminium-alloy down pipes, of 4½-in. diameter, located inside the structure.

Corrugated aluminium-alloy sheeting treated by the Alchrome process and supplied by the British Aluminium Company, Limited, Norfolk House, St. James's-square, London, S.W.1, was used for the cladding on the east wall. The sheeting is lined with $\frac{3}{16}$-in. thick asbestos-wood board and "Sunfoil" reflective insulation held in position by extruded aluminium T-sections. Below the sheeting, a dado wall of 9-in. brickwork, 8 ft. 9 in. high, runs the full length of the east wall. The west wall is sheeted only above the roof level of the annexe. The main sliding and folding doors, which give a clear opening of 200 ft. by 44 ft. 9 in. high, were supplied by Esavian Limited, 171-181, High Holborn, London, W.C.1. Two smaller doors, 12 ft. wide by 15 ft. high, but of a similar pattern and made by the same firm as the main doors, have been built into the east wall.

Full advantage was taken of the light weight of the aluminium structural assemblies in planning the erection, which was undertaken by Carter-Horseley (Engineers), Limited, Merebank-lane, Waddon, Surrey. The erection of the portal frames was given careful consideration in order to obviate any undue lateral distortion. The first portal frames to be erected were the two joined by the wind bracing, previously described, situated at the southern end of the structure. The two legs on each side of the hangar were assembled as a pair, complete with wind-bracing, and then lifted by the cranes into an upright position, where they were held by temporary props and back ties. The construction of a stable framework was completed by the erection of the portal girders, which were conveyed to the site in two sections; the two

ALUMINIUM HANGAR FOR "COMET" AIRCRAFT.

STRUCTURAL AND MECHANICAL DEVELOPMENT ENGINEERS, LIMITED, SLOUGH.

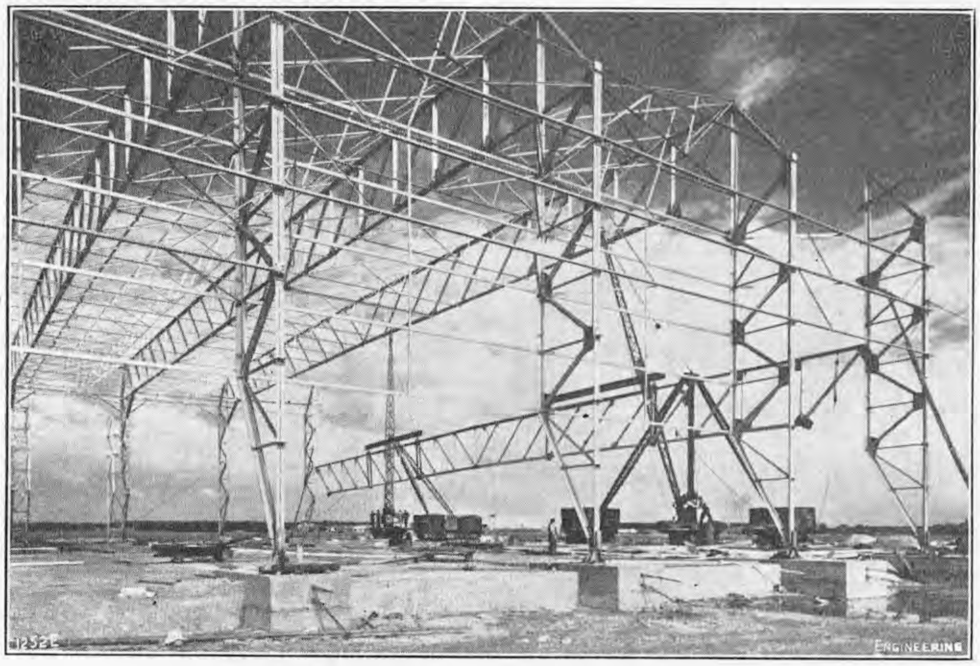


FIG. 5. LIFTING A PORTAL GIRDER INTO POSITION.

sections were brought together along the centre line of the portal frame, mated and lifted into position by two lifting beams at about 100-ft. centres. Although the weight of the portal girder was only 4·5 tons, two 5-ton hand cranes, with 60-ft. long jibs, were used for the erecting work, which is shown in progress in Fig. 5, above. With the completion of the frame so far, the roof trusses of the first bay were then hoisted into position by hand, using light tackle rigged from erected members. From this stage the erection of the structure progressed regularly along its length, the cranes being used to hold the portals in position until sufficient trusses were connected to give lateral support to the portals. Longitudinal ties, braces and the glazing purlins were then fixed by hand. The assembly of each portal frame took about two days and the operation of lifting the horizontal girders was completed in three hours. In all, the erection of the complete framework, which weighs about 180 tons, took a team of 18 men thirteen weeks.

The portal-frame bases have been secured to the reinforced-concrete foundation blocks by means of four 2-in. diameter holding-down bolts designed to resist the shear forces and uplift to which they may be subjected. The bolts themselves were anchored into the foundation block by threading them through steel flats embedded in the mass of the concrete. The necessary freedom to allow movement of the bolt during the final adjustment of the structure, was achieved by the use of "Hy-Rib" reinforcement; with the final setting of each frame the baseplates were grouted-up in the usual manner. Spreading of the foundation blocks due to the action of the horizontal thrust at the foot of the portal frames has been prevented by concrete tie beams, 18 in. square in section and prestressed by the Freyssinet system, built into the floor of the hangar. The contractors for the foundations, the floor, the surrounding apron and approach roads are Gilbert Ash, Limited, 2, Stanhope-gate, London, W.1.

The principal contractors for the construction of the hangar were Structural and Mechanical Development Engineers, Limited, 2, Buckingham-avenue, Slough, Buckinghamshire. The architects to the de Havilland Aircraft Company are James M. Monro and Son, 6, Spring-gardens, London, S.W.1.

LITERATURE.

Road Engineering.

By E. L. LEEMING, M.Sc. (Tech.), M.I.C.E. Third edition. Constable and Company, Limited, 10-12, Orange-street, London, W.C.2. [Price 30s. net.]

THIS book was first published in 1924 and this new edition brings it up to date so far as basic principles and the latest practice are concerned, though no attempt has been made to describe in detail such operations as large-scale resurfacing with modern mechanical plant; instead, the original purpose of expounding the basic engineering principles of road-making has been enlarged upon, taking into account the latest American practice. The 31 chapters, concisely written and amply illustrated, cover the ground from the primary consideration of sub-soil drainage to the supervision of actualconstruction. Four appendices contain useful information on the subjects of Acts of Parliament, suitable concrete mixes, conditions of contract, and British Standards for cement, with particular reference to the design and construction of roads.

The chapters on "Camber," "Curves" and "Super-elevation" are both interesting and commendable. The seven advantages enumerated in favour of super-elevation are well argued. That super-elevation must reduce wear both of road surfaces and vehicle tyres would seem to be obvious, for which reason it is not so obvious why, in the British Isles, so many comparatively new roads have been constructed without it. Among the other chapters is one on "Traffic Surveys," and numerous illustrations afford comparisons between the layouts adopted on the German *Autobahnen* and in the United States of America, at roundabouts and road junctions. The book should be of considerable value to those engaged in the various branches of road engineering.

Tables of Coulomb Wave Functions, Volume I.

National Bureau of Standards. Applied Mathematics Series 17. The Superintendent of Documents, United States Government Printing Office, Washington 25, D.C., U.S.A. [Price 2 dols.]

THE solutions of the differential equation

$$\frac{d^2y}{d\rho^2} + \left[1 - \frac{2\eta}{\rho} - \frac{L(L+1)}{\rho^2}\right] y = 0$$

are encountered as the radial component in the separation of Schrödinger's wave equation for a Coulomb field of force and continuous energy values. They are useful for the calculation of the scattering of charged particles from atomic nuclei or their binding by nuclei, and also in connection with the problem of stability of laminar Poiseuille flow in hydrodynamics. This equation may be shown to have a regular solution and a logarithmic solution which are denoted by $F_L(\eta, \rho)$ and $G_L(\eta, \rho)$, respectively, when properly normalised. The power series expression for the former is $F_L(\eta, \rho) = C_L(\eta)\,\rho^{L+1}\,\Phi_L$, (η, ρ) and the main table gives $\Phi_L(\eta, \rho)$ for L ranging from 0 to 21, η ranging from -6 to $+6$ and ρ ranging from 0 to 5. Tabulation is to seven decimal places in steps of 0·2 in ρ for $L = 0(1)5$, 10, 11, 20, 21 at the integral values of η. For purposes of interpolation, values of the "reduced" derivatives of Φ_L with respect to η are also included in this first table. The normalising factor $C_L(\eta)$ can be expressed in terms of $C_0(\eta)$ and values of the latter are given in Table IV to eight significant figures from $\eta = 0$ to 10. The seven-place accuracy is helpful in the determination of $\Phi_L(\eta, \rho)$ by recurrence for values of L not listed and in the calculation of $G_L(\eta, \rho)$, which often involves the difference between two nearly equal numbers. Table II gives the real part of $\dfrac{\Gamma'(1 + i\eta)}{\Gamma(1 + i\eta)}$ and Table III values of arg $\Gamma(1 + i\eta)$ which are needed for purposes described in the introduction by M. Abramowitz, which also contains details of the method of computation and examples of procedures for interpolation. A foreword by Professor Breit outlines the special problems in nuclear physics for the solution of which these tables have been primarily designed.

PRICE OF NICKEL.—The Mond Nickel Co., Ltd., state that, following the announcement in Canada by the International Nickel Company of Canada, Ltd., of an increase in the price of nickel effective on January 14, they are, as from the same date, raising their price for refined nickel in the United Kingdom to 483*l*. per ton, delivered at works, with appropriate increases for other countries.

ALMANACS AND CALENDARS.—Monthly tear-off wall calendars have been received from the European public relations officer, Canadian Pacific Railway Co., 62, Trafalgar-square, London, W.C.2; Chloride Batteries Ltd., 6-10, Whitfield-street, London, W.1; and Nordac Ltd., Cowley Mill-road, Uxbridge, Middlesex. John Laing and Son, Ltd., 4, Regent-street, London, S.W.1, have sent us a copy of their special coronation calendar, which contains reproductions in full colour of six paintings of typical British scenery. A copy of the *South African Pictorial Calendar* for 1953, issued by the publicity and travel department of South African Railways, Johannesburg, has been received from their commercial representative in London, whose address is South Africa House, Trafalgar-square, W.C.2. This wall calendar is printed in English and Afrikaans, and contains 50 photographic illustrations of South African scenes. The United States Lines, 50, Pall Mall, London, S.W.1, have sent us a calendar giving particulars of the whole year on one sheet.

INDUSTRIAL BELT VULCANISER.—An industrial vulcaniser for the repair of rubber and canvas conveyor belts has been developed by Stenor, Limited, Kew Foot-road, Richmond, Surrey. It is made in three models, a bench model for rigid fixing, a pillar-mounted bench model, and a pillar-mounted portable model. Both the pillar-mounted models incorporate an attachment which permits the repair of belts at varying angles. The portable model is mounted on castors and has a pillar of sufficient height to permit repairs to be made 9 ft. from the ground. All models make use of a main casting in the shape of two arms which carry the electrically-heated vulcanising plate and support plate. The vulcanising plate has an effective curing area of $8\frac{1}{2}$ in. by $5\frac{1}{2}$ in. and a penetration of $\frac{5}{16}$ in. Penetration to $\frac{3}{4}$ in. can be obtained if the support plate is replaced by a vulcanising plate. The equipment will repair belts not exceeding 52 in. in width, and the normal time taken to make a repair is between 20 min. and 30 min. Moulds and plates for repair of rubber cables and air-lines, etc., are also made for use with this equipment.

THE PROPAGATION OF FRACTURES IN MILD-STEEL PLATES.

By G. MURRAY BOYD, M.Inst.N.A.

(*Concluded from page 69.*)

Experimental Support.—In order to check the somewhat striking results reported in the first part of this article, the angles θ have been carefully measured from photographs, rubbings, and Hilger projections of fractures covering a wide variety of materials and thicknesses, with the results shown in Table I, from which the mean values are plotted in Fig. 14. Considering the difficulties in the accurate measurement of the angles, the agreement with the theory is considered satisfactory. There is, however, a slight tendency for the measured angles to be less than the theoretical angle, and possible reasons for this will be discussed later.

An even more striking agreement is shown by Fig. 15, in which the actual measurements made by Dr. Tipper on the specimen shown in Fig. 3 (see Fig. 103 of Ref. 9) are compared with the theoretical envelope curve and with the generating circles.

The experimental points shown in Fig. 15 indicate the width of the fracture, in the direction of the plate thickness, measured at the successive sections indicated in Fig. 3. The radii are drawn, with the values appropriate to the centres indicated, by means of the relation

$$R = \sqrt{\frac{D\,T}{\pi}}, \qquad . \quad . \quad (21)$$

which follows from equations (8), (9) and (11). The diagram, Fig. 15, shows the discontinuous character of the origination, since in this case the spacing of the origins seems to be several times the focal length of the envelope. The spacing would probably be greater near the end of a fracture than where it is actively progressing. It may be remarked here that the theory does not require the origins to be equally spaced, but that the circles should lie within a parabolic envelope. True, the illustration, Fig. 11, shows equally spaced origins, but an uneven spacing, consistent with the assumption of uniform velocity, can be envisaged by omitting some of the circles in Fig. 11.

Fig. 16 represents an irregular spacing of origins, to show that the occurrence of isolated cracks ahead of the main fracture, as observed by Dr. Tipper[17], is consistent with the theory.

Effect of Anisotropy.—The effects of anisotropy of the material on the geometry predicted by the theory must be considered. For example, if the value of f were different in directions parallel and perpendicular to the middle plane of the plate, the generating circles would become ellipses, with their major axes in the direction of minimum f.* It is known from the results of Izod tests having notches parallel and perpendicular to the plane of the plate, that the former tend to give higher values. From this it should follow that the ellipses should have their major axes in the plane of the plate, which would tend to increase the angle θ slightly.

Effect of Borders on Chevron Angle.—It was observed by De Leiris[15] that the borders appear to "cut off" the chevrons, as indicated in Fig. 17, from which it can be seen that the effect would be to reduce the angle θ. Thus, if r denotes the width of the border, as in Fig. 17, it can be seen from equation (13) that the reduced angle is given by

$$\tan\,\theta = \pi\left(1 - \frac{2\,r}{T}\right), \qquad . \quad (22)$$

so that a ratio $\frac{r}{T}$ of only 0·085 would be sufficient to reduce the angle to 69 deg., i.e. to the mean figure shown by Table I. This effect operates in the opposite direction to that of anisotropy, previously discussed. It is probable that both effects act together, one tending to cancel the other, but the effect of the borders probably predominates, accounting for the mean figure in Table I being slightly lower than the theoretical value.

Relationship of Toughness to Velocity.—The relationship between the "toughness," f, and the velocity of propagation, V, can be seen from equations (3), (6) and (19), which combined give

$$\frac{\delta W}{\delta t} = f\,V\,T, \qquad . \quad . \quad (23)$$

from which it is seen that for a given rate of work-expenditure, i.e. for a given rate of energy release, f and V are inversely proportional. This means that the velocity should be greater in brittle than in tough fractures, in accordance with experience.

Variants of the Simple Plate.—The theory, from equation (6) onwards, has been particularised to

FRACTURES IN MILD-STEEL PLATES.

Fig. 14.

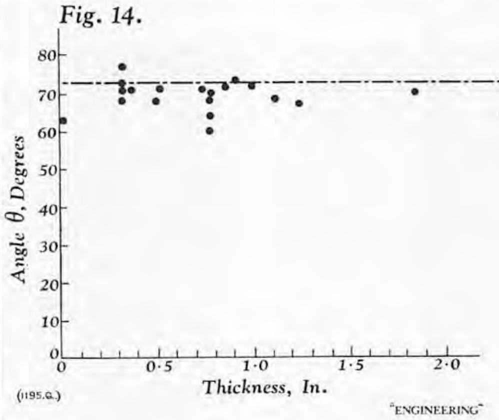


Fig. 15.

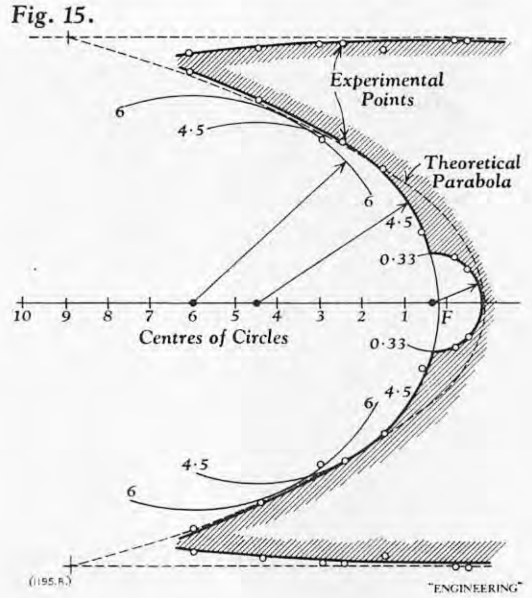


Fig. 16.

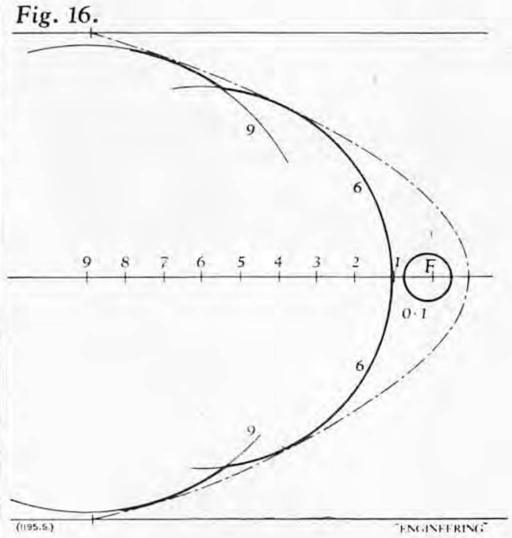


Fig. 17.

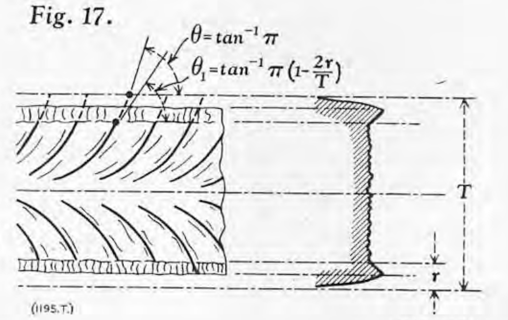


TABLE I.

Number.	Reference No.	Particulars.	See Note No.	Material.	Thickness, In.	Number of Observations.	Angle θ. Max.	Angle θ. Min.	Angle θ. Average.
1	17	Plate 3, Fig. 1 (*a*)	2	Mild steel ..	0·339	11	75	63	68
2	17	Plate X, Fig. 1 (*b*)		,, ,, ..	0·532	23	76	61	71
3	24	Specimen No. 61	2	,, ,, ..	0·79	5	70	66	68
4	24	,, No. 64	2	,, ,, ..	0·79	4	71	68	70
5	24	(Fig. 96)	2	,, ,, ..	0·79	7	61	58	60
6	24	(Fig. 98)	2	,, ,, ..	0·79	7	66	62	64
7	25	Ship plate, (Fig. 54)		,, ,, ..	$1\frac{1}{8}$	4	70	65	68
8	25	,, ,, (Fig. 25)		,, ,, ..	$1\frac{1}{4}$	4	68	63	67
9	26	12 in. notched tensile, (Fig. 3) (*c*) ..	3	,, ,, ..	$\frac{3}{4}$	3	74	65	71
10	10	"Plate Mur," (Fig. 8, page 35) ..		,, ,, ..	$\frac{1}{2}$	6	70	63	68
11	10	Boiler plate, (Fig. 2, page 89) ..	4	,, ,, ..		3	66	60	63
12	15	(Fig. 18) (*a*)	5	Ni-Cr steel ..	1·85	1	—	—	70
13	19	(Fig. 9), Fig. 5	6	Cell. acetate ..	0·02	1	—	—	63
14		Plate 3 } Different parts of	7	Mild steel .	0·339	14	86	60	72
15		,, } fracture	7	,, ,, ..	0·339	18	115	50	77
16		,, }	8	,, ,, ..	0·339	12	74	68	71
17		"Colin P. Kelly" (Ship Plate) ..	8	,, ,, ..	$\frac{3}{8}$	15	76	65	71
18	27	Fig. 20	9	,, ,, ..	0·86	6	79	63	71
19		Photo. by Professor Soete ..	10	,, ,, ..	?	10	76	68	72
20		Ship Plate J.10, Fig. 1 (*c*)	11	,, ,, ..	0·91	7	78	70	73
		All determinations				161	115	50	69

NOTES FOR TABLE I.

1. Figure numbers in brackets refer to the original papers cited in the reference column. Other figure numbers are of this article.
2. Notched tensile specimens, short fractures.
3. Small photograph. Angle derived from shape of front shown by "thumbnail mark."
4. Boiler tube-plate, curved, of varying thickness, not plotted in Fig. 14.
5. Fractured pressure vessel, nickel-chrome steel. The chevrons are not symmetrical, and the average angle has been given.
6. Unsymmetrical chevrons, confused by secondary origins off the centre line (see Fig. 5).
7. Angles measured from tracings from Hilger projections of the actual fracture. (Supplied by Dr. Tipper.) The axis of symmetry appears to wander from the middle plane of the plate. Angles of 90 deg. and over only occurred at one place, about 0·1 in. long. High angles on one edge go with low angles on the other.
8. Measured from ink-prints of fractures, supplied by Dr. Tipper.
9. Photograph supplied by Mr. T. S. Robertson[27]. See Fig. 20.
10. Unknown thickness, plotted as 1 in. in Fig. 14. From photograph supplied by Professor Ir. W. Soete, of Ghent University.

* The author is indebted to Dr. C. F. Tipper for this suggestion.

PROPAGATION OF FRACTURES IN MILD-STEEL PLATES.

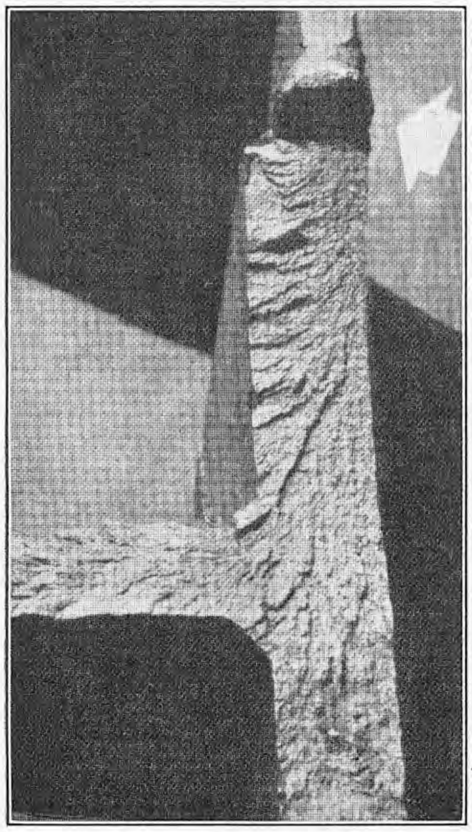
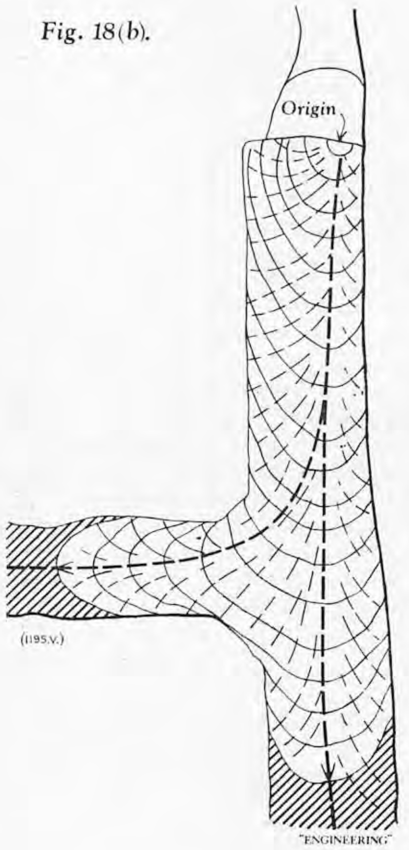


FIG. 18 (a).

Fig. 18(b).



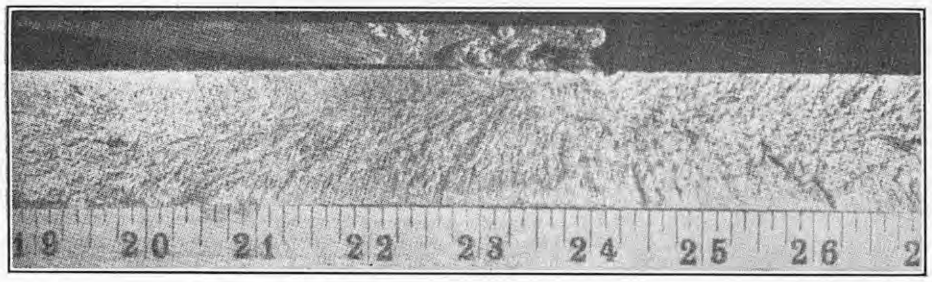


FIG. 19 (a).

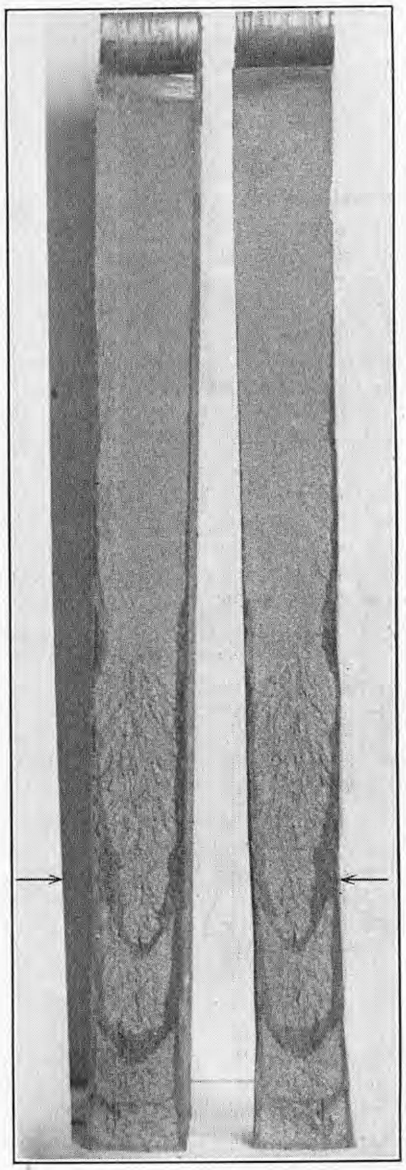
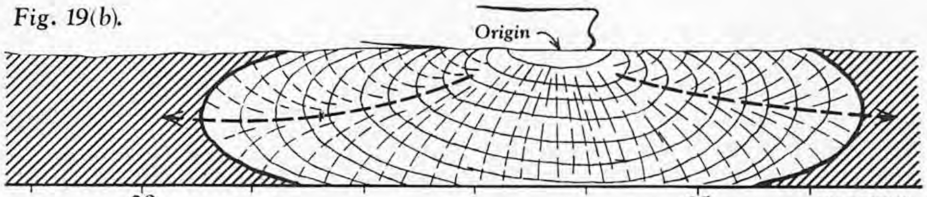


FIG. 20. ROBERTSON TEST OF A STEEL PLATE 0·86 IN. THICK.

Fig. 19(b).



the case in which the progressive, discontinuous origination of the fracture occurs at uniform velocity along a straight line, and has later been further restricted to the simple case of a plate of uniform thickness. The assumptions, however, have been stated generally, and it is therefore of interest to consider the development of fractures in less simple cases, such as the service fractures illustrated in Figs. 18 (a) and 19 (a).[25] These photographs are taken near starting points of actual fractures which occurred in ships, and these starting points are seen to be off the centre-lines of the plates. In the case of Fig. 18 (a) a branching of the fracture into a perpendicular plate is also shown. In Figs. 18 (b) and 19 (b), successive positions of the fracture fronts have been sketched in full lines orthogonally to the dotted chevron curves traced from the photographs. The consistency with the theory, although not established numerically for these complicated cases, is fairly evident. In both cases the paths of origins, i.e. the trajectories of the points of maximum curvature of the fronts, are seen to be curved, tending asymptotically to the middle lines of the plates. The shapes of these trajectories can only be conjectured, but it seems probable that the new fracture origins should occur at the points of maximum "triaxiality" of stress just ahead of the spearhead of the progressing fracture. The main fracture should "pursue" this centre of triaxiality without overtaking it, in which case the paths of origins would be "curves of pursuit," and probably tractrices. In a case involving bending of the plate, the point of maximum triaxiality would be displaced from the centre, resulting in asymmetry of the chevron pattern, as observed by De Leiris.[15]

Clearly, therefore, the shape of the front, and consequently that of the chevrons, should depend on the shape of the specimen, and it should be possible by a development of the theory to predict the successive shapes of the fronts in particular cases, such as the various types of notched specimens in use for the study of "notch ductility." Such developments will not be attempted here, but it may be remarked that according to the theory the toughness, f, i.e., the work per unit area of fracture, should be constant all over the fracture surface, provided this remains flat and the material is uniform. A change in shape of the fracture front, therefore, does not necessarily imply a change in toughness.

The photograph reproduced in Fig. 20, for which the author is indebted to Mr. T. S. Robertson, is of particular interest. It shows the fracture of a specimen of the type described in Robertson's paper[17] in which there is a temperature gradient along the length traversed by the fracture. Thus, at the upper end the temperature was about −70 deg. C. and at the lower end about +60 deg. C. The fracture progressed from top to bottom, i.e., in the direction of increasing temperature and increasing toughness. It can be seen that at the low-temperature end the chevrons are so faint as to be almost imperceptible, the fracture being almost completely crystalline, and that they become more prominent as the toughness increases. The same can be said of the borders, which appear dark on the fracture edges. The fracture was made to progress in stages, and the traces of the fronts at each arrest are clearly seen. These traces are formed by the mat texture which always appears at the beginning of a fracture,[17] so that the fronts at the moments of arrest are the outlines of the light-coloured portions. One of these arrest fronts, arrowed, is seen to be "scalloped" as in Fig. 15, and the generating "circles" are seen to be elliptical, with their major axes parallel to the plate, as predicted. The change in shape of the fronts can be clearly seen where the fracture nears the end. This behaviour suggests a probable reason for the difficulties which have been found in correlating the results of different notched tests.[7] Thus, in a wide plate the natural mode of propagation is as indicated by the simple theory, except near the beginning and near the end. These "end effects" are obviously complicated by phenomena analogous to the formation of "borders." Clearly, the fracture of a small specimen must consist almost entirely of such "end effects," and in tests of which bending is a feature there are additional complications. In these circumstances, the isolation of the intrinsic toughness, f, must be difficult, and the correlation between different specimens well-nigh impossible. Similarly, the correlation of small tests with the fracturing of wide plates must be complicated, in accordance with experience.

Measurement of Toughness.—It has been shown that the coefficient f is identical with the toughness of the material as defined in the beginning, and that this is an intrinsic property of the material, so that its measurement is clearly of special interest. The simplest method of measurement would seem to be to determine directly the work required to propagate a plate fracture, but this involves several difficulties. In the first place, it is essential that the fracture should be of the "fast" type, so that measurement of the energy by ordinary extensometer technique would be impracticable. Conceivably, this could be overcome by the use of electric resistance strain-gauge technique and electronic recording, but the difficulties of this approach are obvious. Another method would be the indirect one of determining the elastic energy released by the fracture, i.e., that accumulated in the specimen and in the testing machine at the moment of fracture. This elastic energy should be equal to the work done in completing the fracture, plus losses such as the kinetic energy of the fractured parts, and vibration, heat, etc. These losses, however, probably form an unacceptably large proportion of the total energy.

A more promising approach would be to provide in the system, comprising the machine and specimen, a known amount of potential elastic energy sufficient to initiate "fast" fracture, but insufficient to complete it. By measuring the fracture area and striking an energy balance, the value of f could be deduced. This is, in essence, the method proposed by Robertson,[27] although his system is complicated by the temperature gradient, and no method has yet been developed for determining the energy balance.

Whichever method is adopted, corrections must be applied to take account of the formation of the borders, and the "end effects." In most of the observed "fast" fractures in plates, the borders are extremely narrow, and are unlikely to affect seriously the average work per unit area of fracture. The "end effects" could presumably be eliminated to sufficient accuracy by using fairly wide specimens, or by breaking several specimens of different widths.

The relationship between the width r of the borders and the toughness, f, is suggested by the Principle of Least Work, which implies that the total work done in forming the borders and the flat part must be an analytical minimum. Thus,

$$\frac{dw}{dV} = \frac{d}{dV}\{\phi(r) + f(T - 2r)\} = 0, \quad (24)$$

whence

$$\frac{d}{dr}\phi(r_0) = 2f, \quad . \quad . \quad (25)$$

where w is the total work per unit length of fracture, $\phi(r)$ is a function to be determined experimentally, and r_0 is the value of r which satisfies equation (24). Since the formation of the borders involves the deformation of elements of volume, the function $\phi(r)$ almost certainly involves powers of r greater than unity. This, moreover, is a mathematical necessity, since otherwise equation (24) could not be satisfied for the conditions of the problem.

Relationship between Toughness and Strength.—It has been seen that the "fast" type of fracture, with which we are concerned, requires for its propagation that the elastic potential energy released should be greater than the work done against the "toughness" of the material. Since the elastic potential energy is proportional to the square of the stress, this means that for a given toughness there is a certain critical stress above which the fracture will be "fast," and below which it will be "slow." This critical stress might properly be termed the "notch strength" of the plate, if it is assumed that some form of notch is present to initiate a fracture. In this conception, the "stress" is understood to be the measurable field of stress in the plate at the moment of crack initiation, and not the unmeasurable "stress concentration" at the root of the notch or at the spearhead of the crack.

The theory does not of itself indicate the relationship between the toughness and the "notch strength" as defined above, and this relationship remains to be determined experimentally. The work of Robertson[27] comes close to revealing the relationship, but the interpretation of his experiments in this respect is not at present clear. He determined the relationship between the temperature at which a "fast" fracture is arrested, and the stress level at which the test was carried out, but did not determine the toughness as defined in the present paper, or its relation to temperature. It appears, however, that until some method is developed for measuring toughness, and for determining its relation to temperature, it would be useful to determine "notch strength" as defined above, and some development of Robertson's method would appear to show promise in this respect.

In the meantime, it is hoped that the proposed theory may lead to a better understanding of the problem, so that further efforts may be more economically directed.

The author acknowledges the help of Dr. C. F. Elam Tipper, of Cambridge University, in the form of constructive discussion and the provision of much of the experimental evidence. Help and encouragement has been given also by the author's colleagues in Lloyd's Register of Shipping, and on the Admiralty Ship Welding Committee, to which body the ideas presented in this Article were originally communicated. Mr. T. S. Robertson, M.Sc. (Eng.), and Professor Ir. W. Soete have also assisted materially by providing photographs of fractures.

The views expressed in the article are not necessarily endorsed by any body or committee with which the author is connected.

REFERENCES.

(References 1 to 23 were given at the end of the first part of the article on page 69, *ante*.)

[24] Campus, F., "Recherches, Etudes et Considerations sur les Constructions Soudées," *Sciences et Lettres*, Liége, 1946.

[25] U.S. Coast Guard, "Shipyard Welding Workmanship," NAVCG-137, June, 1945.

[26] Windenberg, D. F., and Roop, W. P., *The Welding Journal*, November, 1945, page 580-s.

[27] Robertson, T. S., "Brittle Fracture of Mild Steel," paper read to the British Association, Edinburgh, August, 1951. See ENGINEERING, vol. 172, page 445 (1951).

MINIATURE CALCULATING MACHINE.

ALTHOUGH, in many cases where repeated use has to be made of a calculating machine for arithmetical work, the size and weight of the instrument are secondary considerations, this is not always so. If all the work of calculation can be undertaken in one place, a machine of moderate size and weight, supported on a solid foundation, has much to commend it, since it affords the operator great freedom of movement and is usually easy to set, manipulate and read. In other circumstances, a readily portable calculating machine can be a great convenience, if not, indeed, a necessity. A machine moreover, so small and light that it can be carried in the pocket and held without fatigue in one hand during the work of calculation is more generally useful and, from some points of view, preferable to a light-weight machine which requires to be placed on a desk or table before it can be used.

A precision-built calculating machine, which is not only particularly easy and convenient to use, but which also possesses the attributes of small size and portability in a remarkable degree, is illustrated in Figs. 1 to 19, on page 103 and the following pages. Known as the "Curta," it is made by Contina, Limited, Liechenstein, and marketed in Britain by London Office Machines, Limited, 128, Terminal House, Grosvenor-gardens, London, S.W.1. Two models, of generally similar design, are available, of which that illustrated is the smaller. The machines are cylindrical, the smaller one having a maximum diameter of about $2\frac{1}{8}$ in., an overall length of $4\frac{1}{4}$ in., and a weight between 8 oz. and 9 oz. When the machine is protected in its cylindrical shockproof metal case, which is $4\frac{5}{8}$ in. long and $2\frac{3}{8}$ in. in diameter, the total weight is about 12 oz. The larger machine has the same overall length, but its diameter is $2\frac{1}{2}$ in. and its weight 11 oz.

Either machine may be used to perform any of the four operations of arithmetic and all such other calculations as are commonly undertaken on larger calculating machines having equivalent facilities. In the case of the smaller machine, for example, any number of not more than eight digits may be set up and multiplied directly by any number of not more than six digits. The result counter displays 11 digits. In the case of the larger machine, the corresponding numbers are 11, 8 and 15. Either machine can be held conveniently in one hand during the whole of the calculation and, with practice, the fingers of the same hand may be employed to set up the appropriate number and rotate the carriage to the appropriate stations, thus leaving the other hand free to manipulate the crank-handle and note the result of the calculation on paper. With experience, it becomes easy to carry out successive computations without laying down either the machine or the pen or pencil.

The Curta calculating machine was invented by C. Herzstark. In the course of its development, a number of unusual and interesting problems of mechanism had to be solved and the final design is highly ingenious. The requirements of small size and weight, and the stipulation that it must be possible to hold the machine in one hand without fatigue, ruled out the possibility of arriving at a suitable solution by merely scaling down an existing type of machine. The number of components had to be reduced to a minimum. On the other hand, their small size, as compared with those of a larger machine, made the stress problems easier, as can readily be deduced by dimensional analysis. The operating forces are, of course, very much smaller than those of a normal-sized machine. The following constructional details of the Curta calculating machine are taken from a paper by Professor Dr. Karl Holecek of the Technische Hochschule, Vienna. The illustrations were supplied by the makers, Contina, Limited.

Fig. 1 illustrates the method of holding the machine and shows the setting register. The number to be operated on is set by drawing down a series of lugs which project through slots in the barrel, and the number appears as indicated in the illustration. The normal method of setting a number, however, is by means of the thumb of the left hand. The thumb and index finger of the

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FIG. 1. NUMBER-SETTING OPERATION.

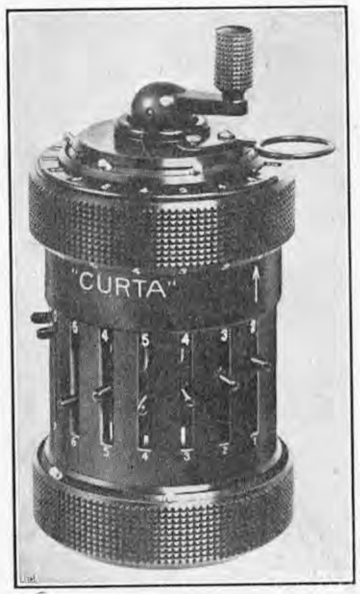


FIG. 2. COMPLETE MACHINE.

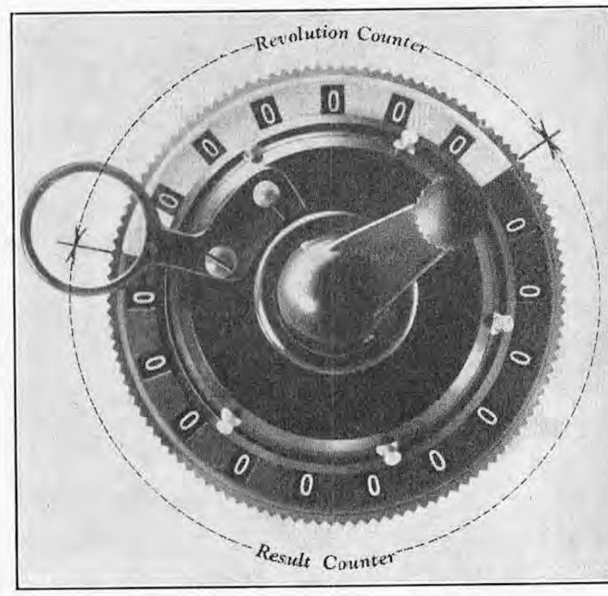
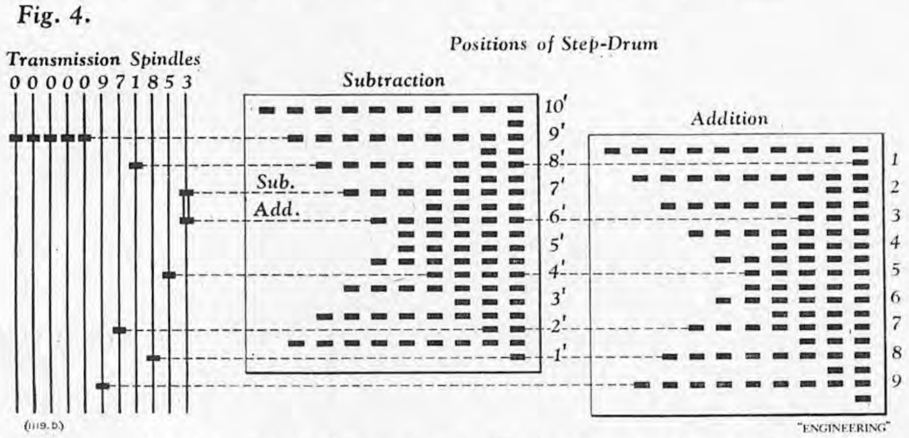


FIG. 3. ROTARY CARRIAGE FROM ABOVE.

Fig. 4.



same hand are employed to rotate the carriage. To accomplish this, the knurled ring at the top of the barrel must first be unlocked by raising it about $\frac{1}{16}$ in. against the force of a spring. It may then be swivelled round to the correct "tens" position, as indicated by the arrow under the scale engraved on the bevel of the ring. Fig. 2 shows the machine in greater detail and, in particular, the result and revolution counters, which are disposed along arcs of the flat top of the knurled cap. The result appears in white numerals on a black background and the revolutions (the multiplier) in white numerals on a black background with a white surround, as shown clearly in Fig. 3. By means of the ring-ended lever, which can be rotated when the knurled cap is raised, either or both of these numbers can be cleared, since the raising of the carriage disengages the counters from the other elements of the machine. Positive checks to the motion of the clearing lever are provided by notches at each dividing line between the two scales. The small white knobs are decimal indicators and may be set as desired.

Owing to the cylindrical design, it was possible to use a single step-drum disposed centrally in the machine in order to transfer numerals to the result counter. This drum passes in succession over all the digits of the setting unit. The addition process, on which multiplication depends, is straightforward. Subtraction, however, is accomplished by adding the "nines complement" of the subtrahend, defined, in this case, as the difference between the subtrahend and the number $10^{11} - 1 = 99{,}999{,}999{,}999$, and then adding 1. The whole operation, however, is accomplished automatically in one stage by withdrawing the crank handle about $\frac{1}{16}$ in. and proceeding thereafter as in the addition process. There is, in fact, only one direction of rotation for the drum, whether the operation be addition or subtraction.

The designer's problem was to devise two different cogged systems which could be brought into mesh selectively within the very restricted space available. The solution was obtained by devising a transfer mechanism consisting of a drum having rings of fixed teeth, arranged to engage with toothed wheels on a series of spindles disposed round the drum. Fig. 4 illustrates the operation of the transfer mechanism diagrammatically. On the right, the drum, known as the "step-drum," is shown developed as a plane in two different positions which correspond to addition and subtraction. The teeth are indicated by thick dashes. The eleven transmission spindles of the main result counter are represented, also in a planar development from their cylindrical arrangement, on the left of the figure. In the machine these spindles are driven by the rotating step-drum and transmit their motion through bevel wheels to the drums which carry the numerals. The first eight spindles, counting from the right, are equipped with adjustable gearwheels used for number setting, which are indicated by thick transverse dashes in Fig. 4. These gearwheels are able to slide along the spindles, but cannot rotate relatively to them. The function of the other three spindles is explained below.

The teeth in the rings of the step-drum which are used for addition range in number from 1 to 9, as indicated on the extreme right of Fig. 4. The vertical distance between the rings is equal to that moved by the adjustable gearwheels when any digit of the number set is changed by one unit. Centrally disposed between the rings is a second and similar series of rings, arranged in the reverse order. When the step drum is raised for subtraction, all the rings of teeth are moved by a distance equal to $1\frac{1}{2}$ times the distance between the primary set, so that the second set come into the positions indicated by the numbers 1' to 9', in Fig. 4. It will be seen from the figure that each of the latter rings is then in the position previously occupied by its complement with respect to 9 in the primary series, so that rotation of the step-drum results in engagement of the nines complement of any digit with the appropriate gearwheel of a transmission axle. It would be possible, therefore, merely by raising the step-drum by the amount indicated, to add the nines complement of any number set. As explained above, however, it is the nines complement plus one unit that must be added to effect subtraction. The mode of adding the necessary unit to the last digit, which is automatic, is described below.

The complementary rings of teeth are out of action when addition is being performed, for they pass freely between the possible positions of the adjustable gearwheels. Likewise, in the position of the step-drum for subtraction, the primary teeth are inoperative. In order that the complete 11-digit nines-complement of a number may be added when the step-drum is in the latter position, 9 must be added to each of the first three digits, which are not accessible on the setting rack. For this purpose, fixed gearwheels are mounted on the corresponding axles at the appropriate height, which is the same as that of the adjustable gearwheels on the transmission axles when the number set in each column is zero, and these wheels engage with the complementary ring, having nine teeth, when the step-drum is raised. In order that one unit shall be added to the last digit, a second gearwheel is mounted on the first transmission axle, at a fixed distance from the other equal to that between successive rings of teeth of either system, and these two wheels move together on one mounting. The upper of the two wheels, as may be seen from Fig. 4, engages with a ring of teeth of the complementary system which has one tooth more than the nines complement of the last digit of the number to be subtracted; hence it is the tens complement of the last digit that is added, since the subtraction wheel assumes control.

The subtraction wheel on the first transmission axle has no effect, however, when addition is being carried out, for then this wheel engages with a ring of teeth of the primary system which has one tooth fewer than the neighbouring ring traversed by the addition wheel. The addition wheel, therefore, is the over-riding control. In order that the subtraction wheel should be able to turn the first transmission axle by $10 = 9 + 1$ units when zero is set as the last digit, a ring of ten teeth, denoted 10' in Fig. 4, is fitted to the step-drum as the topmost ring of the complementary system. The step-drum is shown diagrammatically in plan and elevation in Figs. 5, 6 and 7, on page 104. The toothed segments are formed on a series of plates which are built up on a central body of lighter material.

Rings of teeth at the top of the drum engage

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Fig. 5.

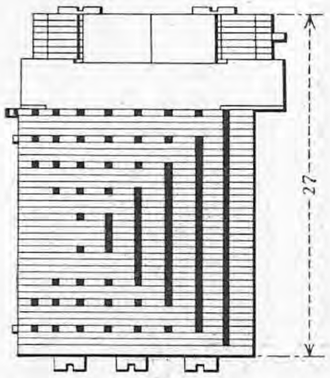


Fig. 6. REAR VIEW.

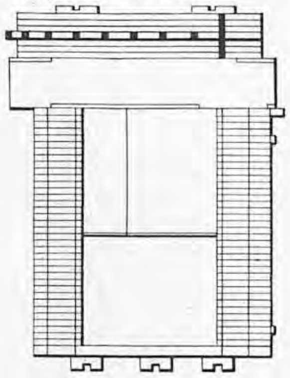
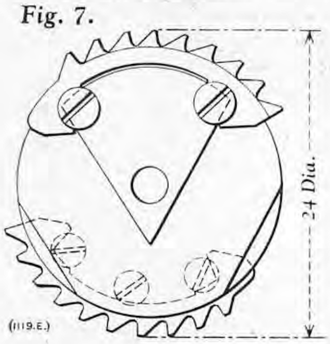


Fig. 7.



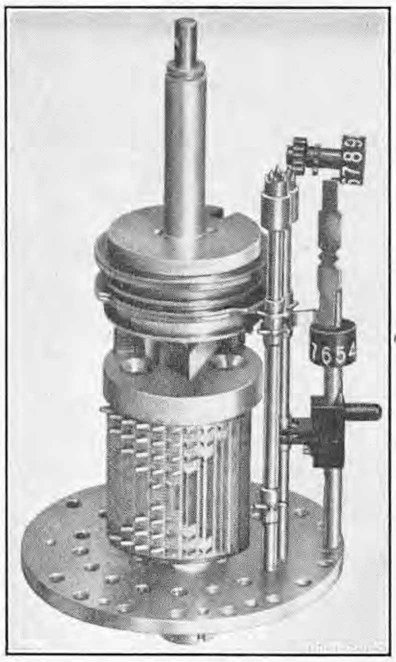


FIG. 8. TRANSFER MECHANISM.

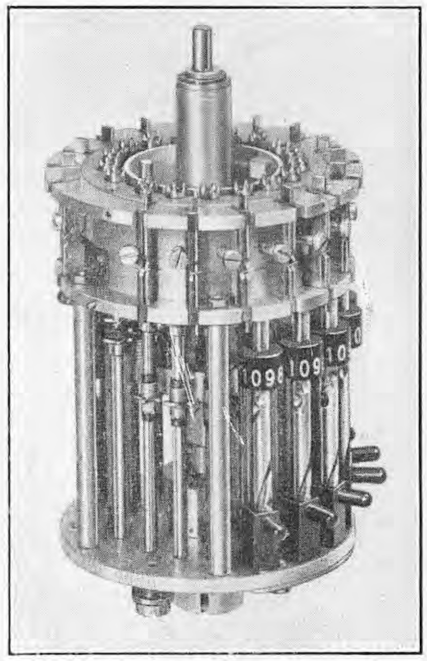


FIG. 9. MAIN ASSEMBLY WITHOUT ROTARY CARRIAGE.

with the wheels of the 6-digit revolution counter, the action of which may be followed from the diagram reproduced as Fig. 10. The appropriate teeth on the step-drum, which is on the right, are indicated by thick dashes. The six transmission axles are shown on the left of the figure, with transfer pinions attached to them. As in the case of the result counter, the transmission of the movement to the numeral wheels N is effected by bevel gearing. In an adding process, when the step-drum is in its lower position, the lowest of the three pinions mounted together on the first axle is moved one tooth space during each revolution of the drum by the single tooth of the top ring. The pinions on the remaining axles do not move. During subtraction, the step-drum is raised by the amount h, which brings the central ring, which has nine teeth, into mesh with the centre pinion on the first axle and with those of the succeeding axles. All the revolution counters, therefore, are advanced by nine steps during one rotation of the step-drum.

Since it may be desirable at times to count subtractive rotations as positive and additive rotations as negative, provision has been made for this to be done. Each pinion of the six axles of the revolution counter is surrounded by a fork, denoted f in Fig. 6, by which all may be moved simultaneously downward through the distance h. The shank of the fork forms a lug which projects through a slot in the casing of the machine and is used to make the adjustment. When the fork is pulled down, the transfer pinions are brought into the same relative position with respect to the toothed segments on the step-drum as they occupy when the latter is raised by the amount h. As a result, additive rotations are counted as negative. If the drum is then raised for subtraction, the single tooth on the lowest ring becomes coplanar with the top pinion of the three on the first spindle of the revolutions counter and advances the counter by one unit in one complete rotation of the drum. The other teeth and pinions do not engage. Thus each subtractive turn is counted positively.

Fig. 10 also shows the method by which decadal transfer is effected. Each transmission axle, except the first, carries a tens-transfer pinion T with a locking pinion L mounted above it. As soon as any one of the last five digits of the counter changes from 9 back to 0, a pin P fixed in the corresponding numeral wheel presses down on a slide S, which, in turn, pushes down the tens-transfer pinion of the preceding digit. This brings the pinion into the plane of the transfer tooth Z

Fig. 10. ARRANGEMENT OF REVOLUTION COUNTER.

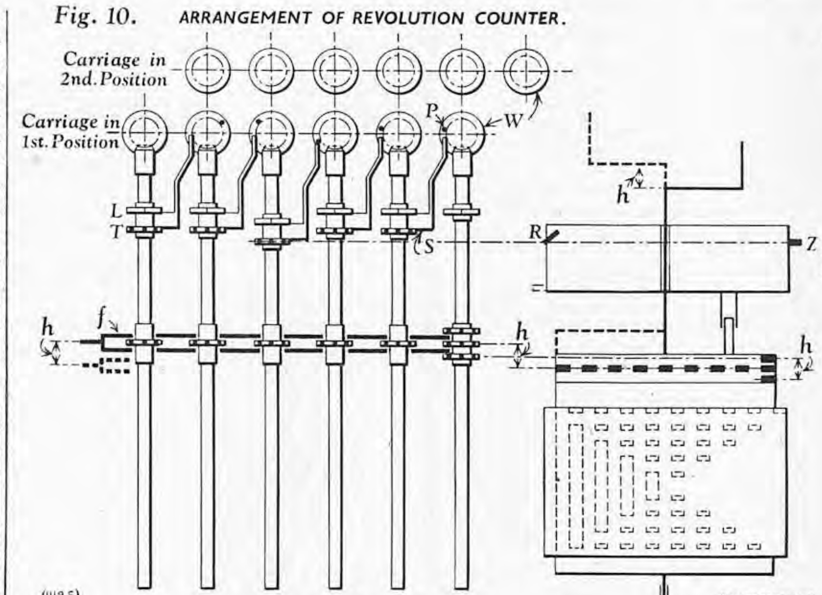
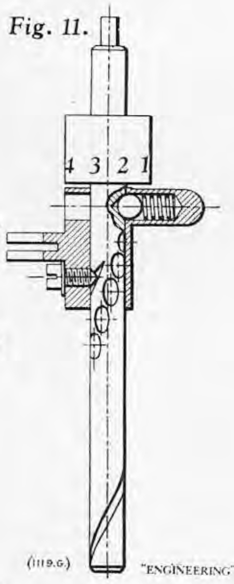


Fig. 11.



on the step-drum, which advances the pinion by one step in a rotation of the drum. The original position of the transfer pinion is restored by an inclined lug R, which revolves with the drum. In Fig. 10, the tens-transfer pinion of the fourth-last digit is shown as having been depressed. The pinion is restored to its former position just before the longest of the toothed segments of the step drum can engage with any of the transmission pinions of the result counter. Hence, should any of the slides S and pinions T be knocked down accidentally, as a result, for example, of striking the machine heavily on the table, the accuracy of the calculation is not affected. The tens-transfer system of the main result counter is of the same type as the above.

Fig. 8 shows the mode of operation of the main components of the machine. One of the eight number-setting spindles, with its slide and numeral drum, is visible on the extreme right. To the left of this spindle are two transmission spindles, one of which is surmounted by a numeral drum of the result counter. The step-drum is visible in the centre. Each transmission spindle carries a toothed driving-wheel at its upper end which engages a pinion on the spindle of the numeral drum. When the machine is completely assembled, all these spindles are supported in journal bearings on the rotary carriage. Fig. 8 also shows the pin which has pushed down the slide in order to effect a tens-transfer to the preceding digit. The tens-transfer tooth is formed on the lowest disc of the cylindrical tens-transfer body visible above the step-drum. This disc also carries the inclined lug which restores the pinion and slide to their previous positions. The two partly recessed discs, visible above that just mentioned, are employed to lock the transmission axles after the passage of the step-drum. In the case of a tens-transfer, the locking of the corresponding axle must not take place until one tooth-space later, and the recess in the lower disc is extended accordingly. Above these discs are the corresponding discs of the revolution counter. The tens-transfer tooth is formed on the lowest of these and those above it are used for locking purposes. The setting and tens-transfer pinions, and the driving heads of the transmission spindles all have five teeth. The number was kept as small as possible in order to save space and obtain a coarse pitch.

Fig. 9 shows the transfer and setting mechanisms completely assembled. The tens-transfer slides are held in guides which are introduced laterally into slots in the body of the machine during assembly. The guides are held in position at the correct height

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Fig. 12. CARRIAGE AT 1ST. POSITION.

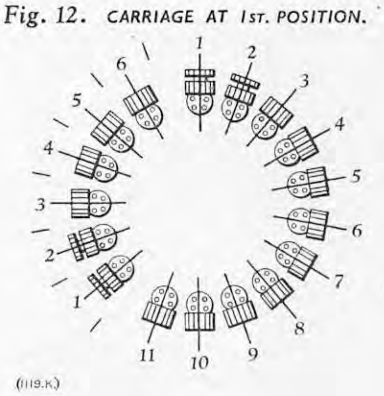


Fig. 13. CARRIAGE AT 6TH. POSITION.

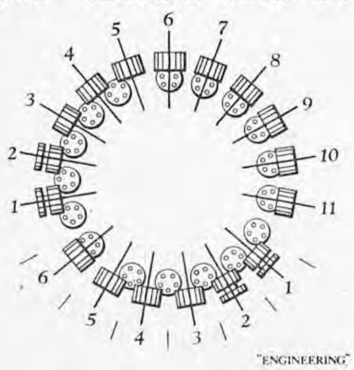


Fig. 14. CLEARING MECHANISM.

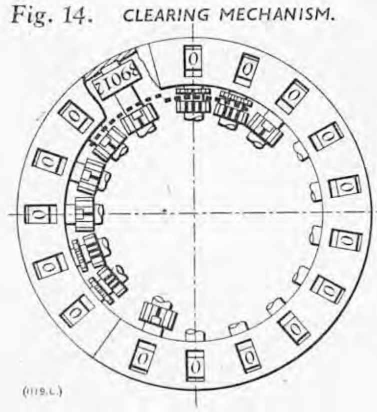
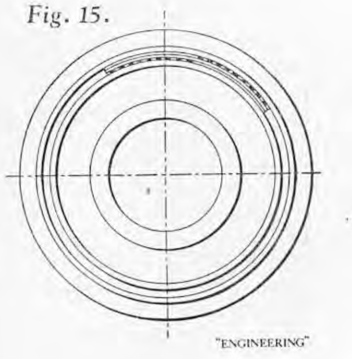


Fig. 15.



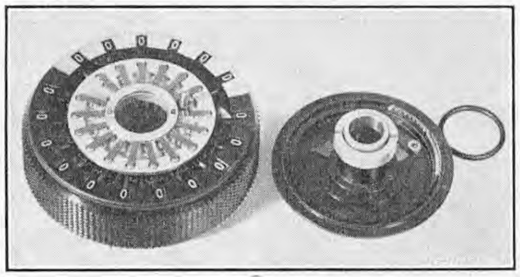


FIG. 16. CARRIAGE WITH COVER REMOVED.

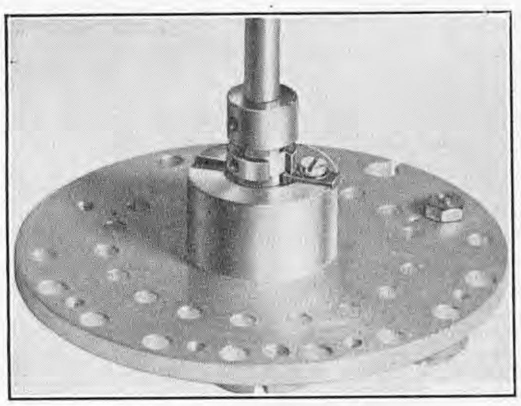


FIG. 17. LOCKING DEVICE FOR OPERATING HANDLE.

Fig. 18.

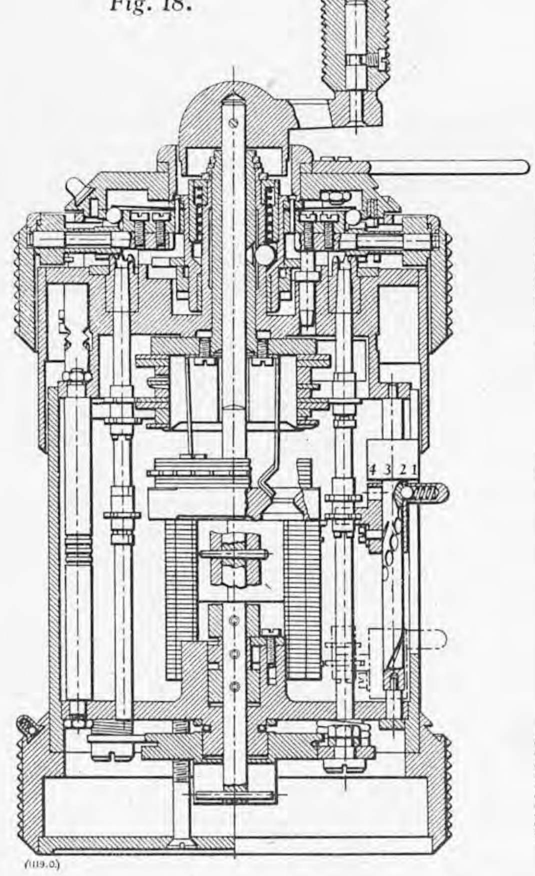
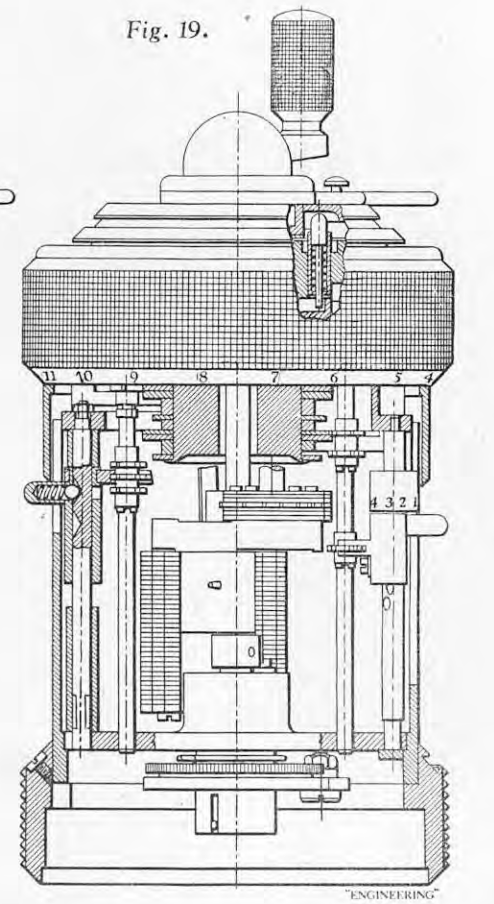


Fig. 19.



by a shoulder on the body. The construction of the number-setting indicator is seen in Fig. 11, on page 104, which shows the arrangement on a single spindle. Each spindle has a helical slot, and on the slide is a grub-screw which moves in the slot. A vertical displacement of the slide, therefore, turns the spindle, and the pitch of the groove is such that one-tenth of a rotation is accomplished when the slide is moved between adjacent stops, corresponding to a change of the numeral by one digit. Checks to the motion of the slide are provided by a spring-loaded steel ball, which drops into a series of recesses in the spindle.

The arrangement of the counter mechanisms in the carriage is illustrated in Figs. 12 and 13. The circular top of the carriage is divided into 18 equal parts and the 11 result counters are spaced out at 20 deg. intervals on the boundary lines between successive sectors. The six revolution counters, however, are arranged on the centre lines of six of the remaining sectors, so as to leave an interval of 30 deg. between the numerals at the extremes of the two registers. By making the driving heads and pinions of suitable size, interference between the transmission axles and pinions of opposite systems has been avoided. It is clear that this mode of construction permits of any desired increase in the number of digits without any alteration in the size of most of the components, provided only that the diameter of the machine and the step-drum may be increased. As already mentioned, a machine of slightly greater diameter, in which the corresponding numbers of digits on the result and revolution counters are 15 and 8, and 11 places are available on the setting register, is also manufactured.

Figs. 14 and 15 illustrate the method of clearing the numbers. The main clearing element is a rack, in the form of a circular arc, which engages the pinions of the numeral wheels when the movable carriage has been raised to disengage the latter from the driving heads on the transmission spindles. The pinions are provided with a milled recess at their zero position so that the counters are always brought to zero by the rack and left there. The problem confronting the designer was to arrange the rack so that it did not interfere with the process of calculating. The rack obviously had to be as long as the circumference of the pitch circle of each pinion of the numeral wheels and, this being so, it would, owing to the close spacing of the counters, hinder the motion of two of them when in its position of rest. A solution to this problem was obtained by constructing the rack in two equal parts fixed at different radial distances from the centre of the machine and staggered in azimuth as shown in Fig. 15. The outer portion of the rack clears only the first two digits of the result and revolution counters, and passes outside the pinions associated with the other digits. The inner rack clears all these remaining digits, but does not mesh with the pinions of the digits cleared by the outer rack, since these pinions are wider and are provided with grooves through which the inner rack passes. As already mentioned, there are two positions of rest for the clearing mechanism, one at each dividing line between the two number registers. This arrangement permits of clearing the result and revolution counters separately, as well as together. Fig. 16 shows the clearing device in greater detail. The central laminated star-shaped spring holds the counter pinions in position when the carriage is lifted, owing to the fact that the leaves exert pressure on steel balls which engage the pinions.

As with other calculating machines, the Curta is fitted with a number of locking devices which prevent it from being wrongly used and guard against accidental displacements of the elements during operation of the crank. Thus, for example, the step-drum cannot be moved from the position for adding to that for subtracting, or vice versa, during a revolution. The manner in which this restriction of movement is imposed may be understood from Fig. 17. The lower end of the spindle of the step-drum is furnished with a collar having two circumferential grooves. A locking plate, screwed to the base, slides in one of the grooves and prevents the vertical displacement of the step-drum during its rotation. Displacement is possible

DIESEL TUG "MAAMAL."

FAIRMILE CONSTRUCTION COMPANY, LIMITED, COBHAM, SURREY.

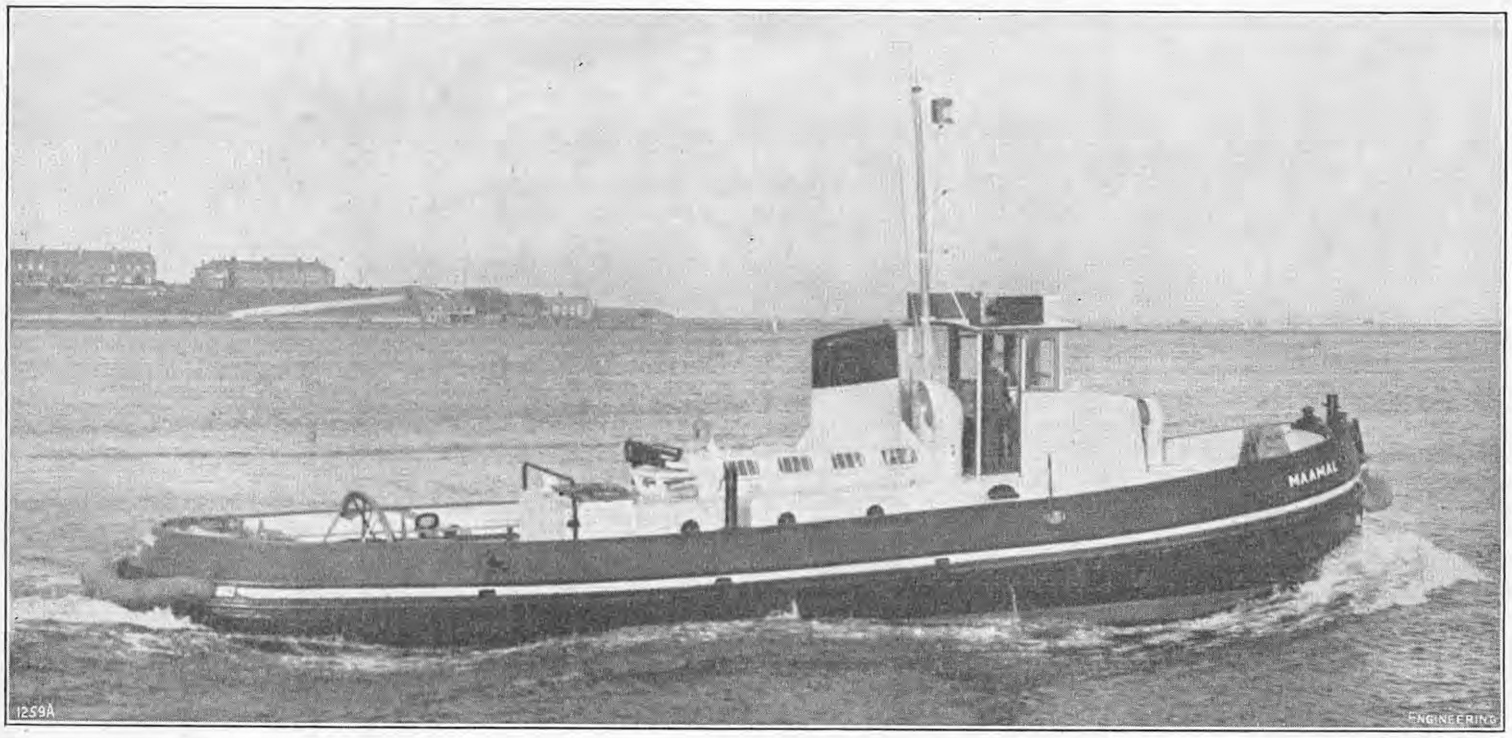


FIG. 1. VESSEL ON TRIAL.

only at the start or end of a revolution, when the locking plate is able to pass through a notch into the other groove. It is effected by pulling upwards on the crank-handle, which moves the step-drum from the additive to the subtractive position, or by pushing it downwards from the latter position. Each of these extreme positions is stabilised and, to assist the user, they are distinguished by the appearance of a bright ring on the centre spindle when the latter is withdrawn.

Other locking devices can be seen in Figs. 18 and 19, on page 105, which shows two vertical cross-sections of the machine. One of these devices prevents the raising of the carriage during a rotation of the crank-handle and, likewise, rotation of the handle when the carriage is raised. The action, in this case, is as follows. If the carriage is raised, an internal conical surface rises with it and pushes a steel ball into a hole bored through each of the two sleeves which surround the central spindle. The inner sleeve is an extention of the tens-transfer body and, therefore, cannot rotate independently of the spindle. The outer sleeve is rigidly attached to the body of the machine. Hence, in the raised position of the carriage, the crank-handle cannot be moved. On the other hand, if the main spindle is partly turned, the steel ball is pushed out of the hole in the inner sleeve, which is tapered, and remains wedged between the hole in the outer rigid sleeve and the conical surface. Hence the latter, and, therefore, the carriage, cannot be raised.

Clearance of the counters before the carriage is raised, and the return of the carriage before the clearing operation is completed, are prevented in a simple manner by the action of a pin mounted in the clearing cover and visible in Fig. 19. This pin is of such a length that, when the carriage is down, it enters one of two holes in the body of the machine; hence, the clearing cover cannot be rotated. On the other hand, when the carriage is raised, and the clearing cover with it, the pin leaves the hole it was in. If the clearing cover is then partly rotated, the pin glides over the top surface of the body and prevents the carriage from returning under the action of its loading spring, should it be released to do so. It is impossible, therefore, to re-engage the gears connecting the transmission spindles and the counters if clearance of either of the latter has been only partly completed.

MOTOR TUG FOR ADEN PORT TRUST.

THE motor tug Maamal, which is illustrated above and on the opposite page, has been built by the Fairmile Construction Company, Limited, Cobham, Surrey, for the Aden Port Trust. She has a length overall (exclusive of belting and fenders) of 60 ft. $2\frac{1}{4}$ in. and on the load waterline of 55 ft.; a moulded beam of 15 ft. and moulded depth of 7 ft. $10\frac{1}{2}$ in.; and draws 4 ft. 9 in. forward and 7 ft. 3 in. aft. The hull is of steel, mainly riveted. The keel is a 5 in. by 1 in. bulb plate, and the frames are 3 in. by $2\frac{1}{2}$ in. by 0·32 in. angles, spaced 20 in. apart; except at the four bulkheads, where the frames are $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by 0·35 in., and in way of the strong beam beneath the after end of the engine and of the two pillars at the forward end, where the frames are $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. by 0·36 in. Reverse frames are fitted at the top of the floors, these being single angles $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by 0·26 in. except in the engine room, where 3 in. by 3 in. by 0·32-in. angles are used. The shell plating is $\frac{3}{8}$ in. thick throughout except for the bow plating at the sheer strake and the two strakes below, which is $\frac{7}{16}$ in. The floors in the engine room are 10 in. deep and of 0·30 in. plate, and, in way of the bulkheads, of 0·28 in. plate. Elsewhere they are 10 in. by 0·26 in. The bulkhead plating is 0·26 in., as also is the plating of the deck, which has a camber of $4\frac{1}{2}$ in. The centre keelson, a 6 in. by 3 in. by 14·49 lb. channel, is bracketed to the bulkheads. The side keelsons are 3 in. by 3 in. by 0·32 in. angles. All the full beams are plain angles, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by 0·36 in. for the main deck and $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by 0·36 in. at the bulkheads. These, as stated, are four in number, of which three are watertight, namely, the collision bulkhead, the forward engine-room bulkhead, and after-peak bulkhead. The bulkhead at the after end of the engine room is not watertight. Half beams are 3 in. by $2\frac{1}{2}$ in. by 0·32 in. angles and the beam knees are 0·30 in. plate. The deck is of teak, 2 in. thick.

The stem bar is 5 in. by 1 in. in section and the stern frame is 5 in. by 2 in.; both are scarphed and riveted to the keel. The bilge keels are constructed with 3 in. by $\frac{5}{8}$ in. flat bar and $5\frac{1}{2}$ in. by $\frac{3}{8}$ in. bulb angle. The gunwale bar is 3 in. by 3 in. by 0·32 in. angle and the bulwarks are of 0·30 in. plate round the stern and 0·26 in. elsewhere, 2 ft. 9 in. high forward, 2 ft. 3 in. amidship and 2 ft. aft. Timber belting of rock elm, 7 in. by 4 in. in section, is fitted round the hull at the gunwale. The hull is divided into three main compartments, the crew's accommodation, which has a deck of white pine, $1\frac{1}{2}$ in. thick, being forward of the engine room and a store room abaft the after engine-room bulkhead. There is a small forepeak ballast tank, with the chain locker above, and a fairly large afterpeak tank, also used for water ballast.

The propelling machinery consists of a Blackstone EVMGR/6 six-cylinder Diesel engine developing 270 brake horse-power at 600 r.p.m. and having a continuous rating of 243 b.h.p., corresponding to a free speed of about 9 knots. The drive is transmitted through an S.L.M. oil-operated 2 to 1 reverse-reduction gear, supplied by Modern Wheel Drive, Limited, of Slough, to the bronze four-bladed solid propeller, which is 5 ft. 3 in. in diameter and 3 ft. $7\frac{1}{4}$ in. in pitch. The cylinders are cooled by fresh water, which is circulated through a Serck heat-exchanger in the engine-room casing; this is the only fresh water that the tug carries, as the crew bring on board their own supplies of drinking water. The two reservoirs for starting air, which is stored at 300 lb. per square inch pressure, have a capacity of 11 cub. ft. each. They are charged by a Reavell CSA2 compressor, with a capacity of $8\frac{1}{2}$ cub. ft. of air per minute at 350 lb. pressure, which is driven by a 7-h.p. single-cylinder Lister Diesel engine of the CDM type, running at 1,000 r.p.m. The same engine drives a Mawdsley 24/32-volt direct-current generator, rated at 1 kW, and a Hamworthy self-priming bilge pump, to deliver 12 tons an hour. This auxiliary set is placed athwartship, at the forward end of the engine room. A similar engine drives the Hamworthy centrifugal fire-pump, which has an output of 120 gallons an hour against a head of 100 ft., and is arranged in the starboard after corner of the engine room. The electric lighting equipment includes a Nife battery with a capacity of 200 ampere-hours, and a 100-watt searchlight. There are two fuel tanks, each holding 2 tons and located one in each wing of the engine room, and two 75-gallon service tanks, mounted on the forward engine-room bulkhead. The oil is transferred to the service tanks by a semi-rotary hand pump.

The steering gear is of the rod-and-chain type,

DIESEL TUG "MAAMAL."

FAIRMILE CONSTRUCTION COMPANY, LIMITED, COBHAM, SURREY.

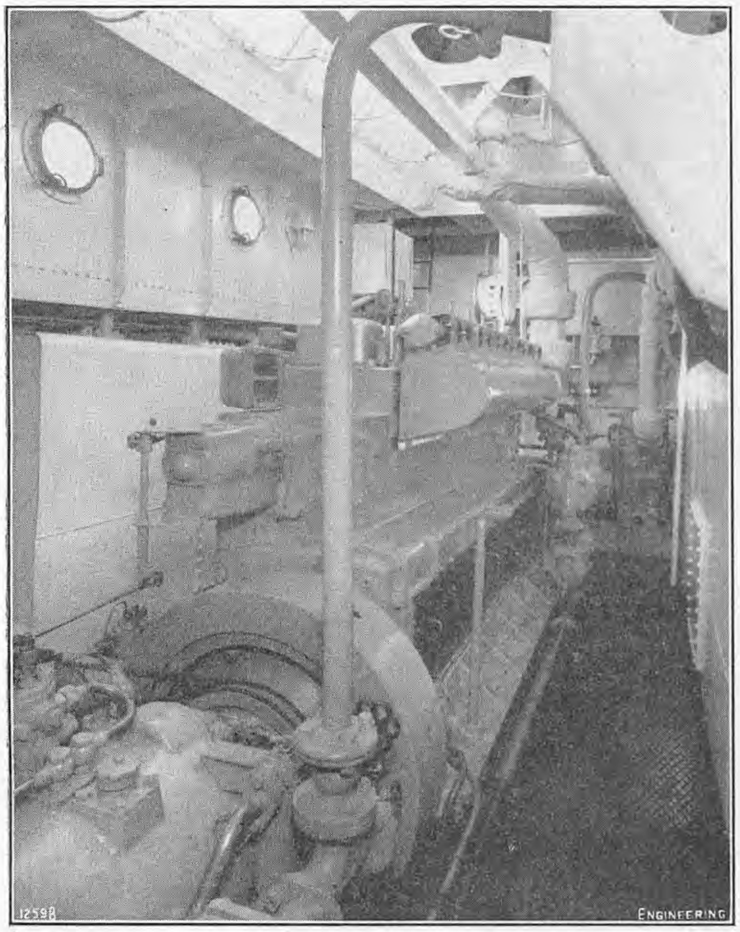


FIG. 2. ENGINE ROOM, LOOKING FORWARD.

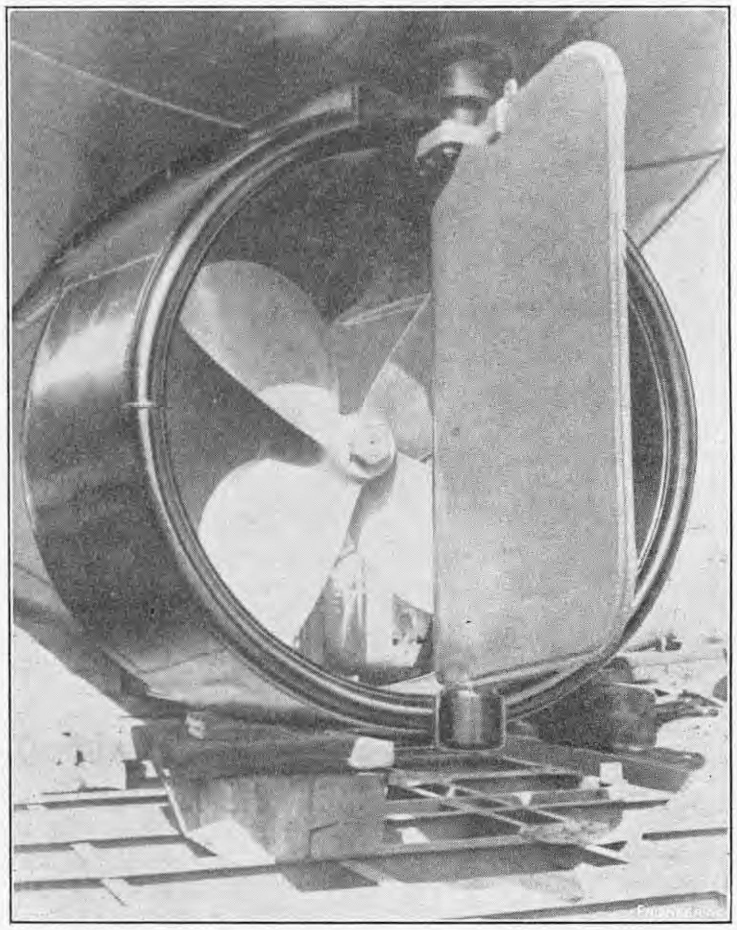


FIG. 3. PROPELLER AND KORT NOZZLE.

operated from the wheelhouse, and was supplied by Thomas Reid and Sons (Paisley), Limited, who also constructed the double-purchase hand windlass for working the anchors. The rudder is semi-balanced, and has an area of about 14 sq. ft. A hand tiller is provided, for use in the event of a breakdown of the main steering-gear. The windlass has two warping barrels as well as the chain lifter. There are two $2\frac{3}{4}$-cwt. stockless anchors and 60 fathoms of $\frac{5}{8}$-in. stud-link chain.

The official trials were held in a somewhat rough sea and a moderate gale, which limited the speed to about 8 knots but served to demonstrate the vessel's weatherly qualities. The turning circle under full helm had a diameter of only $1\frac{1}{2}$ lengths, and, as a result of the close co-operation between the builders and the Kort Propulsion Company, of Blackwall Yard, London, E.14, in the design of the afterbody, the astern manoeuvring was notably good. When floating in 16 ft. depth of water and connected by 15 fathoms of wire hawser to a 10-ton dynamometer on the quayside, the Maamal exerted a static pull of 4·1 tons with the engine running at the designed speed of 600 r.p.m. At 640 r.p.m., the pull was 4·75 tons. These figures are stated to be in excess of the requirements of the Aden Port Trust.

LIGHT-ALLOY VEHICLE BODIES.—The Northern Aluminium Co. Ltd., Banbury, Oxfordshire, have just published a booklet, the first of a new series entitled "Light Alloy Bodies for Road Haulage." The sub-title of Book I is "Materials and General Practice." Book 2 will deal with "Flat Platform and Dropside Designs," and Book 3 with "Pantechnicon and Box Van Designs." Book I provides information on recommended standard structural sections and castings that have been used satisfactorily in vehicle-body construction. All the structural sections are clearly shown, together with dimensions and physical properties, under headings that indicate the part of the body for which they were developed. Methods of cutting and fitting these sections are also shown in small sketches. Recommended methods of working aluminium, by forming, riveting and welding, are given.

BANKSIDE "B" ELECTRIC POWER STATION.

BANKSIDE, the name given to that part of the Metropolitan Borough of Southwark which lies on the south bank of the River Thames immediately opposite St. Paul's Cathedral, may justly claim a mention in any history of London. It was the site of Shakespeare's Globe Theatre and from it Wren watched the construction of his masterpiece. In more modern times, it has been occupied by an electric-power station from which a supply was first given in 1891 by the City of London Electric Lighting Company. This station was extended and modernised from time to time until in 1939, when the plant consisted of two 15-MW, five 10-MW and one 5-MW sets operating on steam at a pressure of 270 lb. per square inch, its replacement was decided upon; but this reconstruction was prevented by the war and, when permission to build a conventional coal-fired station was again sought in 1946, there was considerable opposition, not only from the Dean and Chapter of St. Paul's, and the Society for the Protection of Ancient Monuments, but from the London County Council and other local authorities. The grounds for this opposition were that the station would obstruct the view of the Cathedral and damage its stonework, and that the site had been scheduled for offices, for cultural purposes and for light industries. A public inquiry was held in January, 1947, as a result of which permission was granted for the work to proceed on the conditions that the station exterior should harmonise with the surrounding buildings when site development was complete and that it should be set back from the river so as not to interfere with the proposed promenade. It was also stipulated that oil instead of coal should be used as fuel and that gas-washing plant should be installed. Sir Giles Gilbert Scott, O.M., was appointed architect and the way in which he has fulfilled the first of these requirements will be clear from the exterior view of the station, in Fig. 1, opposite. Bankside "B" comes into the London Division of the British Electricity Authority, of which the Controller is Mr. H. V. Pugh.

BUILDINGS.

The station is being constructed in two halves, the first of which will be completed during the present year. The strata on the site consist of 10 to 15 ft. of made ground and soft clay, below which is 20 to 30 ft. of water-bearing ballast overlying the London blue clay. All the main foundations have been driven into this clay, the excavation being generally carried out in sheet-piled and timbered trenches. The basement retaining wall is of mass concrete and the foundations for the main stanchions and the boilers are of similar construction. Mass-concrete piers, founded on the clay, were built up above the basement floor level in reinforced concrete to form the turbo-alternator foundations. The 300-ft. chimney tower is carried on a cellular reinforced-concrete box, resting on the clay at 30 ft. below datum, upon which the main staunchions are erected. The power station superstructure consists of a steel frame with brick panels and a reinforced-concrete roof in which are glass and concrete lantern lights. The main building is about 545 ft. long by 240 ft. wide and, from north to south, comprises the boiler house, turbine room and switch house. The roof span of the boiler house is 103 ft. and that of the turbine house 76 ft., there being no separating wall between them. The switch house is of the same height as the turbine room. A reinforced-concrete annexe at the west end of the main building accommodates the offices, workshops and stores. The chimney, now on the north side of the building, will be eventually centrally situated. It consists of a steel frame tower 40 ft. square at each corner of which is a cruciform stanchion, tapering from 5 ft. 8 in. by 5 ft. 8 in. at the base to 3 ft. 4 in. by 3 ft. 4 in. at the apex. These stanchions carry steel joists on which the external brickwork is supported. The tower contains four octagonal cast-iron flues, 11 ft. in diameter, which rise from a plenum chamber. These flues are supported on steel flooring at 23-ft. intervals and are provided with expansion joints. The main contractors for the civil engineering work at the station were Sir Robert McAlpine and Sons, Park-lane, London, W.1, the steelwork being supplied by Sir William Arrol and Company, Limited, Glasgow, E.1.

Fuel Supply.

The oil fuel is brought up the river by 500-ton tankers or barges to an island jetty. The west end of this jetty, which has a total length of 293 ft., was constructed of reinforced concrete within a sheet-piled cofferdam and incorporates the circulating-water intake structure as well as a cast-iron shaft, 18 ft. in diameter, for the oil pipes. The east end consists of an open reinforced-concrete frame, which is founded on piled cylinders. The oil pipes are led from the shaft through a 9 ft. 8 in. tunnel, constructed of concrete segments lined with 4½-in. brickwork. This tunnel runs beneath the station to the underground oil store. An intermediate shaft leads up from it to the boiler house. The oil storage lies to the south of the station and is surrounded by a retaining wall of circular arch and buttress construction, the roof consisting of a concrete deck, covered with soil and grassed.

The oil is discharged from the tankers into duplicate 10-in. filling mains. Pumps are provided for discharging the oil from towed barges. The oil is stored in three mild-steel tanks, each about 92 ft. in diameter by 24 ft. high, holding 4,000 tons. The heavy oil used has properties similar to those of "Bunker C," its normal sulphur content being between 3 and 4 per cent. and its gross calorific value about 18,250 B.Th.U. per lb. It has a specific gravity of 0·98 at 60 deg. F. and a maximum viscosity at 100 deg. F. of 6,500 seconds Redwood No. 1. Owing to this high viscosity, it must be maintained at not less than 110 deg. F. to ensure easy handling. The storage tanks are therefore provided with steam heating coils and the pipe lines are "traced" with one or two 1-in. steam lines. In addition, the pumps on the jetty and in the boiler house are steam-jacketed, as are the filters.

The steam for the oil store is obtained at a pressure of 50 lb. per square inch either from two high-pressure evaporators, which are heated by steam from the main 900-lb. range and have an output of 18,000 lb. per hour; or from two Cochrane oil-fired boilers, each of which has an output of 5,000 lb. per hour. Steam from both these sources is also supplied, at 250 lb. per square inch, to the oil heaters on the boilers and for heating and domestic purposes in the station. All the drains are led back either to the evaporators or boilers through de-oiling and filtering plant. The pumps and heating sets for the first two boilers are shown in Fig. 2. The main contractors for this part of the equipment were Austin and Young, Limited, London, W.C.2, while the tanks were made by Westinghouse and Company, Limited, Darlington, and the pumps by Stothert and Pitt, Limited, Bath.

BANKSIDE "B" POWER STATION, LONDON.

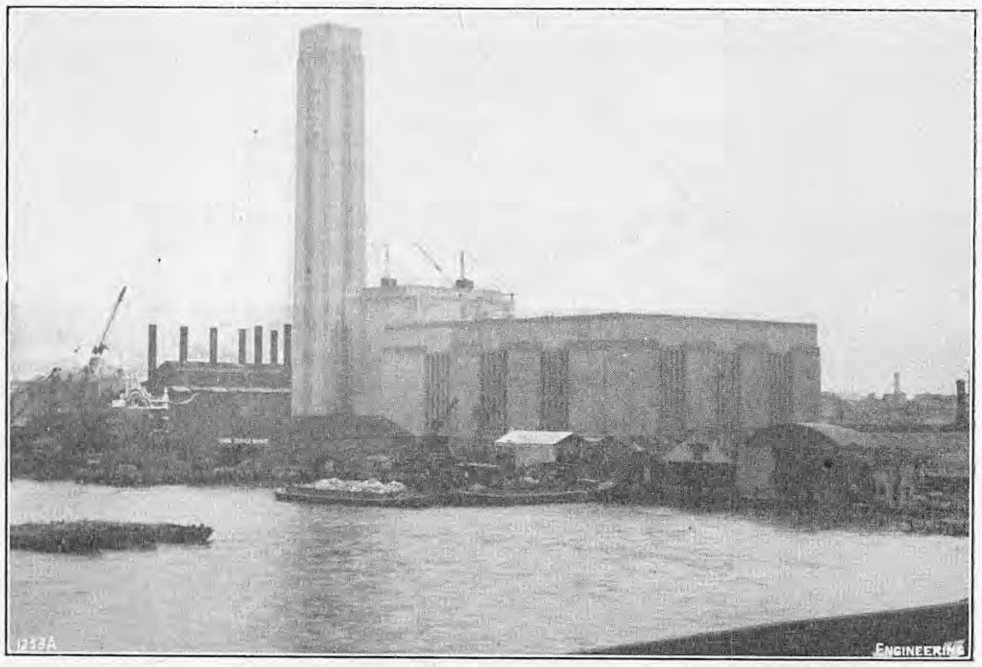


Fig. 1. General View of Station and Jetty.

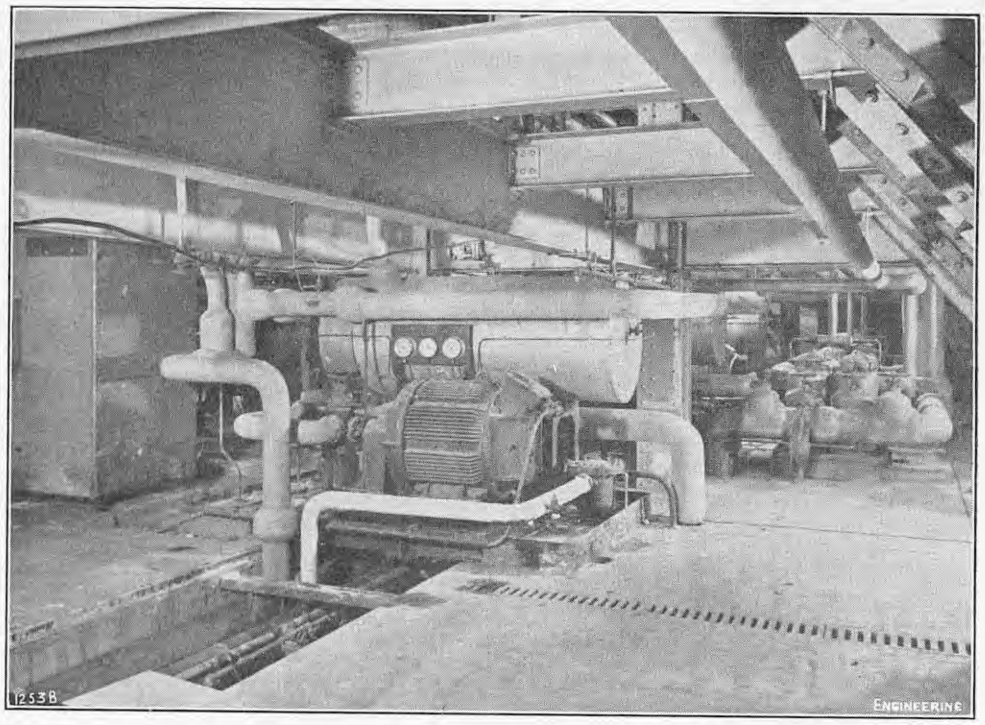


Fig. 2. Fuel Oil Pumps and Heating Plant.

Steam-Raising Plant.

At normal tank levels, oil from storage is supplied to the boilers by gravity. It can also be pumped through a ring main by pumps, each having an output of 40 tons per hour, at a pressure of 40 lb. per square inch. The steam-raising plant in the first half of the station consists of four boilers, constructed by Foster Wheeler, Limited, Ixworth-place, London, S.W.3, each capable of supplying 375,000 lb. of steam per hour at a pressure of 950 lb. per square inch and a temperature of 925 deg. F. at the maximum continuous rating. At this rating, the consumption of oil with a calorific value of 18,250 B.Th.U. per lb. is 26,800 lb. per hour. These boilers, of which two are now in operation, are of the single-drum natural circulation water-tube type and have a furnace volume of 21,750 cub. ft. and a heating surface of 19,715 sq. ft., 13,025 sq. ft. of which is in the water walls. The primary superheater has a heating surface of 7,543 sq. ft. and the secondary superheater one of 6,260 sq. ft., while an additional 1,625 sq. ft. is provided by the connecting tubes. The Green's economiser has a heating surface of 11,540 sq. ft., and that of the air heater, which is in two parts, is 72,048 sq. ft. Both the primary and secondary superheaters are of the horizontal drainable convection type. The primary air heater is of the gilled cast-iron pattern and the secondary heater has plain steel tubes. There is a convection bank between the primary superheater and the economiser, also of plain steel tubes. The tubes forming the superheater and convection heating surfaces are so pitched that any slag accumulation will fall clear, while water-washing installations are provided for the superheaters, boiler convection surface, economiser and primary air heaters, the effluent from which is collected in hoppers.

Fuel is supplied to the burners by pumps driven by variable-speed direct-current motors. These deliver the oil, heated to 250 deg. F., at a pressure of between 250 lb. and 300 lb. per square inch. There are 12 burners of the pressure-atomising type. They were supplied by Todd Oil Burners, Limited, 130, Leadenhall-street, London, E.C.3, and are arranged in two rows in the front wall of the combustion chamber, as shown in Fig. 3. They are fitted with gas pilots for ignition purposes. The boiler output is controlled from the panel illustrated in Fig. 5, on page 112, by varying the oil pressure and altering the number of burners in use. The instruments for this purpose being supplied by George Kent, Limited, Luton. Control of the two forced-draught and two induced-draught Howden fans with which each boiler is equipped is also effected from this position, as is that of the electrically-driven steam soot blowers, which come automatically into operation in sequence. The high-pressure steam pipes were supplied by C. A. Parsons and Company, Limited, Newcastle-on-Tyne, and the high-pressure valves by Dewrance and Company, Limited, Great Dover-street, London, S.E.1.

The generating plant in the first half of the station will consist of two 60-MW turbo-alternators, one of which, now in operation, is illustrated in Fig. 6, on page 112. These machines, constructed by the British Thomson-Houston Company, Limited,

BANKSIDE "B" POWER STATION, LONDON.

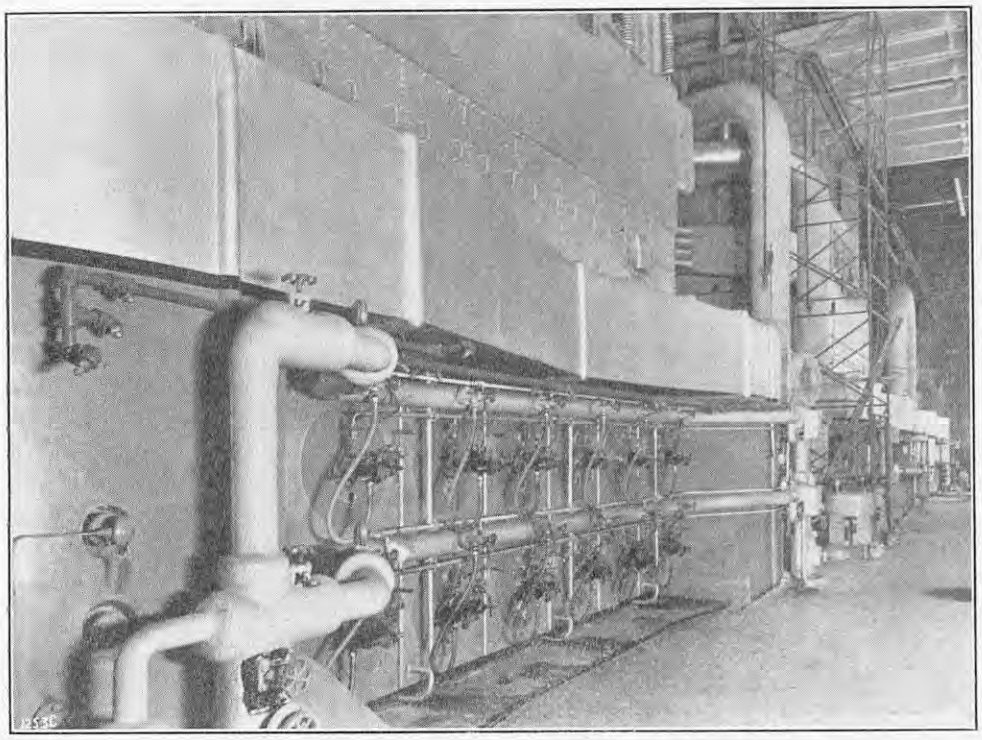


FIG. 3. BOILER CONTROL AISLE.

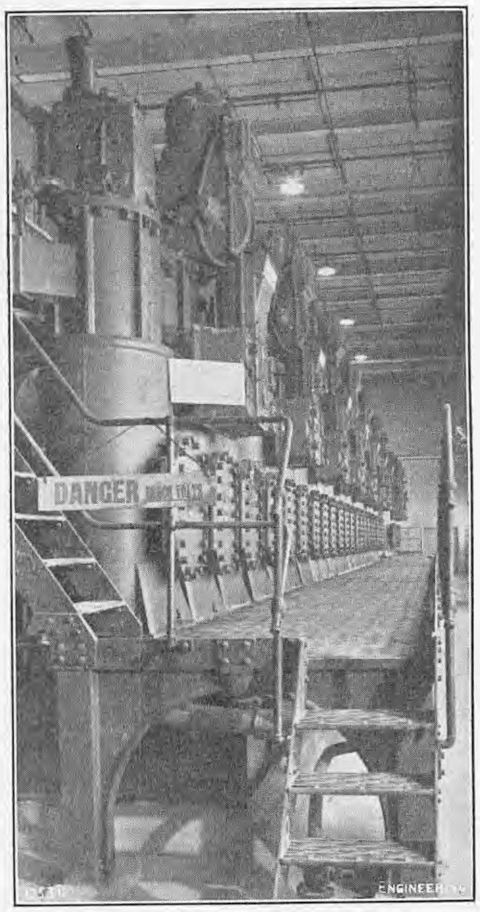


FIG. 4. 2,500-KVA 66-KVA SWITCHGEAR.

Rugby, are of the two-cylinder type with double-flow low-pressure cylinders, and run at 3,000 r.p.m. They exhaust into twin condensers, supplied by Richardsons Westgarth and Company, Limited, Hartlepool, each of which has a cooling surface of 50,000 sq. ft. The cooling water is taken from the river through an 18-ft. diameter shaft and a 10-ft. diameter concrete-lined cast-iron tunnel into a penstock chamber in the chimney foundation. The water is pumped thence to the condensers through rotary strainers by four electrically-driven vertical-spindle Drysdale centrifugal pumps each with a capacity of 1,640,000 gallons per hour. It is discharged through a concrete-lined cast-iron tunnel driven in the clay about 60 ft. below ground level, to the north side of the river, where the tunnel terminates in a cast-iron shaft 18 ft. in diameter, rising to the river bed.

The feed-heating system, also supplied by Messrs. Richardsons Westgarth, operates on the closed-circuit principle. The condensate is extracted by electrically-driven pumps and forced through an air ejector, drain cooler, and low-pressure feed heaters to a spray-type de-aerator. Other pumps extract this water from the de-aerator and discharge it to the suctions of the feed pumps, where it is delivered to the boilers through three high-pressure feed heaters in series. The three electrically-driven feed pumps and one turbine-driven feed pump, all capable of 100 per cent. duty, operate on common suction and common delivery mains. They can supply 600,000 lb. of water per hour at a temperature of 246 deg. F., against a pressure of 1,250 lb. per square inch.

ELECTRICAL EQUIPMENT.

The main alternators are designed to generate three-phase current at 15 kV and a frequency of 50 cycles, and run at 3,000 r.p.m. Each is coupled to a 66-MVA 15/66-kV main transformer, constructed by Ferranti, Limited, Hollinwood, Lancashire. The tanks of these transformers, which are housed in open-fronted cubicles on the ground floor of the switch house, also contain a 5-MVA 15/3-kV unit transformer from which the station auxiliaries are supplied. These auxiliaries can also be supplied from two 7-MVA 66/3-kV house service transformers. Energy is supplied to the London Electricity Board's distribution system at 22 kV through four 25-MVA 66/22-kV transformers and at 11 kV through four 15-MVA 66/11-kV units. Finally, the smaller station auxiliaries are fed through seven 500-kVA 3,000/415-volt transformers. The main 66-kV circuits are controlled by switchgear with a rupturing capacity of 2,500 MVA, constructed by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. This switchgear, illustrated in Fig. 4, on page 109, is installed on the three upper floors of the switch house. The 'bus-bars and connections are of the condenser-bushing type, all the joints and connections being contained in oil-filled sealing chambers. The 22-kV network is controlled from a duplicate 'bus-bar two-section switchboard, supplied by Ferguson Pailin, Limited, Manchester, and is fitted with circuit-breakers with a rupturing capacity of 500 MVA. The 11-kV network is controlled from a similar switchboard, constructed by A. Reyrolle and Company, Limited, Hebburn-on-Tyne, and is fitted with circuit-breakers having a rupturing capacity of 350 MVA. Both the 22-kV and 11-kV switchgear are situated on the ground floor of the switch house. The 3-kV auxiliary switchgear is of the single 'bus-bar type and has a rupturing capacity of 150 MVA. It is partly installed in the switch house and partly alongside each generator in the mechanical annexe. Main and sub-distribution boards for the 415-volt circuits are situated close to their associated transformers. The 66-kV, 22-kV, 11-kV and 3-kV switchgear is all electrically operated from a central control room, which is illustrated in Fig. 8, on page 112. The neutrals of the alternators are earthed through voltage transformers and those of the 66-kV and 22-kV systems through limiting resistors. The 11-kV, 3-kV and 415-volt systems are directly connected to earth. The Bankside station is connected to the Battersea and Deptford stations of the London Division by two 66-kV cables, and ten 22-kV and 12 11-kV cables link it to various substations of the London Electricity Board.

GAS-WASHING PLANT.

As mentioned above, approval of the construction of the station at Bankside was conditional on the provision of flue-gas washing plant. Owing to the difficulties experienced in obtaining castings, this plant is not yet ready, it may be stated that it has been designed to remove 95 per cent. of the sulphur oxides in the flue gases when burning oil with a maximum sulphur content of 4 per cent. It will consist of a washing chamber in each half of the station, which will be constructed of cast iron plate and will be 106 ft. high, 53 ft. wide and 48 ft. deep. Each chamber will contain two absorption passes through which the gases will flow in series, and will be packed to a depth of 55 ft. with timber scrubbers of "egg box" construction which will be sprayed with water through ebonite nozzles. There will also be a transfer pass. The boiler gases will discharge into a mild-steel flue at basement level and will then pass into the bottom of the washing chamber. From the top of this chamber they will be discharged into four cast-iron octagonal flues and thence into the atmosphere. Each flue will be fitted with a damper and nozzle, so that, at any load above 25 per cent., the gases can be discharged at a velocity between 60 and 120 ft. per second.

The wash water will be pumped into the tanks through a 30-in. pipe by eight Pulsometer pumps, five of which have already been installed. These pumps, which are illustrated in Fig. 7, on page 112, are connected to the circulating-water discharge culvert and are each designed to handle 220,000 gallons per hour against a total head of 175 ft. Chalk is injected into the wash water in the form of a 50-per cent. slurry by a further set of pumps. As the water leaving the washing chambers is acidic it is passed through rubber-lined pipes to aeration chambers, where air from a battery of compressors is forced into it through ceramic diffusers. It is, then passed through oil separators before being discharged into the river. The structural steelwork for this part of the station is being carried out by Sir William Arrol and Company, Limited, Glasgow, and the pipe work by Mathew Hall and Company, Limited, London.

The attempt to solve the problems of amenity and town planning at Bankside by the use of oil firing will add something to the cost of operation, compared with coal. It is estimated that the oil consumption of the complete station when running at full load on a two-shift basis will be 67 tons per hour, or 230,000 tons per annum, with an output of 831 million kWh; but the thermal efficiency should be about 30 per cent., and oil-firing will enable the plant to be put on load much more quickly than would be possible with coal and increase its usefulness as a stand-by.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Education in Steam Utilisation.—A one-day conference on steam utilisation, organised by the fuel-technology education advisory committee of the Ministry of Fuel and Power, was held in Glasgow on Tuesday, January 13. It was addressed by Mr. Oliver Lyle, director of Tate and Lyle, Ltd. The conference, which was attended by directors of Scottish firms, executives, and works engineers, will be followed by a course of nine weekly lectures on Tuesday evenings for junior executives, engineers, and foremen. These will be held in the Stow College of Engineering, Glasgow.

Office-Machinery Industry.—A particularly interesting aspect of the growth of the office-machinery industry has been the concentration of a large portion of it in Scottish development areas, which now account for about a third of the total output of this country. This was reported in H.M. Treasury's *Bulletin for Industry*, published on January 14. As a producer of office equipment, Great Britain now ranks second only to the United States.

New Jetty, Aberdeen Harbour.—Permission to proceed with the construction of a new reinforced-concrete jetty in the tidal harbour, eastward of the dock gates island, Aberdeen, has been granted by the Ministry of Transport. They have recommended acceptance of the tender of William Tawse, Ltd., Aberdeen, amounting to 28,307*l*.

CLEVELAND AND THE NORTHERN COUNTIES.

Progress at the Dorman, Long Steelworks.—Writing in "1952 Illustrated," a booklet issued by Dorman, Long & Co., Ltd., Middlesbrough, Sir Ellis Hunter, the chairman and managing director of the firm, states that the second stage of their development plan is nearing completion and it is expected that the new steel plant at Lackenby will be in operation this summer. In 1952 the company had to contend with shortages of materials which resulted in some reduction of steel output. Conditions have improved, however, and they are looking forward to fresh records in 1953. The new Lackenby steelworks have been designed for an annual ingot production of 500,000 tons, capable of expansion to 750,000 tons.

Extensions to Industrial Premises.—At a meeting of the Northern Regional Board for Industry, at Newcastle-on-Tyne, it was reported that 12 development certificates, for extensions to industrial premises covering 181,000 sq. ft., had been approved during the past two months. Major extension schemes were approved for factories at Stockton, Hebburn, Sunderland and Whitehaven. The Sunderland project relates to new machine sheds of 14,000 sq. ft. at the shipyard of William Pickersgill and Sons.

Co-operation Between Management and Employees.—Mr. R. W. Mann, managing director of Victor Products, Ltd., makers of mining equipment, Wallsend, addressing members of the Darlington Rotary Club, said that, 15 years ago, his firm had begun to make provision for their employees and for the future of their old people, and had also put by sufficient capital to carry them through a slump. During those 15 years, the firm had increased their output by 300 per cent. Each man was turning out nearly three times as much work as had previously been the case; employees were obtaining the highest wages in the area; and the turnover had increased eight-fold.

River Tyne Trade Statistics.—At the monthly meeting of the Tyne Improvement Commission at Newcastle-on-Tyne it was reported that coal and coke shipments from the river in 1952 had amounted to 9,251,371 tons, an increase of 6·6 per cent. on the 1951 total, but 27·5 per cent. less than the figure for 1938. During the first 11 months of 1952, imports of general merchandise had amounted to 2,398,540 tons, against 2,288,573 tons in 1951. The main items imported were iron ore (629,978 tons), oil fuel and other oils (577,744 tons), and pit props (207,423 tons). Exports of general merchandise during the 11 months amounted to 362,486 tons against 356,711 tons in 1951. The chief exports were sulphate of ammonia (99,583 tons), oil-fuel (76,684 tons), machinery (32,099 tons), and tar and pitch (31,520 tons).

Problems of River Pollution.—When the question of river pollution was discussed at a recent meeting of the Institution of Works Managers, at Middlesbrough, Mr. J. A. Kenyon, borough engineer of Middlesbrough, asked whether there was not a tendency to over-stress the importance of some aspects of pollution. Mr. A. G. Caddick, of Middlesbrough, said that a 1938 survey had shown that the Tees salmon fishing was worth about 30,000*l*. annually; on the other hand, one firm had estimated that it would cost 40,000*l*. a year to purify the effluent from their works.

LANCASHIRE AND SOUTH YORKSHIRE.

A 200-Ton Steel Casting.—Mr. F. Pickworth, managing director of the English Steel Corporation, Ltd., has announced that a very large casting will shortly be made at the Corporation's Grimesthorpe works, Sheffield. It is for export and needs 210 tons of steel for its production. In its finished state it will weigh 168 tons.

Skilled-Labour Shortage.—Sheffield engineering firms are experiencing the greatest difficulty in attracting the additional skilled labour which has been needed for some time. Recourse to special advertising as well as the assistance of the Employment Exchanges still leaves many vacant posts. A stage has been reached when leading engineering firms are considering whether it may not be necessary to limit their bookings to the extent of the skilled labour available. In particular, there is a dearth of fettlers in the foundries.

Sheffield Steel-Making Records.—Last year, Sheffield steelmakers produced more ingots and castings than in any previous year, exceeding the 1951 average by 2,200 tons a week. In November, 21,120 tons of alloy steel, other than high-speed, were produced, a decline of 120 tons compared with October, but 2,560 tons more than in November, 1951. The output of high-speed steel at 230 tons a week, however, compared with 400 tons a week in November, 1951.

Easing of Australian Restrictions.—Sheffield manufacturers have been advised that a further easing of Australian import restriction is contemplated. This is welcome news, particularly for makers of a wide variety of hand tools, some of whom regarded Australia as their most lucrative export market until the severe import restrictions were imposed.

THE MIDLANDS.

The British Industries Fair.—The Board of Trade have planned a world-wide publicity campaign for engineering products which are to be shown at the Birmingham section of the British Industries Fair, from April 27 to May 8. Photographs have been taken in a number of factories in Birmingham, Coventry, and other Midland industrial centres, showing new products and details of work in progress. These photographs are being circulated, with suitable descriptive matter in twelve languages, to 63 countries. Special efforts are being directed towards the United States and Canada.

Increased Water Consumption.—Two water authorities in the Midlands have reported an increased consumption of water during the past year. In Birmingham, the daily consumption figure has risen to 49,000,000 gallons, an increase of nearly 2,000,000 gallons over the corresponding period a year earlier, and in Wolverhampton the figure is now 9,526,000 gallons a day. Both authorities have brought into use new plant during the year. An additional borehole has been completed at Wolverhampton, and the construction of a new service reservoir there has been authorised. In the case of Birmingham, the construction of the Claerwen dam has almost doubled the former storage capacity.

Power-Station Ash.—The Rural Council of Stone, Staffordshire, are investigating complaints about the dumping of ash from the British Electricity Authority's Meaford power station. It has been reported to the council that 180,000 tons of ash are being deposited each year on land in the neighbourhood, a quantity sufficient to cover four acres to a depth of 10 ft.

Sewer Diversion.—The Upper Stour Valley Main Sewerage Board have authorised the diversion of a sewer at Lye, near Stourbridge, which has been damaged by tipping over a period of several years. There have been some temporary stoppages of the sewer, and the engineer to the Board, Mr. G. P. Deeley, has reported that a permanent stoppage may occur at any time. To uncover and re-lay the sewer would involve the removal of 68,000 cubic yards of material, and the alternative of diverting it has been chosen on the grounds of cost.

New Type of "Zebra" Crossing.—A "zebra" crossing made of earthenware blocks, with a pattern in raised studs, has been laid experimentally at one of Birmingham's busiest road junctions, the corner of Ashted-row and Vauxhall-road. The crossing blocks, which were made at Burslem, are expected to provide a solution to the problem of traffic wear on busy roads, which quickl ydestroys painted stripes.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Welsh Coal Trade.—South Wales coal exports to foreign destinations last year amounted to 3,740,963 tons, showing a substantial improvement over the 1951 figure of 3,007,075 tons. Operators on the market are hopeful that the expansion will be continued during the present year. The threat of the Saturday shift and overtime coming to an end when the current agreement governing their working terminates at the end of April, however, has caused shippers a good deal of anxiety. The miners have made its continuance conditional upon acceptance by the National Coal Board of their demands for increased wages for all day employees.

Trade Statistics of South Wales Ports.—The South Wales ports last year handled a total trade of 22,618,551 tons, an increase of 2,158,360 tons on the 1951 figure. Imports were 637,059 tons heavier at 10,042,144 tons, despite the fact that, in 1951, over 250,000 tons of American coal were received as against none in 1952. Exports were 1,521,301 tons higher at 12,576,407 tons. Tin-plate shipments abroad, last year, were 278,285 tons, compared with 208,851 tons in 1951, while iron and steel goods were 235,340 tons, showing a decline from the previous year's total of 256,146 tons. Oil and spirits exported to foreign countries rose from 1,444,217 to 2,075,402 tons. Imports of oil and spirits aggregated 3,794,709 tons, against 4,572,275 tons. Arrivals of iron ore, at 2,191,589 tons, were 1,999,915 tons heavier.

Rhoose Airport, Barry.—Cardiff Corporation Airport Committee has received official notification that the Rhoose airport, near Barry, is to become the State airport for Cardiff and South Wales. In a letter from the Ministry it was stated that the most urgent requirements at Rhoose were the extension of passenger accommodation and the erection of a hangar with workshop facilities.

Labour Dispute at Trostre.—A dispute involving members of the Amalgamated Engineering Union and the Electrical Trades Union brought operations in the cold-reduction plant at the Trostre Works, Llanelly, of the Steel Company of Wales, Ltd., to a standstill. The men, however, returned to work on the following day. The dispute between 200 fitters of the A.E.U. and the management resulted in the closing of the works on January 14. A statement by the management said that, because the fitters concerned refused to perform their normal duties in connection with the changing of rolls on the electrolytic line and pickling installations, production in these departments had been brought to a standstill. As a consequence, the management were unable to keep other departments in operation and the 900 employees of the plant ceased work at 2 p.m. on January 14. The works resumed at 10 p.m. and production in all departments was restarted at 2 p.m. on Friday, January 16.

The Redundant Tin-Plate Mills.—Swansea Corporation Parliamentary Committee have recommended the Swansea Council to invite the Minister for Welsh Affairs, Sir David Maxwell Fyfe, to convene, in the town, a conference of local authorities and trades unions concerned, to discuss the position of redundant tin-plate mills in West Wales. The committee had received notification from the Iron and Steel Corporation of Great Britain of a recommendation by the standing sub-committee of the Welsh Tin-plate and Sheet Trades Joint Industrial Council that, because of present circumstances, six West Wales works would be closed down as soon as possible. Following a meeting of the special joint sub-committee of the Welsh Tin-plate Joint Industrial Council, it was officially stated that plans were in hand for the re-employment, at other works, of a substantial proportion of the men who would be affected by the closing of the mills.

Silting of River Taff.—To meet the problem of silting at the entrance to the docks caused by the River Taff, the Cardiff Port Development Association have consulted Sir Claude Inglis, Director of Hydraulics Research of the Department of Scientific and Industrial Research, who has visited Cardiff and inspected the river.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—*Radio Section:* Monday, January 26, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Relative Merits of Harmonic and Intermodulation Measurements in Assessing Distortion in Audio Equipment," opened by Mr. E. W. Berth-Jones. *North-Eastern Centre:* Monday, January 26, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Design of High-Speed Salient-Pole Alternating-Current Generators for Water-Power Plants," by Mr. E. M. Johnson and Mr. C. P. Holder. *North Midland Centre:* Tuesday, January 27, 6.30 p.m., College of Technology, Cookridge-street, Leeds. Discussion on "Lighting and Illumination in Electrical Engineering Courses," opened by Dr. E. C. Walton. *Western Centre:* Tuesday, January 27, 6.30 p.m., Colston Hall, Bristol. Faraday Lecture on "Light from the Dark Ages or the Evolution of Electricity Supply," by Mr. A. R. Cooper. *South Midland Centre:* Tuesday, January 27, 7.15 p.m., Winter Gardens Restaurant, Great Malvern. "Colour Television," by Mr. L. C. Jesty. *Supply Section:* Wednesday, January 28, 5.30 p.m., Victoria-embankment, W.C.2. "Researches on Circuit-Breaking by Means of High-Voltage Circuit-Breakers, with Special Reference to Current-Chopping," by Mr. A. F. B. Young.

INSTITUTION OF THE RUBBER INDUSTRY.—*Manchester Section:* Monday, January 26, 6.15 p.m., Engineers' Club, Manchester. "The Study of Ozone Cracking by Cinematography," by Miss D. Wyatt and Mr. V. E. Gough.

ILLUMINATING ENGINEERING SOCIETY.—*Leicester Centre:* Monday, January 26, 6.30 p.m., Offices of East Midlands Electricity Board, Charles-street, Leicester. "Automobile Lighting," by Mr. K. J. Jones. *Liverpool Centre:* Tuesday, January 27, 6 p.m., Offices of Merseyside and North Wales Electricity Board, Whitechapel, Liverpool. "Black Light: Its Effect and Application," by Mr. H. L. Privett.

INSTITUTION OF PRODUCTION ENGINEERS.—*Manchester Section:* Monday, January 26, 7.15 p.m., College of Technology, Manchester. "Manufacture of a Large Water-Wheel Generator," by Mr. R. H. S. Turner. *Luton Section:* Tuesday, January 27, 7.15 p.m., Town Hall, Luton. "Problems of Machine Maintenance," by Mr. R. M. Buckle. *Lincoln Section:* Tuesday, January 27, 7.30 p.m., Canteen, Ruston and Hornsby, Ltd., Boultham Works, Lincoln. "Fundamentals of Production Management," by Mr. M. Seaman. *Cornwall Section:* Wednesday, January 28, 7.15 p.m., School of Mines, Camborne. "Planning and Controlling the Processes of Production," by Mr. B. E. Stokes.

INCORPORATED PLANT ENGINEERS.—*West and East Yorkshire Branch:* Monday, January 26, 7.30 p.m., The University, Leeds. Film on "Basic Principles of Lubrication." *South Yorkshire Branch:* Thursday, January 29, 7.30 p.m., Grand Hotel, Sheffield. Film on "Oxygen in Industry."

ROYAL INSTITUTION.—Tuesday, January 27, 5.15 p.m., 21, Albemarle-street, W.1. "Experimenting at High Pressures." I. "The Measurement of High Pressure," by Professor D. M. Newitt, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.—*Railway Engineering Division:* Tuesday, January 27, 5.30 p.m., Great George-street, S.W.1. "The Design of Structures in Relation to Maintenance and Inspection," by Mr. F. Turton and Mr. N. S. Cox.

INSTITUTE OF FUEL.—Tuesday, January 27, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Efficiency of Domestic Space-Heating Appliances," by Mr. L. L. Fox. *Yorkshire Section:* Wednesday, January 28, 6.30 p.m., The University, Sheffield. (i) "Ash and Clinker in Practice: Handling and Disposal," by Mr. W. G. Marskell and Mr. C. W. Pratt; and (ii) "External Boiler Deposits," by Dr. H. E. Crossley.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 27, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Production of Sound Castings by Controlled Rate of Heat Transfer," by Mr. B. W. Payne and Mr. C. A. Parlanti.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, January 27, 7 p.m., Grand Hotel, Sheffield. "Hydrogen in Steel: A General Survey," by Mr. K. C. Barraclough.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, January 27, 7 p.m., Manson House, 26, Portland-place, W.1. "Instrumentation in the Paper-Making Industry," by Mr. F. W. Hayward.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*West Midlands Section:* Tuesday, January 27, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. "The Search for Band-Width Economy in Television," by Mr. D. A. Bell.

ROYAL AERONAUTICAL SOCIETY.—*Graduates' and Students' Section:* Tuesday, January 27, 7.30 p.m., 4, Hamilton-place, W.1. "A Physical Interpretation of Supersonic Flow," by Mr. R. Stanton Jones. *Society Lecture:* Thursday, January 29, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Titanium," by Major P. Litherland Teed.

ROYAL STATISTICAL SOCIETY.—Wednesday, January 28, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Regional Variations in United Kingdom Incomes from Employment, 1948," by Miss Phyllis Deane. *Birmingham Industrial Applications Group:* Wednesday, January 28, 6.45 p.m., Chamber of Commerce, 95, New-street, Birmingham, 2. "Sources of Variation in a Transformer Sheet Mill," by Mr. A. D. Grace.

INSTITUTE OF PETROLEUM.—Wednesday, January 28, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Geophysics: Its Problems and Trends," by Dr. D. J. Germain-Jones.

WOMEN'S ENGINEERING SOCIETY.—*Manchester Branch:* Wednesday, January 28, 6.30 p.m., Engineers' Club, Manchester. "The Projection of Microscopic Structures," by Mr. W. J. Garnett.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Lancashire and Cheshire Branch:* Wednesday, January 28, 6.30 p.m., College of Technology, Manchester. "The Structural Design of a Medieval Cathedral," by Mr. Ronald Oates.

INSTITUTE OF MARINE ENGINEERS.—Wednesday, January 28, 7 p.m., Gravesend Technical College, Gravesend. "Photo-Elasticity," by Dr. J. Ward. Thursday, January 29, 7.30 p.m., Barrow-in-Furness Technical College, Barrow-in-Furness. "Construction of Marine Boilers," by Lieut.-Cmdr. (E) A. P. Monk.

INSTITUTION OF ENGINEERING INSPECTION.—*West of Scotland Branch:* Wednesday, January 28, 7.30 p.m., 351, Sauchiehall-street, Glasgow, C.2. Film Evening.

INSTITUTE OF BRITISH FOUNDRYMEN.—*London Branch:* Wednesday, January 28, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. Three papers on "Runners and Risers," by Mr. E. D. Daybell, Mr. P. A. Russell and Mr. R. W. Ruddle. *West Wales Section:* Friday, January 30, 7 p.m., Works Canteen of Richard Thomas and Baldwins Ltd., Landore. "Strength, Structure and Composition of Unalloyed Grey Irons," by Dr. H. T. Angus. Also at the *Wales and Monmouthshire Branch:* Saturday, January 31, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. *Falkirk Section:* Friday, January 30, 7.30 p.m., Temperance Café, Lint Riggs, Falkirk. "Synthetic Resins," by Mr. R. Carswell.

INSTITUTION OF MECHANICAL ENGINEERS.—*East Midlands Branch:* Wednesday, January 28, 7.30 p.m., B. E. A. Generating Station, Peterborough. "The Measurement and Interpretation of Machinery Noise, with Special Reference to Oil Engines," by Mr. C. H. Bradbury. *Institution:* Friday, January 30, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Steam Group*. "Scale Formation in Sea-Water Distilling Plants and Its Prevention," by Mr. H. Hillier. AUTOMOBILE DIVISION.—*Birmingham Centre:* Tuesday, January 27, 6.45 p.m., James Watt Memorial Institute, Birmingham. "Research and the Engineering Process, with Particular Reference to the Automobile Industry," by Dr. H. E. Merritt. *Western Centre:* Thursday, January 29, 6.45 p.m., Grand Hotel, Bristol. Open Meeting.

ROYAL SOCIETY.—Thursday, January 29, 10 a.m. and 2 p.m., Burlington House, Piccadilly, W.1. All-Day Discussion on "*V*-Particles and Heavy Mesons," opened by Professor C. F. Powell, F.R.S.

INSTITUTE OF METALS.—*Birmingham Section:* Thursday, January 29, 6.30 p.m., James Watt Memorial Institute, Birmingham. Discussion on "Modern Technique in Spectrographic Analysis."

INSTITUTE OF WELDING.—*Medway Section:* Thursday, January 29, 7.15 p.m., Sun Hotel, Chatham. Film on "Arc Characteristics," with introduction by Dr. H. Orton.

ROYAL METEOROLOGICAL SOCIETY.—*Scottish Centre:* Friday, January 30, 5 p.m., The University, Drummond-street, Edinburgh, 8. Repetition of 1952 Symons Lecture on "World-Wide Oscillations in the Earth's Atmosphere," by Dr. M. V. Wilkes.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 30, 6.15 p.m., Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Thickness of Tubes for Water-Tube Boilers," by Mr. D. W. Crancher.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 30, 7 p.m., Townsend House, Greycoat-place, Victoria-street, Westminster, S.W.1. "Metal Spinning," by Mr. R. E. Baskerville.

INSTITUTION OF CHEMICAL ENGINEERS.—*Midlands Branch:* Saturday, January 31, 3 p.m., The University, Edmund-street, Birmingham. Annual General Meeting. "The Treatment of Waste Gases in the Chemical Industry," by Mr. W. A. Damon.

PERSONAL.

LORD WALERAN has been appointed a vice-chairman of the International Road Federation, *ex-officio* councillor, and a vice-chairman of the Council. The appointments of MR. H. R. B. WATERS and COLONEL W. P. F. MCLAREN as councillors have been confirmed.

The formation of a joint management board, known as the RICHARD THOMAS STEEL COMPANY MANAGEMENT BOARD, and charged with the duties of managing the STEEL COMPANY OF WALES LTD., and RICHARD THOMAS AND BALDWINS LTD., has been announced. MR. E. H. LEVER retains the joint chairmanship of the two companies, but has relinquished the managing directorship of Richard Thomas and Baldwins Ltd. MR. H. F. SPENCER, now managing director of the latter firm, and MR. E. JULIAN PODE, managing director of the Steel Company of Wales, are members of the new board, as is also MR. T. GRIFFITHS, joint secretary of Richard Thomas and Baldwins, and secretary of the board. The two companies, however, will retain their separate identities and their names will remain unaltered.

MR. A. G. E. BRIGGS, who was created a Knight in the New Year Honours List, and who, as stated on page 47, *ante*, has left the Ministry of Supply to resume his full-time duties with Tube Investments Ltd., has consented to remain on the Royal Ordnance Factories Board of Management as an additional non-official member.

DR. W. J. WORBOYS, B.Sc., has been appointed chairman of the Council of Industrial Design, Tilbury House, Petty France, London, S.W.1, in succession to DR. R. S. EDWARDS, who retires on January 31 after holding office for five years. MR. R. A. MACLEAN, chairman of the Scottish Committee of the Council, has accepted the invitation to remain in office for a further two years from February 1.

MR. R. H. HEMMINGS has been appointed chairman of the British Refrigeration Association, 1, Lincoln's Inn Fields, London, W.C.2, for 1953, in succession to MR. A. E. LEACH, who has held office for three years.

MR. J. P. A. MELDRUM, O.B.E., B.Sc., M.I.E.E., has been appointed manager, home sales, Metropolitan-Vickers Electrical Co. Ltd. MR. A. E. GRIMSDALE, B.Sc.(Eng.), has been made special assistant, sales management and MR. J. C. WAY, A.M.I.E.E., A.M.I.Loco.E., sales manager, traction department. All three appointments took effect on January 1.

MR. JOHN ELLIOT, chairman of the Railway Executive, and vice-president of the International Union of Railways, has been nominated an Officer of the Legion of Honour by the French Government.

MR. W. COOLING, A.M.I.Mech.E., has been appointed chief designer of Leyland Motors Ltd., Leyland, Lancashire.

MR. A. ROBERT JENKINS, J.P., has been appointed managing director of Robert Jenkins & Co. Ltd., Rotherham, in succession to the late MR. ERNEST TWIGG. He will also be managing director of the firm's subsidiary concern, the Rotherham Motor Co. Ltd.

MR. R. R. C. RANKIN, O.B.E., A.M.I.E.E., A.R.T.C., a director of Mullard Equipment Ltd., has been appointed a director of Telcon Telecommunications Ltd. (owned jointly by Mullard Ltd., and the Telegraph Construction and Maintenance Co. Ltd.) in place of DR. C. F. BAREFORD, who has resigned following appointment as chief superintendent of the Long Range Weapons Establishment, at Salisbury and Woomera, South Australia.

MR. C. M. LANGLEY has joined the board of Stelcon (Industrial Floors) Ltd., Clifford's Inn, London. E.C.4.

MR. J. W. SCOTT, chief estimator to Head, Wrightson & Co. Ltd., Teesdale Iron Works, Thornaby-on-Tees, retired on December 31. He commenced work with the firm in 1887.

British Insulated Callender's Cables Ltd. announce that MR. T. L. PURVES is the new manager of their Bristol branch, in succession to MR. R. S. GOUGH, and that MR. L. R. GREET has succeeded MR. T. R. THOMAS as branch manager, Cardiff.

OPPERMAN GEARS LTD., Newbury, Berkshire, have appointed SAUNDERS AND PURVES LTD., 12, St. Mary's-place, Newcastle-upon-Tyne, 1, to be their sole agents in the North of England; and ANDREW MCNAIR & Co., 261, West George-street, Glasgow, C.2, to be their sole agents in Scotland.

BURTON, GRIFFITHS & CO. LTD., the sales organisation of the B.S.A. TOOLS GROUP, announce that their Leeds branch office has been removed to 27A, Butts-court, Leeds, 1 (Telephone: Leeds 34251/2).

POLDI (ENGLAND) SUCCESSORS LTD., 4, Machon-bank, Sheffield, 7, have taken over the selling organisation and manufacturing programme, in this country, of the POLDI STEEL COMPANY (ENGLAND) LTD.

BANKSIDE "B" POWER STATION OF THE BRITISH ELECTRICITY AUTHORITY.

(*For Description, see Page* 107.)

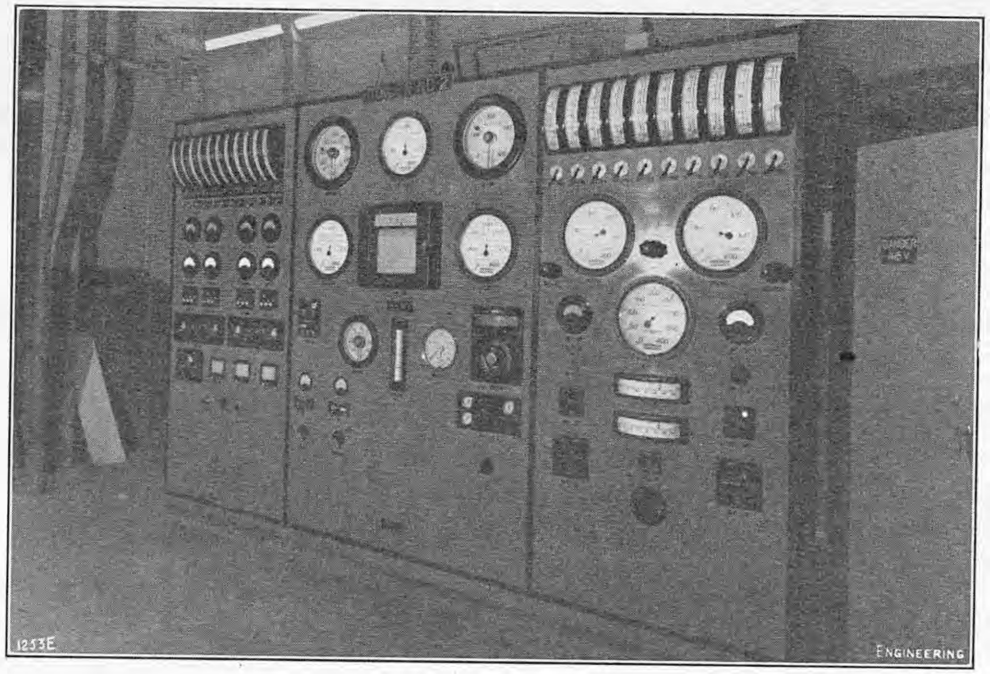


Fig. 5. Boiler Control Panel.

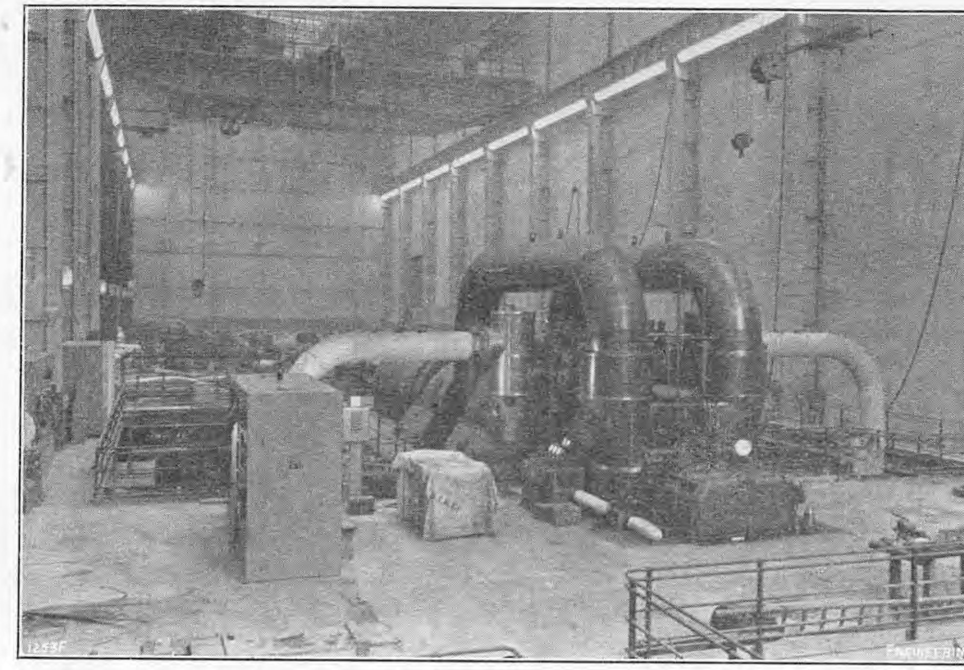


Fig. 6. 60-MW Turbo-Alternator and Control Panel.

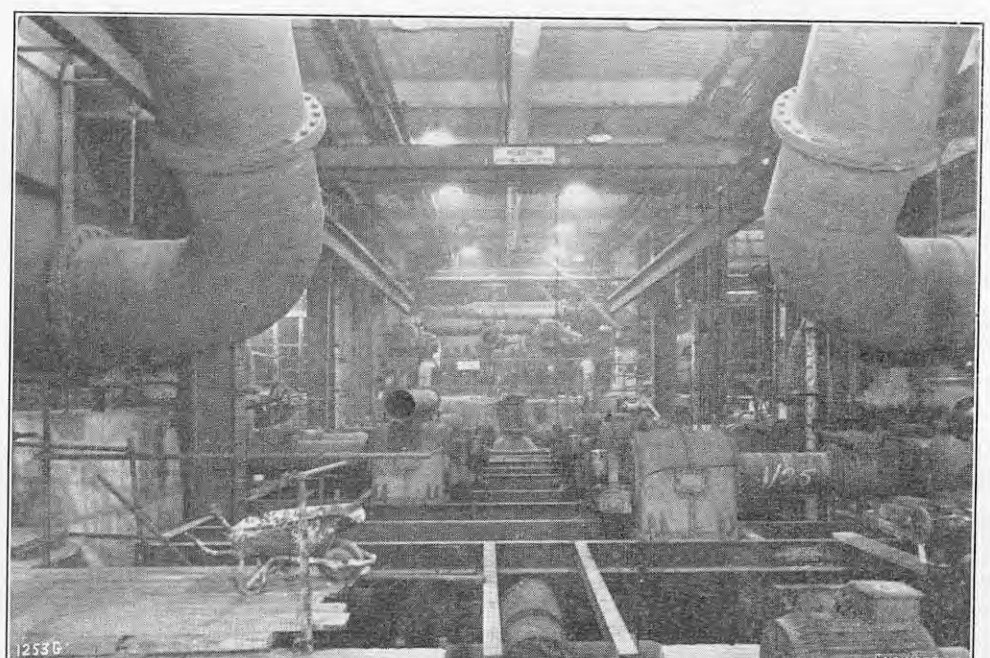


Fig. 7. Flue-Gas Washing Plant in Course of Erection.

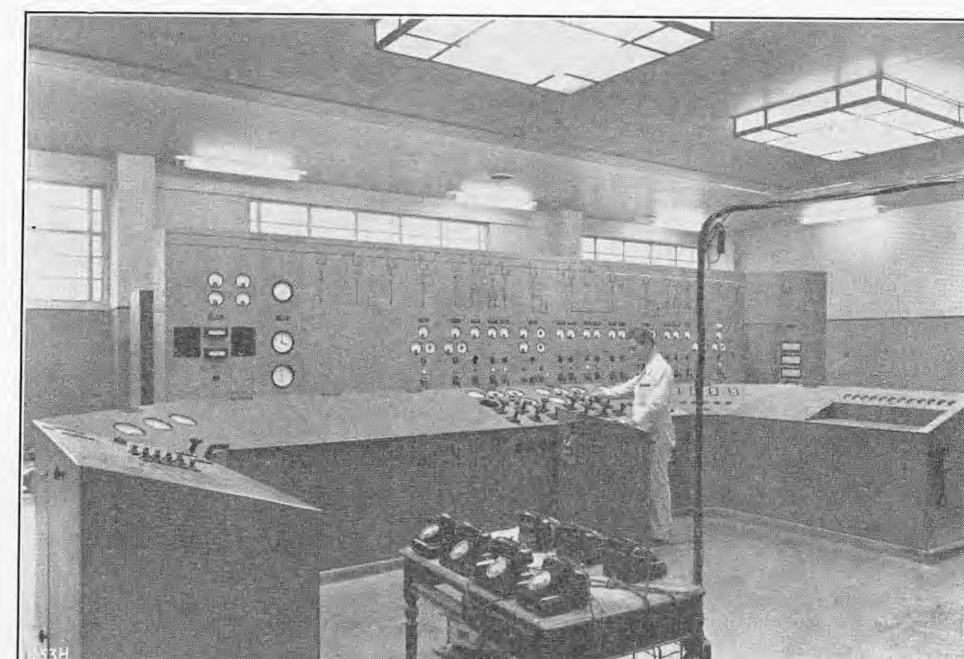


Fig. 8. Electrical Control Room.

ENGINEERING

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ENGINEERING

FRIDAY, JANUARY 23, 1953.

VOL. 175. No. 4539.

THE GOVERNMENT AND THE IRON FOUNDRIES.

WHEN, in 1948, the Bill which eventually became the Iron and Steel Act, 1949, was under consideration, the policy of the then Government was stated to be that of bringing under public ownership only the basic processes of steelmaking. It was recognised that, in acquiring the properties of the private firms who carried on those processes, the new Corporation that was to be set up would inevitably acquire also a number of works engaged on other activities, because they were wholly-owned subsidiaries. It was not the intention, however, that the acquisition should extend, in general, beyond the basic steel-producing organisations to those which existed for the purpose of "converting" into commercial end-products the basic material on which the work of "conversion" was done. In practice, this intention was carried out by the Act of 1949. The Iron and Steel Corporation of Great Britain was duly formed, and its permissible activities were defined in the Second Schedule to the Act as covering "the working and getting of iron ore, the smelting of iron ore in a blast furnace with or without other metalliferous materials, the production in the form of ingots of steel (including alloy steel)" and "the changing of the cross-sectional dimensions or cross-sectional shape of steel by hot rolling in a rolling mill."

When, however, the present Government turned their attention to implementing their election promise to return the industry to private ownership, they were not content merely to repeal the Act of 1949 and thus to restore the *status quo*—which, admittedly, would be difficult, and practically impossible, to accomplish precisely. They were pledged to maintain some form of public control over the industry, in view of its vital bearing upon the commercial prosperity of the nation, and the method by which they proposed to do this, as outlined by Mr. Winston Churchill in 1950, was to revive the organisation which had exercised supervision over the industry, under the powers of the Ministry of Supply, from 1946 to 1948, and which continued, in effect, the operations of the war-time Iron and Steel Control. These intentions were set out in more detail in the White Paper on the *Iron and Steel Industry*, issued in July, 1952, which outlined the constitution and intended powers of the proposed new Iron and Steel Board.

At once it became clear that the control contemplated went far beyond the scope of the public ownership that it was designed to replace, and that it was to bring under supervision (and, to some extent, direction) "all the main processes which make up the iron and steel industry . . . thus bringing the whole industry again under the supervision of a single authority and ending the present distinction between nationalised and non-nationalised sectors." It was stated, however, that "the Board will not be concerned with the extensive engineering and other extraneous activities which, though not part of the iron and steel industry, were brought under the control of the Iron and Steel Corporation because they happened to form part of the activities of the companies which were nationalised." Unfortunately, the effect of this admirable sentiment was largely nullified by the appendix to the White Paper, which disclosed that it was the intention to control, not only the four fields of activity specified in the Second Schedule to the Iron and Steel Act, 1949, but also "the casting of iron or steel by any process, the processing, with or without heat, of iron or steel by rolling or forging (excluding drop forging and blacksmiths' hand forging), the production from iron or steel of hot-finished tubes or pipes or bright bars," and "the production of tinplate or terneplate." In short, "new presbyter was but old priest writ large," and still to be in possession of scarcely diminished powers of inquisition and, presumably, even of excommunication; for an Act that did not confer power to impose "sanctions" in cases of manifest infringement would soon become a dead letter.

It was with some surprise, therefore, that we learned from the Council of Ironfoundry Associations, a couple of months ago, that they were disposed to accept without serious objection the inclusion of iron foundries within the supervisory scope of the proposed new Board; and this surprise seems to have been shared by a large majority of the individual owners of foundries, who began at once to organise a protest. It appears, according to a letter that we have received from one user of castings, that "1,276 ironfounders have answered 'No' to the question whether they want to be supervised, against 86 who do not feel competent to manage their own affairs"; which, our correspondent comments caustically, is "a hopeful indication of our country's convalescence after 14 years of form-filling." He goes on to observe that "No one seems to have consulted those who machine the castings," and asks, "Can there not be a ballot among the users of castings, who must outnumber the foundries by ten to one or more? . . . And let us have the answers from individual firms, not trade associations."

Evidently, the strength of the opposition to the proposals which the Council of Ironfoundry Associations accepted so uncritically has impressed the Minister of Supply, for, at a meeting at which, last week, Mr. Duncan Sandys met representatives of the employers and trade associations concerned, he indicated that the Government were to propose a number of amendments to the Iron and Steel Bill, designed to meet the objections raised; though they were still determined to include foundries within the scope of the new Board's supervision. One of these amendments, he stated, would define the terms "rolling" and "forging," to make it clear that there is no intention to extend supervision to processes which are essentially functions of the engineering industry; another would exempt foundries from the obligation to submit development schemes for the Board's approval; and yet another would provide that the Board would have power to fix maximum prices of castings and forgings only in cases where monopoly or restrictive practices existed and where the Board had been unable to ensure by negotiation that prices should be "reasonable." Moreover, the powers of the Board to demand information about costs would be definitely restricted, and they would have no power to inspect property compulsorily; though it is intended that they should retain the power to inspect books and documents, to a limited extent, for the purpose of enforcing their decisions on development and prices—which seems curious, if foundries are under no compulsion to submit their development schemes for the Board's approval.

In this matter, we are much inclined to sympathise with the view of the 1,276 protesting foundry firms. In our opinion, it is preferable that the Board's supervisory authority should not extend beyond the production of the pig iron; not because we feel that their supervision would necessarily be detrimental or indirectly restrictive—though any avoidable increase in official "paper-work" is *prima facie* suspect—but because there seems to be no real occasion for anything of the sort. It should be no concern of the Board whether a purchaser of pig iron uses it to make castings or as permanent ballast in a ship, and we see no particular case for interference in the business of the one user rather than the other. Moreover, the making of iron or steel castings is so intimately associated with engineering design and construction, in what is probably a majority of cases, that it may be reasonably contended to be quite as much an engineering activity as the fabrication of components by welding. If the Board were to seek, or the Government proposed to give them, powers to subject welding fabricators to even the modified supervision now contemplated in the case of foundries, the absurdity of the claim would be self-evident.

A similar argument would apply, of course, in the case of rolling and forging operations performed on steel after it had passed out of the hands of the steelmaker into those of the steel user—even though, in many instances, this would mean merely a transfer from one shop to another in the same organisation. The arguments in favour of nationalising the steel industry were, primarily, that private ownership of the means of producing an essential raw material of industry was fundamentally wrong, and, in the second place, that it was inefficient. There are some who, as a matter of principle, would like to nationalise the whole engineering industry, but that is another matter; most of the advocates of nationalised steel did not concern themselves with the activities of the user, and the more moderate, at least, would probably recognise that there is no essential difference, as processes, between forging a propeller shaft under a hydraulic press and forging a horseshoe by hand in a village smithy. The dividing line between the one and the other is set, in practice, by the weight and size of the piece of metal to be handled, and by the economics of the operation, which is largely a question of scale. As Sir Alfred Herbert observed in his letter in *The Times* of January 17, the matter cannot be left where it now is, and Members of Parliament who represent industrial constituencies would do well to ascertain the views of their constituents on these aspects of the Bill and to act accordingly. As a general principle, and one which is particularly applicable to Government interference in industrial affairs, there is much force in the aphorism of Mr. Eisenhower's predecessor, Thomas Jefferson, that "The best Government is the one that governs least."

THE QUEEN'S HIGHWAY.

THE post-war years have been marked, in this country and many others, by a widespread tendency in politics and economics to put what should have been "first things" last, or, at least, a long way down the scale of priorities. Luxuries have come before necessities, welfare before capital investments, new Government offices before new offices for commerce, and the nationalisation and safeguarding of basic industries before the creation of the right climate for the end-product industries, on which the prosperity of the nation—including the basic industries—ultimately depends. Whatever has been dearest to the hearts of the electorate has been given priority; anything that was one stage removed has been deferred, if not actually neglected. Thus, this country's roads, because their significance is not spontaneously and directly apparent to all, have been permitted to remain totally inadequate for modern transport. It matters not, apparently, that approximately 1,780,000 persons—one-tenth of the adult male population—are giving their working lives to what is, after all, the largely unproductive service of road transport; or that, because of the condition of the roads, this large number of people, and the immense capital equipment that they operate, are daily working at something appreciably less than optimum efficiency.

Public opinion, however, is swinging in favour of increased road expenditure—not because of a sudden and general awareness of the basic facts, but because the horror of road accidents has been brought home to people's imaginations. No one would underestimate the sorrow and misery caused by death and injury on the roads, or even the purely financial loss to the country; but industry as a whole would welcome any concessions that the Government can make towards greater expenditure on road works, because it is realised that production costs, for the home market and for export, will come down appreciably, if and when efficiency on the Queen's highway can be substantially improved. No engineering firm would tolerate, in its internal transport, the friction and muddles that are common accompaniments of commercial transport on the public roads.

Except for the period of petrol restriction, the number killed on the roads of Great Britain last year—4,705—was the lowest since records were started in 1926. The number seriously injured was 50,371, which was 1,998 less than in 1951, and the total accident figures—killed, seriously injured and slightly injured—were 208,141, which was a drop of 8,352 compared with the total for 1951. The Parliamentary Secretary to the Ministry of Transport, Mr. Gurney Braithwaite, M.P., claimed in a broadcast on Monday that these encouraging results were mainly due to zebra crossings, "which caught the public imagination." He was announcing the Government's plans for a crusade to reduce road casualty figures in the Coronation year by at least 10 per cent. The nation, he said, could not invest as much in better roads as they would like, but his Ministry was doing its best to deal with a number of "black spots" where accidents continued to happen. As a result, about 1,000 of the worst accident spots in the country would disappear in the near future. A striking example of the benefit of such a policy was provided a few years ago by a comparison of the accident rates before and after the reconstruction of the Sawley cross-roads, south-east of Derby, where the trunk roads A6 and A453 intersect. Originally the cross-roads was controlled by halt signs on one of the roads, but there were 29 accidents in seven years. The crossing was redesigned, a roundabout was introduced, and during the 18 months following the completion of the work in June, 1950, there were no accidents at all.

There was a similar improvement also at Watersfield, north of Arundel, in West Sussex, after a comparatively simple improvements had been carried out in the same month. A right-angled triangle formed by three roads was the scene of eight accidents in five years; the acute angles at two of the road junctions were the prime cause. By making one side of the triangle a one-way route, and by altering the layout slightly to ensure that traffic approached a road ahead at right-angles instead of obliquely, the accident rate was reduced to nil in two years. The other influences which Mr. Braithwaite stressed were chiefly the all-important human factors. There are to be more "courtesy cops," to set a better standard of road conduct by advice and example, and the safety of children is to be improved by employing more school crossing wardens. In addition, it is hoped to introduce a new Road Traffic Bill, in which provision will be made, *inter alia*, for improving the standard of vehicle lighting by methods which have been developed by recent research.

In spite of the importance of safety on the roads, however, these measures (which will, in any case, cost the country something, whether it is measured in man-hours or money) will only incidentally improve the roads as a means of transport. The British Road Federation stipulate six fundamental requisites of a good road system: uniformity of all features in the planning and layout of roads; adequate road space; good visibility; the segregation of different types of traffic; clarity, simplicity and standardisation of all signals and roadside information; and amenity. To achieve these requisites will require the reconstruction of some old roads and the building of new roads. The arrears of road maintenance were estimated to be 200,000,000*l*. last year. No doubt, the figure would be very much higher if it included desirable new construction as well as maintenance. Such a cost, however, should not be taken as an indication of the impracticability of coping with the problem, but rather as a measure of the work that needs to be carried out, and for which some part of the national income, however far short of the required amount, should be set aside as a regular feature of Governmental "good housekeeping."

Some twelve months after the end of the war, a ten-year programme of highway development was announced by the then Minister of Transport, Mr. Alfred Barnes. It was divided into three stages, of two, three and five years, respectively. The first stage was to be devoted largely to overtaking the arrears of maintenance; accident "black spots" were to be attended to, and road-works forming part of the reconstruction of bombed areas were to be put in hand. In the second stage, the arrears of maintenance were to be eliminated and there was to be increased activity in the major works of reconstruction, including motor-ways. The reconstruction of weak bridges on important routes was to be speeded up, and work was to be undertaken to relieve traffic congestion in London and other cities. For the concluding five years, the programme proposed a comprehensive reconstruction of the principal national routes, including a considerable mileage of motor-ways. This programme, which the Minister declared, with truth, would be an advantage to the economy and well-being of the country as a whole, was postponed indefinitely. Modernisation of the road system has thus been held up and the funds made available by the Government, and those which highway authorities are permitted to spend, have been so severely cut that even the routine maintenance of roads has been neglected. The public are well aware of the circumstances which compelled this change of plan, but every responsible citizen will hope that the achievements of the nation's industries during the past few years will soon be enhanced by a fiscal policy which will restore road development to its rightful place in the national economy.

NOTES.

GOVERNMENT FINANCE AND BRITISH INDUSTRY.

THE economic position of the nation has been examined recently by the Federation of British Industries and the National Union of Manufacturers, the results being embodied in a statement, the keynote of which is pessimistic. The immediate need, it is postulated in this document, is a further increase in exports, a need which industry is anxious to meet. It will not be able to do so, however, unless the Government and the people recognise the existence of certain conditions which are essential to success. These include, in particular, the ability to compete in overseas markets, which, in turn, depends on efficiency of production. To achieve this end, a much more rapid programme of development and re-equipment is considered to be necessary. Such progress is, however, hampered by the financial stringency which arises from excessive taxation. This not only deprives industry of funds sufficient to maintain even the existing scale of operations efficiently, but discourages that individual enterprise which is based on the hope of reward. In fact, far too high a proportion of the national product is now being diverted into the hands of the State by taxation and Government borrowing, with the result that there is no longer a sufficient flow of capital into industry; a state of affairs, the two bodies are convinced, which will inevitably lead to a fall in productive efficiency and competitive ability. A permanent increase in overall production and in exports will not be achieved until taxation has been materially reduced. Curtailment of imports and capital investment have been inevitable, but, being restrictionist in nature, they militate against the essential expansion of international trade. The Government, in the forthcoming Budget, should therefore take further steps towards setting up a sound internal financial policy by creating conditions in which an adequate measure of corporate and private saving can be resumed.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Simplification of the control gear of direct-hydraulic presses, a reduction in the variety of pressures, and the elimination of electric wires, push-buttons, limit switches, micro-switches, relays, solenoids, thermostats, etc., was the theme of a paper on "Control Valves for Direct-Hydraulic Presses" which Mr. F. H. Towler and Mr. J. M. Towler presented to the Institution of Mechanical Engineers last Friday, January 16. They did not propose the complete abolition of electrical control of presses, but, as Mr. J. M. Towler said in reply to the discussion, the field which seemed to be most fruitful for oil valves was that of relatively simple presses, with simple cycles and working very rapidly. Nevertheless, in the 1,000-ton forging and planishing press which they described, a single lever, operating oil valves, gave the operator control over a wide variety of motions and cycles: up, down and stop; a simple semi-automatic cycle, comprising fast approach, forge, "instantaneous" reversal, return by a predetermined amount, and stop; and fully-automatic repeated cycles, consisting of fast approach, forge, "instantaneous" reversal, return, fast approach . . . at speeds up to 70 strokes a minute, the operator merely pressing the control lever right down. Mr. A. F. Marshall commented that such speeds were not particularly high, since comparable steam-intensifier presses were worked at speeds up to 120 strokes per minute. Most speakers, however, seemed to accept the authors' claim that, by all-hydraulic control, a direct-hydraulic press could be made "as lively as a pneumatic hammer." Among the other advantages of such a system, the authors mentioned the use of unpacked piston valves and the elimination of corrosion; but they emphasised that it was essential to avoid any form of lock—hydraulic, dirt or mechanical. Referring to the article on hydraulic lock by Mr. D. C. Sweeney, and the subsequent correspondence, which were published in vol. 172 of ENGINEERING (1951), the authors considered that, the nearer a condition of zero clearance was approached, the less likely was hydraulic lock to occur. With reference to this, Mr. Sweeney said that, on the contrary, with fine clearances a very high degree of accuracy of the surfaces was necessary to ensure an absence of lock. It could be positively obviated by providing a clearance which diverged very slightly towards the high-pressure end. Mr. J. M. Towler, however, subsequently said he had found that, unless a very large clearance was provided (giving excessive leakage), a minimum clearance resulted in less lock; not necessarily hydraulic lock, as it was difficult to distinguish between that and dirt lock. The latter phenomenon was also discussed in the paper, the authors referring to Mr. J. E. C. Stringer's treatment of it in an article in vol. 173 of ENGINEERING (1952).

PROPOSED MEMORIAL TO WILLIAM FROUDE.

Following a suggestion made at the Sixth International Conference of Tank Superintendents at Washington in 1951, the Council of the Institution of Naval Architects have been considering a proposal to commemorate the pioneer work of William Froude (1810-79) in ship-model research, and have agreed to support the proposal. It is now proposed that the memorial should consist of a bronze plaque, to be set up near the site of Froude's original experiment tank at Chelston Cross, near Torquay, and the publication of a volume containing his published technical papers. It is suggested that the plaque should bear, beneath his name and the dates of his birth and death, the inscription: "William Froude was born in 1810 at Dartington, Devon, and lived at Chelston Cross from 1867 until his death in 1879. His outstanding contributions to the science of Naval Architecture brought him world-wide renown. He was the pioneer of ship model research, and in 1872 built the first experiment tank in the world on this site for the Admiralty, for whom his main work was carried out. This memorial was erected in 1954 by Naval Architects of many countries as a grateful tribute to his memory and genius." To carry out this proposal, the Council are appealing for 2,500*l*. and have opened the list with a donation of 100*l*. Subscribers of 3*l*. 3*s*. 0*d*. or more will receive a copy of the volume and will have their names included in it. Further particulars may be obtained from the secretary of the Institution (to whom, also, subscriptions should be addressed) at 10, Upper Belgrave-street, London, S.W.1. Cheques should be drawn to the "Froude Memorial Fund."

THE THIRD NATIONAL PACKAGING EXHIBITION.

In opening the third National Packaging Exhibition and Convention at Olympia on January 20, Major Gwylim Lloyd George, the Minister of Food, spoke of the importance of packaging in the hygienic handling of food. Machines for handling, weighing, wrapping, packing and sealing food containers formed a major proportion of the exhibits on show and many other stands displayed the containers themselves, which combined attractiveness with serviceability. The exhibition was not restricted, however, to the food industry, and the requirements of the engineering industry were met on a number of stands: conventional wooden crates could be contrasted with containers made from light alloys; grease and other rust-proofing agents could be compared with polythene envelopes; and mechanical loaders and stacking trucks were also demonstrated. The exhibition is organised by Provincial Exhibitions, Limited, City Hall, Deansgate, Manchester, 3, in association with F. W. Bridges and Sons, Limited, Grand Buildings, Trafalgar-square, London, W.C.2, working in conjunction with the Institute of Packaging. In a foreword to the catalogue, Mr. Charles Lein, the chairman of the Institute, pointed out that the Third Exhibition came at a crucial moment in the fortunes of British industry, since a buyers' market was now operative both overseas and, to an increasing degree, at home. In such conditions, every penny of cost was important, but so was the appearance and the safe delivery of articles to the customer. Details of the activities of the Institute, which was formed in 1947, can be obtained from the secretary of the Institute of Packaging, 20-21, Took's-court, Cursitor-street, London, E.C.4.

BRITISH ELECTRICAL POWER CONVENTION.

The fifth British Electrical Power Convention will be held at Torquay from Monday, June 8, to Friday, June 12, under the presidency of Sir John Hacking. According to a preliminary programme, which has now been issued, the papers presented will emphasise the importance of the electrical industry in national recovery. The first meeting will be held at the Pavilion on Tuesday morning, June 9, when, after a civic welcome, the President will deliver an address. In the afternoon, a paper on "Electricity and National Prosperity," by Sir Henry Self, will be read and discussed. On Wednesday morning, June 10, four papers on "Electricity and Industrial Production," by Colonel B. H. Leeson and Mr. E. R. Wilkinson; on "Electricity Supplies for Industry," by Mr. A. O. Johnson and Mr. C. P. Holder; on "Combined Electricity and Heat Supplies," by Mr. H. G. Prosser and Mr. A. W. Pedder; and on "Industrial Applications of Electricity," by Mr. T. B. Rolls will be presented, and the discussion on them will be continued at the meeting on Thursday morning, June 11. At a meeting on Thursday afternoon, papers on "Electricity and Food Production," by Mr. S. F. Steward; on "Electricity for Agriculture," by Mr. C. A. Cameron Brown; on "Electricity for Horticulture," by Mr. A. W. Gray; and on "Electrical Equipment for Food Production," by Mr. F. E. Rowland will be read and discussed. On the morning of Friday, June 12, there will be an Electrical Forum and this will be followed by the annual general meeting. Social events will include the annual dinner on Thursday evening, June 11, at which Sir Archibald Forbes will be the principal guest; and a reception by the Mayor and Mayoress of Torquay and the President and Lady Hacking, on Tuesday, June 9. An Electrical Exhibition, at the Torwood Garage, will be opened by the President on Monday evening, June 8.

NATIONAL COAL BOARD SPECIFICATIONS.

There is a need for the standardisation of equipment in the mining industry, and it is to the obvious advantage both of the National Coal Board and of the manufacturers associated with the industry that the Board should endeavour to simplify the requirements stipulated and to obtain a greater measure of standardisation than exists at present. To this end, the Board, in close association with the British Standards Institution, are preparing specifications for their own particular requirements. It is pointed out that in many instances, these lay down more precise dimensional standardisation or preferred sizes than is the practice with many British Standard specifications. The primary purpose of the Board's specifications is to provide guidance for managements, engineers and supply officers, but it is expected that, in time, the Board's purchases will conform more and more to the appropriate specifications, with the result that the organisation of purchasing and stores procedure will be simplified. Seven specifications, designated Nos. P 3, 4, 7, 8, 9 and 10/1950, and 24/1951, have already been issued within the industry and placed on sale to the public. These cover flameproof air-break electrically-operated gate-end boxes of two sizes; flameproof air-break circuit breakers, an air-cooled flameproof single-phase lighting transformer gate-end box for medium-tension supply, flameproof air-break electrically-operated 50-cycle and 150-cycle drill gate-end boxes, and a high-tensile electrically-welded steel conveyor chain. The specifications are obtainable, price 1*s*. each, from the National Coal Board, Hobart House, Grosvenor-place, London, S.W.1. Additional specifications will be issued in due course.

SHIPPING STATISTICS.

The 1953 Appendix to Lloyd's Register Book, which includes the annual statistical tables, based on the entries in the Registry Book at July 1, 1952, shows that the world total of merchant shipping then stood at 90,180,000 tons gross, an increase of 2,935,000 tons over the 1951 total. The United States possesses the largest merchant fleet—27,245,000 tons in all, including the reserve fleet—but this total is some 87,000 tons less than it was a year ago. The British Commonwealth comes next, with 22,237,000 tons (an increase of 163,000 tons), of which 18,624,000 tons are owned by Great Britain and Northern Ireland; this is 73,000 tons more than at July, 1951. Much larger increases are shown, however, by Japan, Italy, Germany, Liberia, France and Sweden, the respective total tonnages and increases being as follows: Japan, 2,787,000 (605,000); Italy, 3,289,000 (372,000); Germany, 1,398,000 (367,000); Liberia, 898,000 (303,000); France, 3,638,000 (271,000); and Sweden, 2,332,000 (219,000). There is still a preponderance of ships of 6,000 to 8,000 tons because of the heavy war-time construction of vessels of these sizes; but many of them are laid up, and, of the post-war tonnage, the largest amount consists of vessels of 10,000 to 15,000 tons, many of them being tankers. The world total of tankers now amounts to 19,989,000 tons—22 per cent. of all tonnage, compared with 21 per cent. a year ago; the tonnage of tankers registered in Great Britain and Northern Ireland is 4,533,000 tons gross. Norway has 3,076,000 tons of tankers and Panama has 1,843,000 tons. In the classification of world shipping according to age and size, it appears that, in the group of vessels less than five years old and between 15,000 and 20,000 tons, 89 per cent. are tankers. Of the total steam and motor tonnage, 29 per cent. are motorships, compared with 27 per cent. a year ago. In Norway, motorships form 77 per cent. of the total tonnage, in Sweden 73 per cent., and in Denmark, 72 per cent. In Great Britain and Northern Ireland, the proportion is 38 per cent.; but in Greece and the United States the percentages are only 3·6 and 4·4, respectively. Only 15 per cent. of the world's tonnage now uses coal as fuel, compared with 45 per cent. in 1939 and 97 per cent. in 1914. At the end of June, 1952, the number of merchant ships having the classification of Lloyd's Register (now united with the British Corporation) was 9,885, representing 37,682,000 tons gross. The Appendix is published by Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, at the price of 105*s*., plus postage, in the United Kingdom.

MODERN AMERICAN FACTORIES.

In a paper read before the Royal Institute of British Architects on January 20, Mr. W. A. Allen, B.Arch., A.R.I.B.A., discussed modern American practice in factory construction. He said that the three largest firms who make this class of construction their main interest handle between them some 200*l*. million worth of work per annum. The modern tendency, apparently, is to make use of a single-storey design of considerable adaptability, and to standardise a span of 40 ft. Steel fabricators maintained stocks of roof trusses of this span, classified according to the hung loads they are designed to take; these hung loads generally ranged from one to three tons at each panel point. He observed that this system saved much time and trouble, and made possible constructional times of from four to five months for factories. In the matter of lighting, the American view was that top-lights were more trouble than they were worth, and the usual practice was to use fluorescent lighting, which was kept on all the time, by day and night. In air-conditioning, typical practice was to keep buildings down to 80 deg. F. in summer and up to 70 deg. F. in winter, with relative humidity intended to be constant at 50 per cent. In conclusion, he said that standardised, adaptable and attractive steelwork should be stocked by British constructors, and that there should be standardised adaptable ventilation plant, co-ordinated with the steelwork on the American lines. He would like to see an effort made to devise a reinforced concrete design with the adaptability which was fundamental in American methods.

LETTERS TO THE EDITOR.

CREATION AND INVENTION.

TO THE EDITOR OF ENGINEERING.

SIR,—Your editorial reflections on creation and invention, on page 49 of your issue January 9, are both timely and instructive. The engineer, by reason of his training and work, has always, it seems to me, adopted a much too materialistic approach. Because of his familiarity with the laws of the machine, he has tended to give scant attention to the more subtle laws which operate in the realm of mind.

In fact, comparatively few engineers can be made to admit that the study of psychology has any relevance in an engineering context. As a consequence their achievements in the field of design and invention are less successful than they otherwise might be. It is appreciated that a knowledge of the laws governing the creative process is not always necessary for the operation of these laws. At the same time, there can be little doubt that such knowledge is a valuable asset for the average engineer who has not been born a genius.

The chief merit of your policy in reminding your readers from time to time of these wider horizons is, I am sure, that it calls attention to the ever-present danger of too much specialisation and the consequent loss of the creative capacity. It has a bearing, too, on the whole problem of the education of engineers. Technical education can be too literally interpreted.

Yours faithfully,
S. C. MCKENZIE.

Allandale,
63, Sidney-road,
Rugby.
January 15, 1953.

EXTENDED SURFACES FOR HEAT EXCHANGERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of December 12, 1952, on page 745, you deal with extended surfaces for heat exchangers. While the advantage of the construction for oil coolers is evident, I would like further information on the relative pressure drops of the gas flows across the heat-transfer surfaces shown in Figs. 8 and 9, particularly for a period of operation in flue gas; on the strength of the junction of the copper spines with the steel tube for several cycles of heating and cooling; and on the corrosion resulting from operation with two dissimilar metals in flue gas.

Yours faithfully,
H. HAMPSON,
Reader in Mechanical Engineering.

Queen Mary College,
Mile End-road,
London, E.1.
January 12, 1953.

PROPOSED WEIGHTS AND MEASURES LEGISLATION.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the note on page 19 of your issue of January 2, under the above heading, your attention is drawn to the following extract from the statement made by the President in Parliament recently: "Her Majesty's Government are not prepared to proceed with the recommendation for the eventual abandonment of the Imperial for the metric system of weights and measures." (*Hansard*, vol. 507, No. 6, col. 28.)

Yours faithfully,
T. G. POPPY,
Controller.

Standards Department,
Board of Trade,
Chapter-street House,
London, S.W.1.
January 5, 1953.

OBITUARY.

MR. J. WHITCHER.

WE regret to record the death of Mr. James Whitcher, which occurred at Ruislip on Monday, January 12, at the age of 81. He was well known for his work in the design and research branches of electric power supply and for his intuitive grasp of the right solution to the engineering problems with which he dealt.

James Whitcher was born in the Isle of Wight on April 10, 1871, and after being educated privately joined the firm of Messrs. Ernest Fahring as an assistant at the age of 19. He subsequently held a position with Messrs. J. D. F. Andrews and Company, Westminster, and during both these periods attended evening classes at King's College and Finsbury Technical College, London. In 1896, he became a supervising engineer with Messrs. Lea and Warren, Nottingham, being engaged for the next six years on the erection of steam and electrical plant. For twelve months of this period, however, he supervised the installation of cotton and other machinery in the factory of the English Sewing Cotton Company at Barcelona.

In 1902 he was appointed a design engineer with the British Thomson-Houston Company, Limited, Rugby, and thus began his long connection with electric power developments. For the next 17 years he was engaged on the work connected with a number of systems of public electricity supply in London, the provinces, and in India, and on schemes of railway electrification, including those of the London Underground and of the then London Brighton and South Coast, London and South Western, and London and North Western Railways. In 1919, he became senior assistant with Messrs. Kennedy and Donkin, consulting engineers, and was subsequently engaged on the modernisation of the substations and transmission systems of the London Power Company, as well as being responsible for the design of the main and auxiliary generating plant at the Portobello station, Edinburgh, and the re-arrangement of the trunk cabling at that area. He was also engaged on consulting work in connection with the 132-kV grid of the Central Electricity Board in different parts of the country and in similar activities on the technical problems of electric power supply. In this field, his duties consisted mainly in dealing with problems needing a scientific approach to new technical developments, such as the design of switchgear of high rupturing capacity and the stability of turbo-alternators. He retired in 1947, but was still acting as consultant to Messrs. Kennedy and Donkin at the time of his death. Mr. Whitcher was elected an associate member of the Institution of Electrical Engineers in 1902 and was transferred to the class of member in 1934.

BRIGADIER-GENERAL MAGNUS MOWAT, C.B.E.

IT is with much regret, which will be shared by his many friends throughout the engineering profession and industry, that we have learned of the sudden death, on January 19, of Brigadier-General Magnus Mowat, C.B.E., T.D., Secretary Emeritus of the Institution of Mechanical Engineers. General Mowat, who was 77 years of age, was appointed to the secretaryship of the Institution in 1920, on the retirement of the late Mr. Edgar T. Worthington, and held that office for 18 years. He resigned the position in 1938, following a serious illness. We hope to publish a memoir in next week's issue.

HIGH-PERFORMANCE STABILISER.—A new 90-volt stabiliser, which has recently been introduced by Mullard Ltd., Shaftesbury-avenue, London, W.C.2, is of the miniature all-glass type and is designed to operate within a current range of 1 to 40 milliamperes. The drift of its burning voltage during life is comparatively low and there is an absence of sudden large voltage jumps, owing to the sputtered-metal technique which is employed in its manufacture.

HYDRAULIC CONTROLS FOR AIRCRAFT.

BOULTON PAUL AIRCRAFT, LTD., WOLVERHAMPTON.

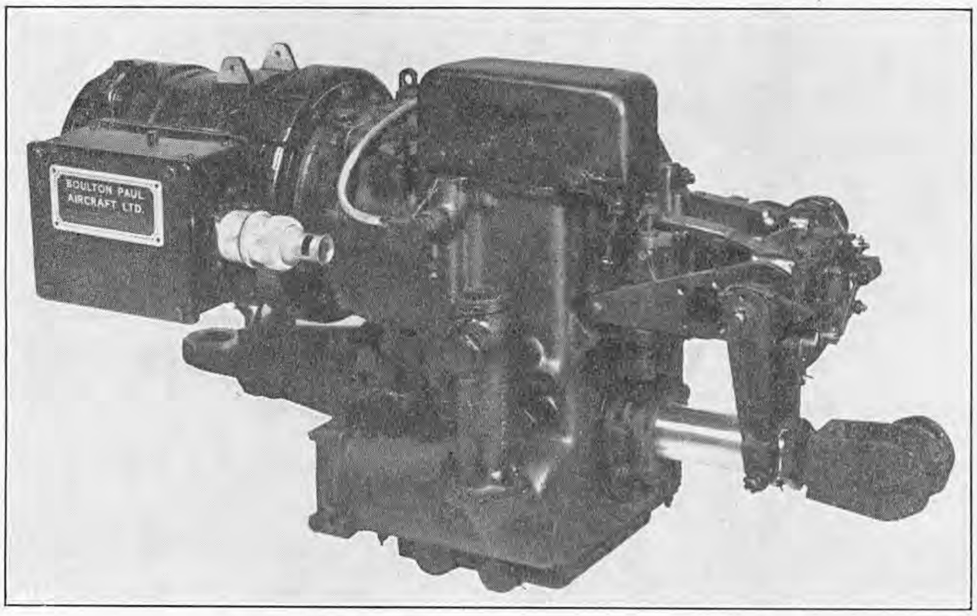
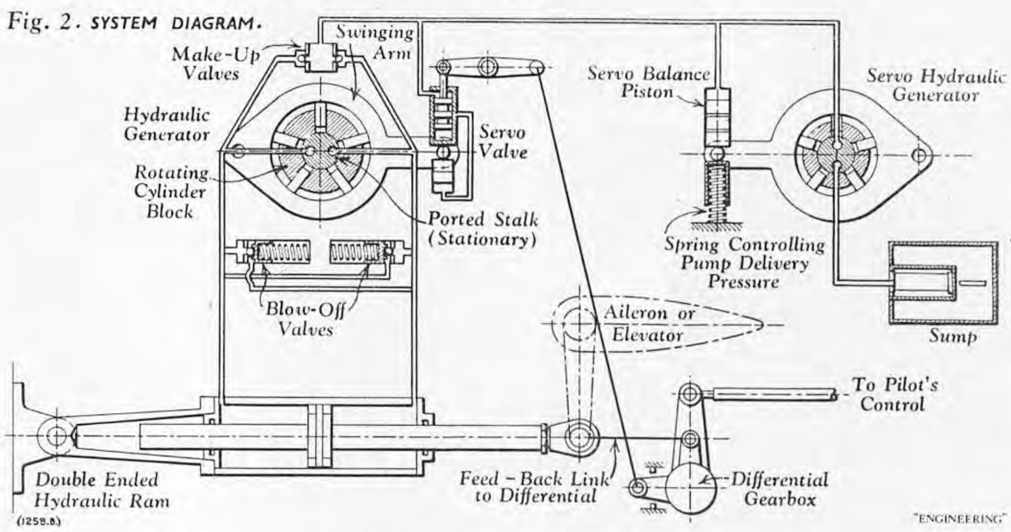


FIG. 1. HYDRAULIC POWER CONTROL UNIT.

Fig. 2. SYSTEM DIAGRAM.



DESIGN AND TESTING OF HYDRAULIC CONTROLS FOR AIRCRAFT.

SINCE the end of the second World War it has become apparent that, as the size and speed of aircraft increase, the control-surface loads are surpassing the physical strength of pilots, and servo operation has become necessary. Although the conception of power-operated flying controls has not been universally accepted for large civil aircraft, it is probably true that all high-speed military aeroplanes now under construction are either power-operated or power-assisted. Since, as Mr. R. E. Hardingham pointed out recently in the Eighth British Commonwealth and Empire lecture to the Royal Aeronautical Society, the elements of a power-operated system are inherently less reliable than a simple rod or cable system directly linked with the pilot's controls, rigorous testing of the reliability, responsiveness, and stability of the power system is essential before it is installed in the aircraft.

THE BOULTON PAUL POWER-CONTROL UNIT.

We recently had the opportunity of seeing some of the test methods used by Boulton Paul Aircraft, Limited, Wolverhampton. The power-control units developed by this company have been adopted in many British aircraft, including the Saunders-Roe Princess flying boat, the control system of which was described on page 371 of our 174th volume (September 19, 1952). The control unit illustrated in Fig. 1, one of the most recent to be produced by the company, differs from those installed in the Princess in that it incorporates the hydraulic power unit, servo control valve and operating jack in a single unit which is installed close to the control surface, and, therefore, works under arduous ambient conditions; whereas, in the Princess, the hydraulic power generators and motors were installed in the air-conditioned cabin and were connected by lengths of torque shafting to screw jacks at the control surfaces. In passing, it may be noted that there is no standard Boulton Paul control unit in quantity production; individual systems are designed for each type of aircraft, and, therefore, mass production and inspection methods are not employed. The operating principle, however, remains the same. The self-contained unit illustrated in Fig. 1 has built-in oil-ways and only two mounting points, one on the jack ram and one on the casing, which is attached to the aircraft structure.

Briefly, the ram-type Boulton Paul control unit contains a three-bank hydraulic pump, driven by an electric motor. Two of the pumping banks in parallel constitute a hydraulic generator supplying fluid under pressure to an actuator jack, with which they are connected in a closed circuit, as shown in the system diagram reproduced in Fig. 2, so that fluid displaced by the jack ram is returned to the input side of the generator. Any loss of fluid in the closed circuit is made up by the third bank, known as the servo hydraulic generator, which is a pump supplying oil at low pressure from a sump built into the control unit. This bank also supplies the operating pressure for the servo valve controlling the output of the main hydraulic generator. The output of the servo generator is regulated by a spring-loaded piston which responds to changes in the demand for oil to operate the servo-control valve and for making up losses in the main pumping banks.

Each pumping bank comprises a rotary cylinder block, of phosphor bronze, rotating about a stationary nitrided-steel rotor stalk incorporating oil-ways and ports which register periodically with the rotating cylinders. Each cylinder block has five radial pistons, the outer ends of which bear on a ball race mounted on a swinging arm which forms the outer casing of the cylinder block. (The ball race is not shown in Fig. 2.) The concentricity of the swinging arm can be varied relatively to the cylinder block: when the arm and the block are concentric, no sliding motion is imparted to the pistons by the rotation of the block, and no pumping action occurs. When, however, the centre of the swinging arm is displaced, to either side, from that of the cylinder block, the variable-stroke pistons commence to pump oil in the required direction and at the appropriate rate. The eccentricity of the swinging arm of the main banks is controlled by the servo-valve in response to the pilot's signals. The pressure developed in the main circuit is determined by the external load on the control surface; blow-off valves are, therefore, provided to guard against excessive pressures.

The pilot's control system is connected to the crown pinion of a differential gearbox in which all the gears are of the same diameter. One differential pinion is coupled, through a suitable linkage, to the master piston of the servo valve. The opposite differential pinion, which provides feedback, is connected to the output side of the operating jack ram. Thus, when the pilot makes a control movement, the feedback pinion is initially held stationary by the ram and the pilot's signal is transferred directly through the differential to the servo-valve, so that oil is pumped to the operating jack to bring about the required movement. As the ram moves in response to the pilot's signal, it rotates the feedback pinion, thus resetting the rate of operation of the servo-valve and eventually cancelling the signal when the required control-surface movement has been completed.

TESTS OF POWER CONTROL UNIT.

Each individual control unit is thoroughly tested before leaving the Boulton Paul factory. Before assembly, the operation of the various components and sub-assemblies is checked. In order to determine that the clearances of the moving parts are satisfactory, the end leakage between the cylinder block mounted on its stalk and the leakage between adjacent cylinder bores are checked to ensure that they lie between certain experimentally-established values. The blow-off valves are tested for operating pressure, "cracking" pressure and re-seating pressure, and the suction valves are checked for tightness. The operating characteristics of the servo valve, which is of the type where a master piston is used to control the movement of a slave piston, are checked to ensure free movement and to determine the leakage rate and the degree of "dead spot." The slave piston is loaded, and the operation of the valve is observed to ensure that the slave piston follows the master within close limits. Ram assemblies are also tested under pressure for leakage.

The cylinder block, assembled on its stalk, is immersed in oil at 0 deg. C., and when the assembly has attained this temperature, the torque required to rotate the cylinder block is determined, a maximum torque value having already been experimentally established to ensure that there will be no risk of seizure during running. The complete control-unit assembly is also subjected to torque tests, both at room temperature and at 0 deg. C., to ensure that the moving parts run freely.

After satisfactorily completing these tests, the pump unit is assembled and "run in." Volumetric efficiency is then measured, the jack and servo-valve are assembled, and performance tests are carried out, followed by endurance tests,

HYDRAULIC CONTROLS FOR AIRCRAFT.

BOULTON PAUL AIRCRAFT, LTD., WOLVERHAMPTON.

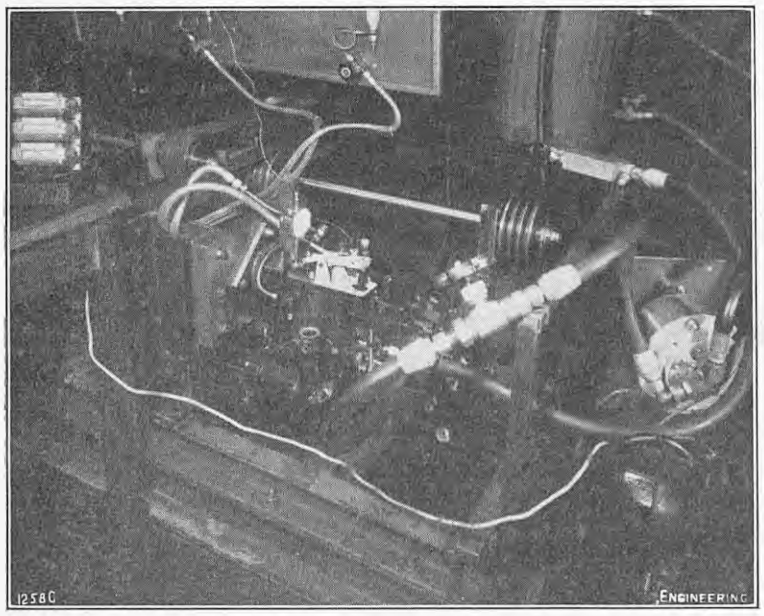


FIG. 3. VOLUMETRIC-EFFICIENCY TEST RIG.

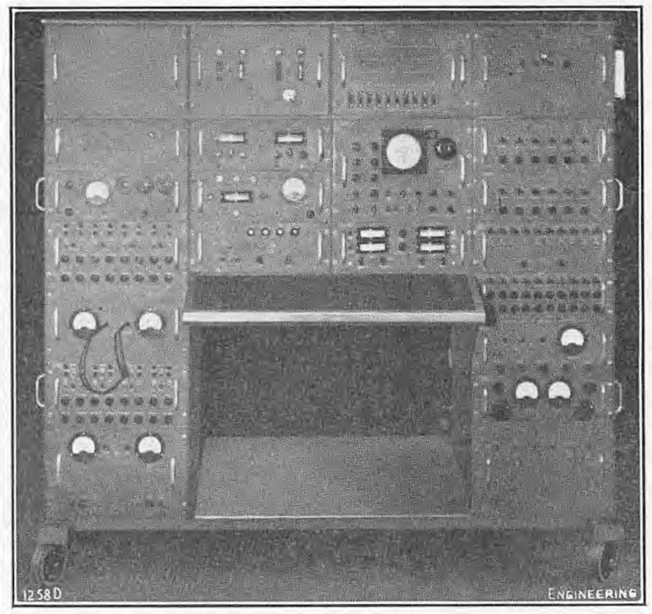


FIG. 5. TEN-CHANNEL TEST RECORDER.

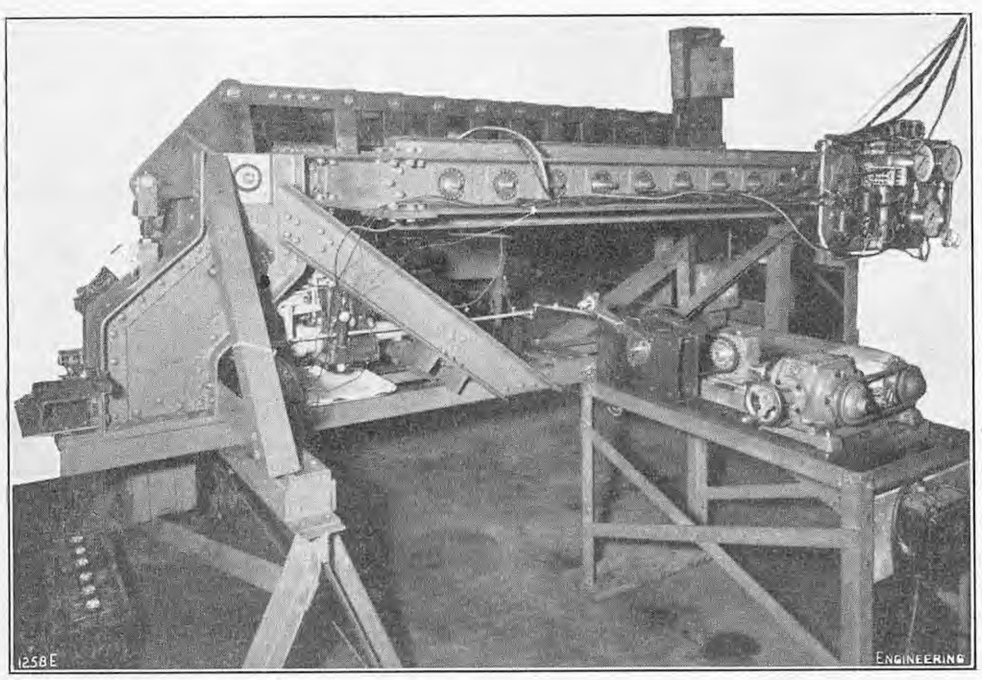


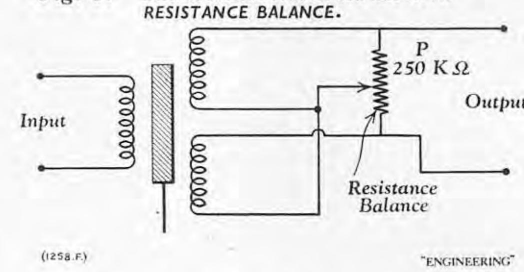
FIG. 4. PERFORMANCE TEST RIG FOR ELEVATOR CONTROL UNIT.

after which the control unit is stripped for examination.

One type of rig on which the volumetric-efficiency calibration of the pump units is carried out is illustrated in Fig. 3. It is designed to accommodate two pump units, belt-driven by a variable-speed 440-volt direct-current motor. The illustration shows only one pump unit on the rig. The pump unit delivers oil, through a throttle valve which can be adjusted to vary the pressure against which the pump has to operate, to a calibrated hydraulic motor which runs unloaded. On leaving the motor, the oil is passed through a cooler and returns to the pump unit. The speed of the motor is measured, through a 24-volt contactor, by a solenoid-operated counter unit which indicates simultaneously the number of revolutions of the hydraulic motor and of the pump unit, which are timed over one-minute intervals. Since the characteristic of the hydraulic motor is known, the pump output can be calculated and compared with its theoretical displacement. The volumetric efficiency is of the order of 98 per cent. at 1,000 lb. per square inch. Volumetric-efficiency curves are plotted against pressure over a range of displacements, the pump stroke being mechanically locked during each test in order to maintain physically stable operating conditions.

After the servo-valve, differential gear and operating jack have been assembled with the pump unit to form a complete power-control unit, the latter is adjusted and tested rigorously on a rig in which the estimated control-surface inertia and the stiffness of the control runs in the aircraft are reproduced. The aircraft electrical circuit controlling the power-control system is also reproduced. A typical performance test rig, in this case for testing the elevator control unit of a high-speed military aircraft, is illustrated in Fig. 4. The control unit is mounted on the rig framework, the operating ram being connected through a linkage to a triangular "inertia" lever (this can be seen at the left upper corner), using a system of nine hexagonal torsion bars representing the load on the control surface that has to be overcome by the jack ram. The outer ends of the torsion bars are clamped to the framework by adjustable clamps. Thus, the loading on the jack can be altered by varying the twisting length of the torsion bars and by varying the number of torsion bars in use. The differential gear controlling the servo-valve is connected,

Fig. 6. DIFFERENTIAL TRANSFORMER WITH RESISTANCE BALANCE.



through a rod and lever linkage representing the control run within the fuselage, to an electrically-driven crank, seen in the foreground of Fig. 4, which imparts a sinusoidal motion of adjustable magnitude to the input side of the control unit. A series of tests is then carried out, at various input frequencies, input amplitudes and jack loadings, to determine the ratio of output to input amplitude (and thus to check on the stability of the system), and the phase lag between input and output. Two potentiometers are coupled, respectively, to the input driving crank and to the jack output, and their signals are compared on cathode-ray oscilloscopes. The motor current consumption and the oil-temperature rise are also checked during the run. This rig is used, in addition, for measuring the rate of jack movement and, by applying a load from the "control surface" end, the stiffness of the jack is determined.

In addition to these tests at room temperature, which are carried out on every control unit manufactured, one unit of each type is also tested in a hot room, at temperatures up to 70 deg. C.; in a refrigerating chamber, at temperatures down to −50 deg. C.; and in an altitude chamber in which the pressure is reduced to simulate altitudes up to 70,000 ft. Tests are also carried out to ensure that the unit will operate satisfactorily at the appropriate angles of climb, dive and roll, and, in some cases, in inverted flight.

An endurance test, for at least 250 hours, and possibly up to 1,000 hours, is also carried out, usually on the performance rig, but instead of a sinusoidal input, a cam is used which applies an arbitrary duty cycle to the input of the control unit. The current consumption, oil pressures and temperatures are recorded at regular intervals during an endurance run.

On a separate rig, which also simulates the inertia and stiffnesses of the aircraft, "impedance" tests are carried out to ensure that no flutter or instability arises in the control circuit as a result of feedback from the control surfaces. An exciter is attached to the inertia lever and vibration tests are carried out at the calculated natural frequencies of the relevant control surface. The amplitudes at the lever and at the jack are recorded, and the resulting loads on the jack are also measured by resistance strain gauges.

ELECTRONIC MEASURING EQUIPMENT.

General-Purpose Recorder.—For use with the test rigs, the electronics department of the Boulton Paul company have developed some interesting instruments, most of which have useful applications in other fields. The most substantial piece of equipment is, perhaps, the 10-channel general-purpose recorder illustrated in Fig. 5, which attracted much attention when it was shown for the first time at the Society of British Aircraft Constructors' display at Farnborough last year. It is built up from units mounted on racks on a mobile trolley, which incorporates a desk for the test observer. At the top right-hand corner of the instrument are the 10-channel oscillograph unit and the recording camera; the latter, which has a speed range from ½ in. to 20 in. per second, can be loaded with up to 56 ft. of film 5½ in. wide, and records ten oscillograph traces simultaneously, with a peak amplitude of 0·5 in. Below the oscillograph unit is a large low-frequency monitoring oscilloscope which enables the observer to make check measurements by connecting a flying lead to the various signal points. The monitoring oscilloscope is provided with a "magic eye" peak-reading voltmeter for the accurate measurement of peak positive and negative voltage levels.

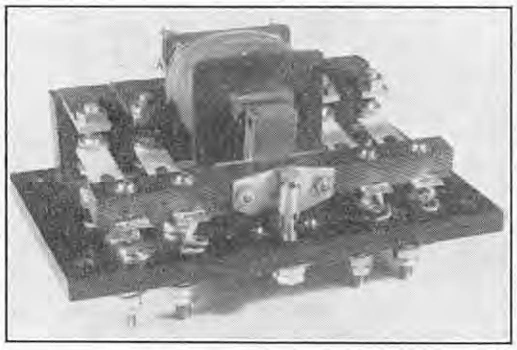
The facilities provided in the recording equipment include the necessary power supplies and amplifiers for the recording oscillograph and also for driving a pen recorder, although this is not actually fitted at present; supplies and controls for twelve 2,000-cycle carrier-operated bridge-type or transformer-type pressure displacement transducers and six direct-current strain-gauge bridge circuits; three-channel current and three-channel line-voltage measurement panels, with calibrating and switching circuits for measuring peak and steady-state values; two frequency-indicating instruments for use with direct-current tachometers for measuring rotational speed; two alternating-current millivoltmeters for indicating the steady-state outputs from alternating-current transducers, which are used for pressure and displacement measurements, etc.; a high-speed electronic counter for measuring time intervals accurately to ± 0·5 millisecond, especially useful for lag measurements; and means for measuring up to six displacements in simple harmonic motion of component levers, cranks, etc., at frequencies up to 5 cycles per second, using wire-track potentiometer transducers.

Displacement and Pressure Transducers.—In conjunction with the general-purpose recorder, displacement transducers of the differential-transformer type have been developed for measuring the relative displacements of various components and their stiffness under load, vibration characteristics, etc. They are also used for comparing output motion with input motion for small displacements. In the Boulton Paul type Xl-36 displacement transducer, which operates over the range ± 0·1 in., on a 2,000-cycle supply, a light armature is connected by a non-ferrous coupling rod to the component of which the displacement is to be measured. Movements of the armature vary differentially the degree of electrical coupling between a primary and two secondary circuits. The two secondary windings are connected in anti-phase series, so that when the coupling between the primary and each secondary circuit is the same, the output voltage should theoretically be zero. In practice, however, a certain residual voltage remains, due to iron hysteresis and slight inequalities in the resistance and inductance of the coils. To compensate for the latter factor, a resistive balance control is added, as shown in the diagram reproduced in Fig. 6. The instrument is designed to give its best performance on a 10-volt 2,000-cycle supply to the transformer primary, but can give useful results over a wide range of supply frequencies. Over the displacement range of 0 to ± 0·1 in., the output is proportional to displacement to within ± 0·002 in., and the unit has a sensitivity of 10 volts per inch displacement. From this instrument, a miniature displacement transducer has been developed with an operating range of ± 0·05 in. and a sensitivity of the order of 2 volts at maximum displacement. It is 1½ in. long and ½ in. in diameter.

For measuring hydraulic pressures, in conjunction with the general-purpose recorder, a differential-transformer type of pressure transducer has also been introduced. In this instrument, which is similar in principle to the displacement transducer and also operates on a 2,000-cycle supply, the armature is connected to a pressure-sensitive diaphragm. Four interchangeable diaphragms are provided, giving pressure ranges varying between 0 to 10 lb. per square inch and 0 to 3,000 lb. per square inch.

HEAVY-DUTY RELAY FOR ELECTRICAL CIRCUITS.

THE accompanying illustration shows a relay which has been introduced by Electro Methods, Limited, 220, The Vale, London, N.W.11, for use on alternating-current and direct-current circuits where conservation of space is an important factor. These relays, which are of the two-pole change-over and four-pole change-over types, with or without dust covers, are intended for the control of power and lighting loads and in connection with interlocking switching systems. They can be



operated through a two-wire circuit by a push switch, toggle switch, thermostat or another relay. Alternatively, three-wire control can be employed, using a free "normally open" contact on the relay for holding on.

As regards construction, the U-shaped frame and armature forming the magnetic circuit are of silicon-iron laminations. The armature is self-aligning and is provided with a fixed air-gap to prevent sticking. It carries a hinged assembly to which the contact blades are fixed, the arrangement being such that a relatively high degree of resistance to vibration is provided. The contacts themselves are of fine silver and are designed so that there is a wiping action between the upper and lower fixed contacts. Continuity is therefore secured, even with small loads and low voltages. The fixed contacts are adjustable to compensate for wear and are easily replaceable. The coils are fully impregnated and baked and are available for all voltages up to 250 volts direct current or 440 volts alternating current. The power required by the relay is 6·5 watts. As the alternating current rating is 30 amperes at 250 volts, the relay occupies an intermediate position between the general type which switches up to 5 amperes and the more heavily rated contactor.

SURGE PHENOMENA IN ELECTRIC-POWER SYSTEMS.—A course of six lectures on "Surge Phenomena in Electric-Power Systems" will be delivered by members of the staff of the British Electrical and Allied Industries Association at the Polytechnic, Regent-street, London, W.1. The first lecture will be on Friday, February 20, 1953, at 6.30 p.m. and the remainder on the five following Fridays, at the same time. The fee for the course is 20s. and full particulars, with enrolment forms, can be obtained from the Head of the Electrical Engineering Department.

FOIL STRAIN GAUGES FOR TORQUE AND PRESSURE MEASUREMENT.

ON page 266 of the 174th volume of ENGINEERING (August 29, 1952), we recorded the development of a new type of resistance strain gauge by Messrs. Saunders-Roe, Limited, East Cowes, Isle of Wight, in collaboration with Technograph Printed Circuits, Limited, 32, Shaftesbury-avenue, London, W.1. It was of greatly increased sensitivity, simplicity and reliability in comparison with the conventional wire-resistance strain gauge, and it consisted of a metal foil resistor which was deposited on a thin lacquer-film base. Since the ratio of contact-surface area to volume of the foil resistance element is much greater than that of a wire resistor of circular cross-section, the current-carrying capacity of the foil gauge, and hence the voltage output per unit strain, is many times that of the wire gauge, thus affording an appreciable increase in sensitivity, particularly if the gauge is required to operate a power-sensitive recorder rather than a voltage-sensitive recorder. It has been suggested by the designers of the foil gauge that this significant feature may lead to a new approach being made to dynamic strain-recording problems.

The foil gauge can also be produced in a wide variety of two-dimensional shapes, and this has led to two new applications, for the measurement of torque and of pressure. The conventional wire-resistance strain gauge is often used for measuring torque in shafts, applied at 45 deg. to the principal axis. Usually, four such gauges are arranged in a bridge circuit, to compensate for bending effects in the shaft. The new foil strain gauge, which is much simpler to affix, is produced in the form of a ribbon, 6 in. or 12 in. long, carrying two parallel foil patterns sensitive to strains at 45 deg. and 135 deg. to its long axis. To apply the gauge to the torque-loaded member, the required length of ribbon is cut off, wrapped around the shaft, and bonded in position. The electrical supply and signal wires are then soldered on. It is not necessary to mark out the shaft before fixing the gauge. Since the foil gauge completely surrounds the shaft, the sensitivity is still further increased, in comparison with the wire-gauge system, in which the strains are picked up at four points only.

For measuring hydraulic or pneumatic pressures, a diaphragm gauge has been developed, comprising a double-spiral foil pattern, which is applied to a diaphragm subjected to the pressure under investigation. The foil pattern integrates the circumferential strains over the diaphragm area, and thus makes the most effective use of the gauge material and the strain response of the diaphragm. The gauge is calibrated by applying known pressures and plotting the electrical output against pressure. This type of gauge is suitable for use on relatively stiff diaphragms with small total deflections. A gauge for more flexible diaphragms is at present being developed in conjunction with the Admiralty Research Laboratory. In it there are two parallel linear foil patterns in the central tensile zones, with two radial patterns in the outer compressive zones. The whole configuration forms a four-gauge bridge of high power sensitivity. For connecting the gauges in the circuit, Technograph Printed Circuits, Limited, have designed a printed and etched conductive pattern in copper foil, which is laid over the gauge pattern and soldered at the appropriate points.

It should be mentioned that Messrs. H. Tinsley and Company, Limited, Werndee Hall, South Norwood, London, S.E.25, have entered into an agreement with Messrs. Saunders-Roe, Limited, and Technograph Printed Circuits, Limited, and are now marketing foil-resistance strain gauges with their measuring equipment. To make full use of the advantages offered by the foil gauge, the Tinsley company are also developing new bridges for accurate static measurement, as well as apparatus for general purposes, which will widen the field of application of the strain gauge, rendering it suitable for use in technical colleges and in general mechanical laboratories.

CONTRACTS.

The English Electric Co., Ltd., Stafford, are manufacturing, for the City of Seattle, Washington, U.S.A., high-voltage transformers to a value of approximately 700,000 dols. The transformers are each of a capacity of 125,000 kVA, three-phase, 60-cycles, with a voltage ratio of 220/26 kV.

The National Gas and Oil Engine Co. Ltd., are supplying 58 generating sets to the Central Electricity Board, Malaya, for use in re-settlement camps there. Each set comprises a horizontal single-cylinder oil engine developing 20 h.p. at 500 r.p.m., and, driven by a V-rope from the engine, a 12-kW alternator made by Hopkinson Electric Co., Ltd., Cardiff.

The Siemens and General Electric Railway Signal Co. Ltd., have received an order from the Rhodesia Railways for the supply of a further section of centralised traffic-control equipment for an 89-mile length of track from Gwelo to Gatooma. The new section includes 14 crossing sidings and 200 running and subsidiary signals.

The Fairey Aviation Co., Ltd., have received an order for Gannet anti-submarine aircraft for the Royal Australian Navy. The aircraft are driven by turbo-propeller "Double Mamba" Armstrong-Siddeley engines.

Peter Lind & Co., Ltd., Stratton House, Piccadilly, London, W.1, have obtained the contract for the construction of a reinforced-concrete barrel-vault shell roof at Waterloo Dock goods station, London Midland Region, British Railways, Liverpool.

Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex, have received an order valued at 300,000*l.*, for television equipment for Italy. The order includes studios for Rome and Milan, medium-power transmitters at Rome and Pisa, and outside broadcasting units at Rome. The main transmitter will be at Rome, and a satellite at Pisa, and each will have a 7½-kW vision and a 2½-kW sound transmitter. The whole system will operate on a 625-line standard, 50 cycles.

During December the British Electricity Authority placed contracts for equipment for power stations, transforming stations, and transmission lines, amounting, in the aggregate, to 5,373,691*l.* The principal contracts include, for Marchwood power station, near Southampton, condensing and feed-heating plants for four 60,000-kW turbo-generator sets, with Hick, Hargreaves & Co., Ltd.; for Brimsdown power station, near Enfield, four reinforced-concrete housings for electrostatic precipitators and two natural-draught reinforced-concrete cooling towers and ponds, with Beirrum and Partners, Ltd.; for Ince power station, near Ellesmere Port, two brick chimneys, with D. Theaker & Co., Ltd.; for Wakefield power station, 132-kV 2,500-MVA switchgear, with A. Reyrolle & Co., Ltd.; for Skelton Grange power station, Leeds, 132-kV 2,500-MVA switchgear, with British Thomson-Houston Co. Ltd.; for Carrington substation, near Manchester, 132-kV cables with W. T. Glover & Co., Ltd.; the Drakelow, Burton-on-Trent, to Carrington 275-kV 0·4 sq. in. overhead transmission line, with the British Insulated Callender's Construction Co., Ltd., and the Keadby, Scunthorpe, to Ferrybridge 275-kV overhead transmission line, with Watsham's Ltd.

Ten Diesel-engine driven generating sets have been ordered by the British Electricity Authority for installation in various power stations. Mirrlees, Bickerton and Day Ltd. will supply two 2,000-kW sets for Walsall; three 1,330-kW sets for Lister Drive, Liverpool; and one 2,000-kW set for Macclesfield. Ruston and Hornsby Ltd., are to supply one 1,040-kW set for Basingstoke, and the English Electric Co. Ltd., a 950-kW set for Clacton and two 950-kW sets for Southend.

The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, have received an order from British Railways in connection with the Southern Region's change of frequency scheme, whereby the present frequency is being brought into line with the standard 50-cycle Grid supply. There will be three separate control rooms; one at Lewisham for the Eastern Section, controlling 27 substations and 24 track-paralleling stations; one at Selhurst for the Central Section, controlling 31 substations and 24 track-paralleling stations; and one at Raynes Park for the Western Section, controlling 40 substations and 27 track-paralleling stations.

The United Steel Companies Ltd., 17, Westbourne-road, Sheffield, 10, announce that their Samuel Fox Branch, Stocksbridge, near Sheffield, have received a contract for the supply of razor-steel strip to Gillette Industries in the United States. The initial contract calls for the supply of 45 tons of strip a month, for 6 months, which should make between 60 and 65 million razor blades. The monthly value of the order will be about 16,100*l.*, or approximately 45,000 dols. The total value of the order will be 96,600*l.*, or 270,000 dols.

LABOUR NOTES.

For several years now, the people of Britain have not, as a nation, been earning their keep. The sooner this grim economic fact is fully grasped and influences the behaviour of everyone, the sooner will the country emerge from the vicious circle it is now in, and from a condition which has made staggering from crisis to crisis a normal feature of its post-war economy. This is one of the points developed by Mr. Lincoln Evans, C.B.E., the general secretary of the Iron and Steel Trades Confederation in an editorial article on "The Road Ahead" in the January issue of *Man and Metal*, the Confederation's official journal. Mr. Evans, whose appointment to the honour of knighthood was announced in the New Year Honours, reminds his readers that the supreme problem facing Britain at the present time is how the nation is to pay its way. To achieve that end, the Chancellor of the Exchequer has stated that exports must be increased by 300 million pounds during the present year.

Britain lives by trade and the task before her people is no less than that of making and selling enough goods abroad to balance her accounts, and maintain the standards of the 50 million persons living on this island. If that cannot be done, Mr. Evans affirms, there are but two alternatives: either to reduce those standards or reduce the number of inhabitants. It is a battle for survival and one which can only be won by a combination of the genius of Britain's inventors, the craftsmanship of her workers and the wisdom displayed in the conduct of her industrial relations. That the nation possesses all these qualities in abundance has been shown time and time again. It is the first job of any Government to see that there are no obstacles in the way, because, unless the nation balances her accounts, there is nothing that Parliament can do which will shield her people from the consequences.

Mr. Evans refers to the improvement in employment in the iron and steel industry which took place during 1952 and to the falling off in the demand for tinplates, which occurred at the end of the year. This, unfortunately, will involve closing some of the older hand mills in that section of the industry. The centralisation of nearly all the tinplate trade in South Wales makes the problem of redundancy a heavy one for the area, in spite of the Abbey and Trostre strip-rolling plants being located there, for those plants require far fewer men to produce an equal tonnage. The coming of the strip process made redundancy inevitable at some time and only the great post-war demand for tinplates has delayed it for so long. Although this was foreseen and is part of the price that has to be paid for technical progress and industrial efficiency, its consequences afford little consolation to men who have worked in these old plants and who may now have to seek employment in other plants or other industries.

Employment will no doubt be found, Mr. Evans recognises, for a number of displaced workpeople at plants where an eight-hour shift is at present in operation. A return to a six-hour shift is provided for in the industry's agreements and its resumption would create a number of vacancies. Turning to the question of the Iron and Steel Bill, Mr. Evans says that although the Government's proposals may be disliked, they cannot be resented, because the people of this country returned the present Government to do precisely what it is doing.

Wage increases in the patternmakers' trade are referred to by Mr. W. B. Beard, O.B.E., the general secretary of the United Patternmakers Association, in the Association's *Monthly Report* for January. He states that the remaining applications for wage increases now appear to have been concluded and that the Imperial Chemical Industries Limited has granted an increase of 2*d.* an hour to craftsmen and 1½*d.* an hour to employees engaged on process work. As a result of these concessions, craftsmen have obtained a lead, for the first time for many years. When announcing these improvements, Mr. Beard reports, the company stated that further wage adjustments must have regard, not to outside wage negotiations, but to the position of the company.

Mr. Beard recognises that conditions at this firm are "extremely good" in many ways, and that the company's management is always prepared to meet representatives of the trade unions for the discussion of problems which may arise. The company does stress, however, Mr. Beard states, that negotiations must be related to its own particular position "as there is otherwise no point in the two sides meeting." The same view has been emphasised by other non-federated firms in which the conditions are better than those obtaining under the Engineering and Allied Employers' National Federation. He suggests that the inference is that if trade unionists in the engineering industry want wage fluctuations they can have them, but that they cannot have the best of both worlds. Increases similar to those granted by Imperial Chemical Industries have been given in the gas, paper-making and board-making industries.

Owing to the lack of success which has so far attended the efforts of the National Dock Labour Board to reduce the number of men whose names are included in the dock employment registers, a modification of the voluntary scheme inaugurated last month was announced on January 17. This will come into effect immediately, and provides that, during the present year, men may be released from the Board's service to take up alternative employment, provided that such releases are for periods of not less than three months. Under the scheme as it originally existed, dockers transferring to the dormant registers were subject to recall to dock work during next year, but might have had to wait until early in 1955 to exercise their right to have their names replaced on the active list.

The Board hopes that the shorter period of release will induce many redundant dockers to take outside work, as the risk to them will be much less now that they are assured of reinstatement after so short a time, if they require it. It is stated that only about 300 men have so far applied for release out of a total of 77,000 registered dock employees, although between 12,000 and 16,000 of these are reporting each day without obtaining work. "Fall back" pay amounting to 4*l.* 8*s.* a week is granted to registered men for whom there is no employment.

About 100 men were dismissed last week at the Coventry works of the Daimler Motor Company, Limited, owing to redundancy, and a statement issued by the company last Friday reported that a further 150 employees would require to be discharged during the coming three weeks. The uncertainty as to the continuance of purchase tax on motor cars had had a disastrous effect on that side of the company's business. Every effort had been made to avoid dismissals, but a position had been reached when it was essential to suspend temporarily the manufacture of certain models.

Reference was made by Sir Norman Kipping, M.I.E.E., the director-general of the Federation of British Industries, in a speech at Glasgow on Friday last to the serious loss of prestige and of valuable overseas contracts which was arising owing to the failure of British firms to keep to their delivery dates. He considered it a very serious matter, in relation to the country's export prospects, that manufacturers here were rapidly earning a reputation throughout the world for not keeping their promises. Cases of that character were more frequently encountered in the engineering and cognate trades than in any other branch of the national industry. He realised that engineering firms were confronted with many difficulties, but that fact did not excuse them for failing to keep their promises. Deliveries were too often left to juniors to arrange, instead of being, as they should be, the special care of "high-powered executives."

HOSE-LAYING FIRE APPLIANCE.

MERRYWEATHER AND SONS, LTD., LONDON.

FIG. 1.

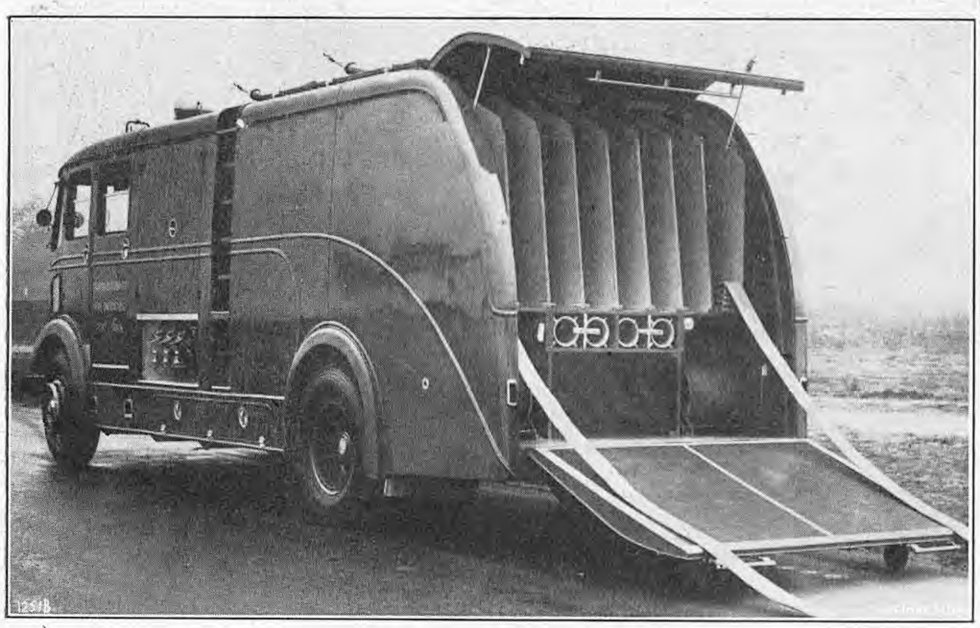


FIG. 2.

DIESEL-ENGINED HOSE-LAYING FIRE APPLIANCE.

WE illustrate above a hose-laying Diesel-engined fire appliance recently delivered by Merryweather and Sons, Limited, Greenwich High-road, London, S.E.10, to the Trinidad and Tobago Fire Brigade in the British West Indies. The appliance is the first of two such vehicles, capable of laying over a mile of 3½ in. hose in two lines at a speed of 20 m.p.h., ordered as part of a re-equipment policy instituted by Major R. G. Cox, G.I. Fire E., the Chief Officer of the Brigade. The body is of the limousine type, the officer being accommodated in the forward compartment with the driver, and the fireman technician in a seat in the compartment behind. Ample locker space is available for carrying the equipment, which includes a 3,000-gallon collapsible water tank. The bodywork is of English-ash framing, panelled outside with aluminium sheet. The inside panels, divisions and lockers are built in mahogany. At the rear of the body there are two flaps for direct access to the hose compartment. One of these swings down and trails behind on a pair of castors, making a platform over which the hose can be paid out; this platform is sufficiently strong to carry the weight of the fireman supervising the operation. The other flap swings up to give headroom. On each side at the rear are compartments for reels of telephone cable, and between them is a rack in which suction hoses are stowed. Above the suction hose stowage, across the full width of the body and extending forward to the ladders built in on each side, are a number of narrow compartments for carrying the 3½-in. rubber-lined hose, which is stored "flaked" and ready-coupled. The only additional coupling required is between the hose in one compartment and that in the next when hose-laying. A push-button bell is provided for communication between the fireman and driver, and the rear platform is equipped with lighting for use at night. On the roof above this rear section are two watertight doors, opening outwards from the centre, to facilitate the stowing of hose. At the front of the roof, in a position not usually seen in this country, are two monitors with independent cut-off valves. Each is capable of delivering 700 gallons of water per minute and can sweep over a large area.

The main fire pump is of the Merryweather single-stage type and is capable of delivering 1,000 gallons per minute at a pressure of 80 lb. per square inch, 850 gallons per minute at 120 lb. per square inch, or 600 gallons per minute at 180 lb. per square inch. The pump impeller is overhung, so that no bearing is required at the suction side, an arrangement which gives easy access to the impeller for inspection. The pump is located between the technician's compartment and the hose stowage, roughly at the centre of the chassis. For priming, there is a two-barrel reciprocating vacuum pump, mounted on the main pump casting. Either barrel may be shut off by valves. The priming pump is connected to the main pump by a gearwheel and driven through a metal-to-metal cone clutch, operated by a hand lever on the control panel. The priming pump will lift water from a depth of 26 ft. to the centre of the main pump at 1 ft. per second. The main pump is driven through a power take-off on the gearbox of the engine and controlled by a hand lever near the driver's seat. On each side of the appliance there is a control panel on which is a standard suction-hose connection with removable internal strainer and blank cap, three delivery valves, the engine throttle control, a pressure gauge and compound gauge for the main pump, and a lever for priming. Other equipment comprises a roof-mounted searchlight operated from the driver's cab, twin flashing lights, and a combined siren and flashing light.

The design of this vehicle is based on the Regent Mark III chassis, built by A.E.C., Limited, Southall, Middlesex, one of the Associated Commercial Vehicles group. The Diesel engine has six cylinders with a bore and stroke of 120 mm., and 142 mm., respectively, and develops 125 brake horse-power at 1,800 r.p.m. The drive from the engine is transmitted to the road wheels through a four-speed gearbox and a tubular propeller shaft, supported at the centre by a spherically-mounted ball bearing in an oil-tight housing. The propeller shaft has three universal joints. The gearbox speed ratios are 5 to 1 in first gear, 2·69 to 1 in second gear, 1·59 to 1 in third, and 1 to 1 in top gear. The ratio for reverse gear is 6·43 to 1. The chassis has a wheelbase of 16 ft. 4 in., an overall width of 7 ft. 6 in., and a turning circle of 66 ft. The road clearance is not less than 9 in., except between the stabilisers which are fitted to the rear axle to control chassis roll when cornering. Single tyres are fitted at the front and twin at the rear, and one spare is carried. The four-wheel brakes are servo-operated and there is also a hand brake, acting on the rear wheels only. A 24-volt electrical system is used. The overall length of the vehicle is 25 ft. 4 in., and the total height, including the searchlight and monitors, is 10 ft. 6 in.

SAFETY CONTROL.—A press-button control unit for use with all types of electrically-controlled machines has been introduced recently by Alfred Herbert Ltd., Factored Division, Red-lane, Coventry. Designed to meet the need for greater safety in industry and to replace the normal press-button starter used on present day machines, it is called the "Presto Safety Device." It aims at keeping the operator's hands clear of any danger when the machine is started, by introducing the use of two push-buttons. To start the machine, the two buttons must be pressed simultaneously, or within one or two seconds of each other. These two buttons would be placed on the machine anywhere convenient to the operator, provided they are far enough apart to prevent operation by one hand. The possibility of "cheating" this device is remote because the pressing of one button separately or the jamming of a button will immediately put the starting circuit out of action and normal operation can only be restored by resetting the control or switching the machine off.

FILM ON CONSTRUCTIONAL ENGINEERING.—The film section of the British Constructional Steelwork Association, 94-98, Petty France, London, S.W.1, have made a 30-minute film in Technicolour with a sound commentary to illustrate the course taken by plates and rolled sections on their way through constructional shop and the industries concerned. Although addressed primarily to would-be apprentices and school-leavers to show the work of the tradesmen employed in the industry, the film is an excellent documentary of the work of the steel-fabrication shop. Applications for loan of the film, which is available in 16-mm. size only, should be sent to the Association.

WELDING IN MARINE ENGINEERING.*

By H. N. PEMBERTON, M.I.Mech.E.

(*Concluded from page 76.*)

Turbines.—During recent years, welding methods have been adopted for the construction, in particular, of the low-pressure turbine casing of marine installations. Since these turbines exhaust direct to an underslung condenser, the outer casing is, in effect, a box which can be readily fabricated; the blade carriers are also fabricated and supported on the casing. Here again, with welded construction complete "freedom in design" is obtained. More serious technical problems arise in the application of welding in the construction of high pressure and temperature marine steam-turbines than in oil-engine construction. These problems are accentuated in gas-turbines which are now in process of development. Welding-research authorities would do well to give prior attention to the problems associated with high-temperature operation, since welding technique and electrodes must be suitable not only to weld the alloy steels required, but also to provide weld-metal capable of service performance equal to that of the parent metal.

There is already a remarkable range of ferritic steels suitable for elevated temperatures. Some of these may be classed as weldable, namely, those steels containing 0·12 per cent. carbon and 0·5 per cent. molybdenum, with or without the addition of chromium or vanadium. The main problem in the welding of these ferritic steels is the tendency to crack in the fusion zone of the weld. In the case of carbon-molybdenum steel, graphitisation in the fusion zone has proved to be a serious defect in welded steam-pipes in the United States. The technique of welding these steels varies with different manufacturers, some employ both preheating and stress-relieving, others stress-relieve only, but the employment of either of these desirable processes depends a great deal on the nature and size of the component being welded. Further, the type of electrode normally used for welding these steels is designed to give room-temperature properties similar to those of the steel. In the absence of information on the long-term behaviour of the weld-metal under elevated temperatures this basis for electrode selection may prove to be misleading. In gas-turbines there is the added complication of the effects of high temperature oxidation and sulphurous gases on the weld-metal.

Special steels have been, and continue to be, developed which give improved heat and oxidation resistance. These steels are at present not weldable. Indeed, weldability must remain a secondary consideration, since the primary purpose of the steelmaker must be to produce a steel to give the required long-term performance under a variety of arduous service conditions. It is by welding research that means must be devised for welding these steels if welding is to play its proper part in the construction of gas-turbines and components required for atomic plant.

The gas-turbine brings its own welding problems, both as regards materials and design. Difficulty in producing austenitic-steel forgings of the required sizes necessitates the fabrication of large turbine rotors by welding together a number of forgings. In high-temperature steam-turbines it has also been the practice of certain manufacturers to fabricate the rotors from forged steel discs welded together round the periphery. An advantage of this type of fabricated rotor for gas-turbines is that more than one type of steel can be incorporated in the rotor, to suit the varying operating temperatures throughout the length of the turbine. As an example of welded construction applied to a steam-turbine rotor-shaft, Fig. 18, herewith, shows the two portions of the rough machined forgings prior to welding.

The production of satisfactory welds in austenitic-steel turbine rotors is an urgent problem, requiring more than the trial and error methods of individual manufacturers. Research organisations should give attention to this matter, bearing in mind not only that the welds should be free from micro-cracks to start with, but that they should also be equivalent to the parent metal in resistance to physical and metallurgical deterioration during the passage of time.

* The 25th Thomas Lowe Gray Lecture, presented to the Institution of Mechanical Engineers, London, S.W.1, on January 9. Abridged.

WELDING IN MARINE ENGINEERING.

FIG. 18. STEAM-TURBINE ROTOR COMPONENTS BEFORE WELDING.

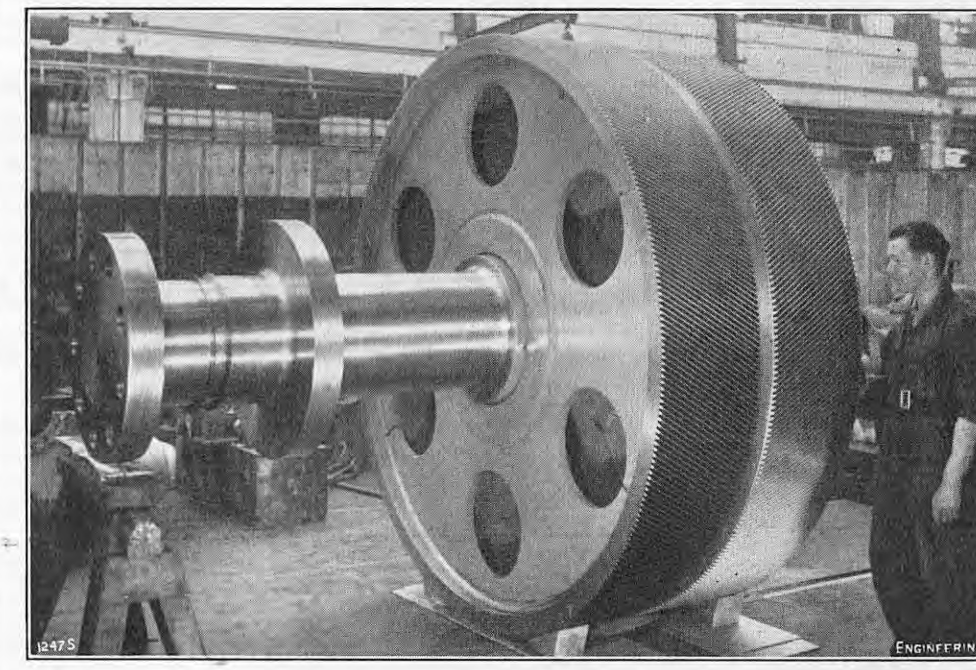
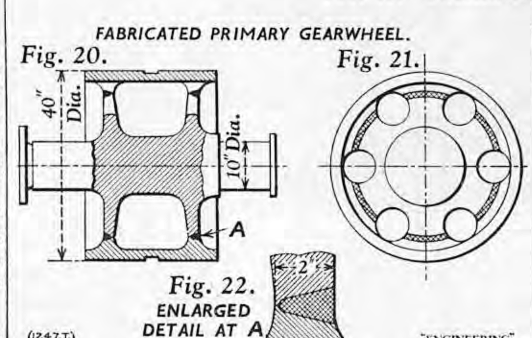


FIG. 19. FABRICATED MAIN GEARWHEEL.



Gearing.—In marine turbine installations it is not uncommon for the main gearwheels to be of welded construction. The hub is usually a mild-steel forging and the radial discs to which the rim is secured are made from rolled-steel plates. The rim in which the teeth are cut may, however, be of alloy steel, and this gives rise to some difficulty in welding it to the discs, to avoid cracking in the fusion zone. The problem is to provide a sufficient degree of flexibility when the alloy-steel rim is being welded to the radial discs.

Fig. 19, on this page, shows a fabricated gearwheel 8 ft. 2 in. in diameter, in which a carbon-steel rim is welded to mild-steel radial plates. It will be noted that slots are cut between the periphery of the radial plates and the lightening holes, to provide some flexibility during welding. Another type of fabricated gearwheel is illustrated in Figs. 20, 21 and 22. This gearwheel, 40 in. in diameter, was constructed from two ingot-steel forgings of tensile strength 31 tons to 35 tons per square inch, the wheel shaft and webs being an integral forging. In this case, the continuity of the circumferential weld was broken by six holes arranged in line axially in each web, and the welding was carried out by beginning at the centre of each circumferential section and welding towards the edges of the holes in each section. The wheel was stress-relieved on completion of the welding.

It is common practice now to fabricate gear-cases from welded mild-steel plate. As with oil-engine bedplates, rigidity is an essential factor in design. It would be of little use to achieve a high degree of accuracy in the cutting of gear-teeth if the gears subsequently were to be housed in a weak and flexing gear-case. Bearing housings may be either forgings, castings, or made from heavy rolled-steel plate and incorporated in the weldment. Flat plate panels forming the sides and ends of the gear-case are stiffened against vibration. A possible objection to the welded gear-case is that it is apt to act as a sound-amplifying box, thus accentuating gear noise which would be more effectively damped in a cast-iron gear-case.

OTHER MACHINERY DETAILS.

Many other examples of welding will be found in the engine room of a modern ship. Suffice it to mention steam condensers, evaporators, feed-water and oil heaters, oil coolers, storage tanks, steam and exhaust pipe bellows-type expansion pieces,

WELDING IN MARINE ENGINEERING.

Fig. 23.
FABRICATED MARINE PROPELLER.

Fig. 24.
SECTION AA.

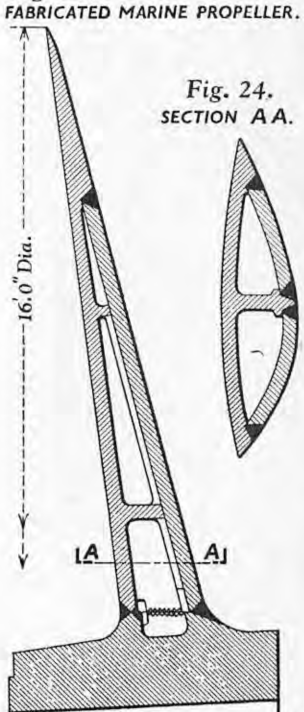


FIG. 25. WELDED DREDGE BUCKET.

superheater headers and tube elements, supporting brackets, ladders, and gratings. Space will not permit a detailed description of these weldments, most of which are so commonplace as to evoke no comment, and indeed to pass unnoticed by the majority of visitors to an engine room.

Apart from gearwheels and turbine and electric rotors, welding is infrequently used for the construction of moving parts of marine machinery. In isolated cases, crankshafts, connecting and eccentric rods, crossheads, and pistons have been fabricated with varying degrees of success. The building of auxiliary-engine crankshafts by welding together a series of drop-forgings has been mooted on more than one occasion. But, while prototypes have been produced and tested, production difficulties have retarded development, and engine builders have naturally preferred to continue to rely on orthodox methods.

A special application of welding which is of interest is the construction of a light-weight marine propeller, fabricated from steel castings and plates, as shown in Figs. 23 and 24 above. It has possibilities in offering a ready means for adjusting weight disposition in design, and also in facilitating the incorporation of corrosion- and erosion-resisting material for the blade faces. It is, however, a very unusual type of propeller. Another uncommon and interesting example of welding is the construction of a piston for the low-pressure cylinder of a steam reciprocating-engine. This special construction was adopted with a view to reducing the reciprocating weights and hence the inertia forces.

During the 1939-45 war, at a time when it was anticipated that the supply of forged-steel propeller-shafts might not keep pace with the building of corvettes and minesweepers, a number of shafts were made from seamless-steel tubes of 16-in. bore, having coupling flanges welded on. It subsequently proved unnecessary to put these experimental shafts into service, although there is little doubt they would have fulfilled their purpose. Torsional fatigue tests carried out on full-size shafts by Lloyd's Register of Shipping revealed, however, that such fabricated shafts were not so good as the solid forging.

Refrigeration Plant.—In marine refrigerating plant, fusion welding is used almost exclusively in the manufacture of pressure-vessels, such as condensers and evaporators, of shell and tube type, liquid-refrigerant receivers, oil separators, etc., though in the smaller sizes the shells are generally made from solid-drawn or forged lap-welded tubing. The design of the vessels follows orthodox lines, but it is perhaps worth mentioning that a usual feature of condensers and evaporators is the tube-plate, which is considerably thicker than the shell—the object being to obtain tube tightness when the tubes are held by expansion into grooves. In some cases, however, thinner tube-plates, with the tubes secured by welding, have been adopted.

A start was made recently in the use of butt-welded intermediate joints in a marine carbon-dioxide piping system instead of the usual flanged joints. Welder and procedure qualification tests were required to be carried out. The butt-welded joints showed obvious advantages over the flanged joints when it came to fitting the insulation.

Dredgers.—A special field of marine engineering in which welding now plays a major part is in the building of dredgers. There are several different types of dredging craft, the best known being the multi-bucket dredge, which is commonly used in Britain. Modern methods of building the hull involve the prefabrication of a number of hull units, which are assembled and welded together on the building berth. Superstructure and bucket-ladder are also prefabricated.

Special mention should be made of an important welding application to dredging equipment, namely, the deposition of hard surfacing on the faces of the upper and lower tumblers that drive the bucket chain, also on the digging edges of dredge-bucket lips. The tumblers are subject to heavy impact loading and severe abrasion. The area of hard surfacing, for which special welding electrodes are necessary, is usually restricted to the width of the bucket-links and to the area of the bucket base in contact with each tumbler. Instead of fitting renewable lips to dredge-buckets, modern practice is to weld a layer of hard surfacing along the cutting edge. This edge is subject to extensive wear, but an advantage of welding is that the hard surfacing can be renewed, as required, without dismantling the dredge equipment. An all-welded dredge bucket is shown in Fig. 25.

GENERAL REMARKS ON NEW CONSTRUCTION.

From the examples of welding described, it may be concluded that welding is the best constructional process for making permanent joints between ferrous metal components. In consequence, it provides the rational method for fabricating pressure-vessels and pipe-lines. In the latter, bolted and flanged connections should be used only where portability is desired, and the degree of portability in a pipe-line should be restricted to a minimum.

Before leaving this review of welding in new construction, it will be of some interest to mention the subject of stress-relieving of welded joints, since there is still some divergence of thought and opinion regarding the importance of this operation. Much research has been carried out to determine the effect of residual stresses induced by welding, but no positive results have yet been obtained to prove that these residual stresses are harmful to the serviceability of the welded joint. The more severe the degree of restraint during welding, the higher are the resultant strains, transversely and longitudinally to the weld.

It should be appreciated that welding stresses arise in a manner similar to that of any other residual stress which is introduced into material that has been worked. In other words, they are due to plastic deformations in the welding metal and the components of the joint. The stress system induced by these deformations is self-balancing, and therefore it is erroneous to regard residual stress as additive to the stresses induced by external loading. If they are additive in one position they must necessarily be subtractive in another, and the collapse load will remain unaffected.

In addition to the stresses induced by plastic deformations, stresses may also result from the volume changes which accompany phase changes when metal is heated or cooled through the critical temperatures. If brittle constituents are formed, cracking may occur. Cracking may also occur if yield is inhibited by restraining forces. Yield inhibitors of various degrees of severity are: a system of bi-axial or tri-axial loading; a notch, which may be a hair crack, slag inclusion or non-penetration in the weld; and low temperatures. It has been proved by strain measurements that the magnitude of residual welding stresses may approach the yield point of the material. It follows, therefore, that the inhibition of yield might well induce a crack. The crack will occur in a direction transverse to the stress responsible for it. Brittle fractures in ductile metals occur through the inhibition of yield.

Since it is unlikely that a fusion-arc weld which is entirely free from notches can be produced under conditions of normal commercial production, then, obviously, the elimination or reduction of residual stress by stress-relieving treatment is desirable. If in service the weldment is likely to be subjected to the further yield-inhibiting condition of low temperature, then stress-relieving becomes even more desirable. The need for what is sometimes termed "machining stability" is another reason for stress-relieving weldments. Where a system of residual stresses exist, the removal of metal by machining results in a redistribution of strain. This may give rise to distortion which might seriously affect the dimensions of the weldment as machining proceeds. Thermal stress-relieving will minimise the tendency to distort, but where stress-relieving for some reason cannot be carried out, distortion must be allowed for by providing sufficient excess metal in the parts which are subsequently to be machined.

From the foregoing remarks, it will be concluded that in all cases stress-relieving is an advantage; in some, it is essential. It is a compulsory requirement for welded boiler-drums and other important pressure-vessels.

REPAIR WORK.

A field of welding which is always of interest to marine engineers is in repair work. Unlike land plant, for which complete resources for repairs are always available, marine machinery may be involved in mishaps and breakdown on the high seas and in remote parts of the world, where repair facilities might be primitive, or even non-existent. Many ships now carry electric-welding equipment, and sea-going marine engineers include welding in their many other manual accomplishments.

For the purpose of this lecture, it is proposed to describe a few examples of weld repairs, some of which have enabled ships to complete their voyages, carrying valuable cargoes with a minimum of delay. In other cases the repairs have been no more than sufficient to enable the ship to reach a suitable port, where more permanent repairs could be carried out.

Boilers.—As stated previously, welding has been in use over a period of many years for boilers, to make good wastage on combustion-chambers, furnaces and boiler end-plates. Repairs to these parts have been made by cropping the plate and adding patches. Welding has also proved to be of

WELDING IN MARINE ENGINEERING.

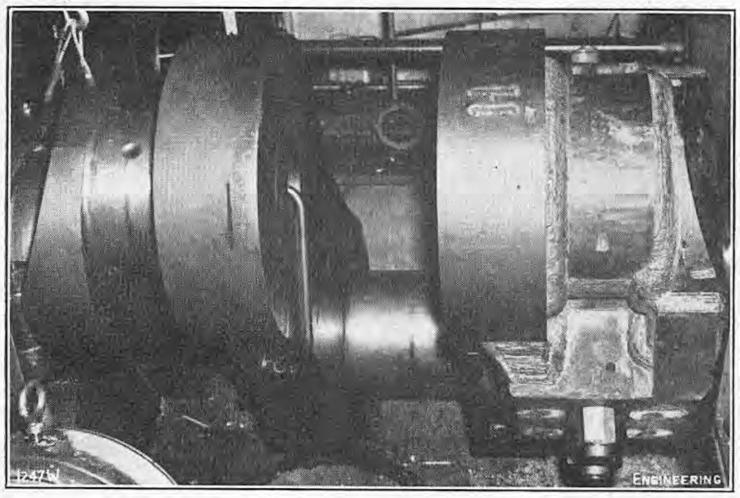
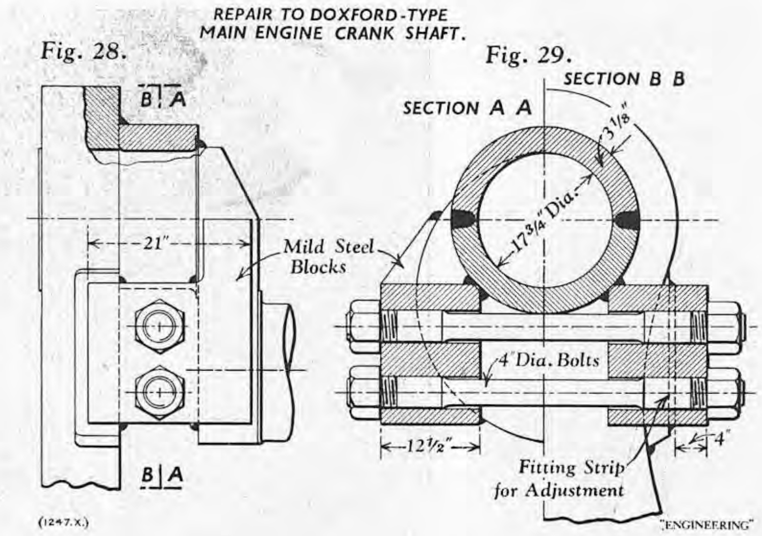


FIG. 26.



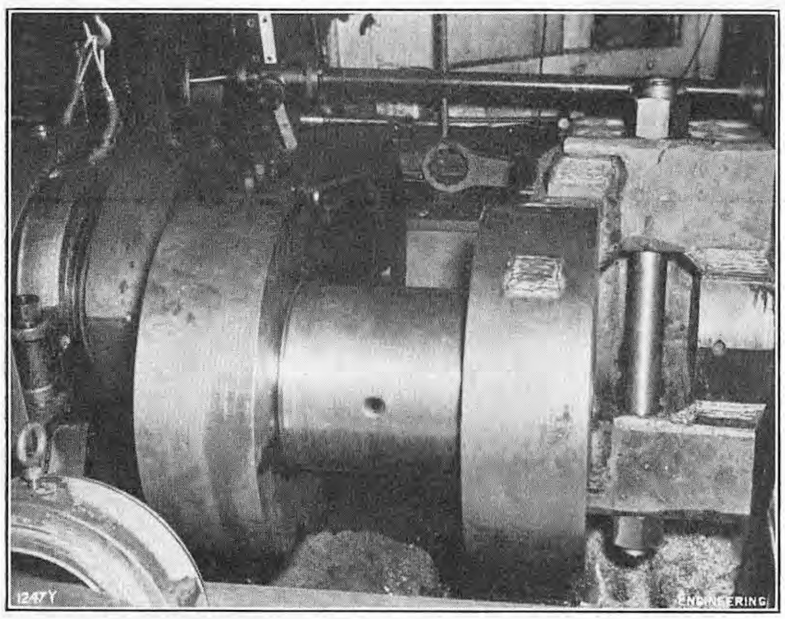
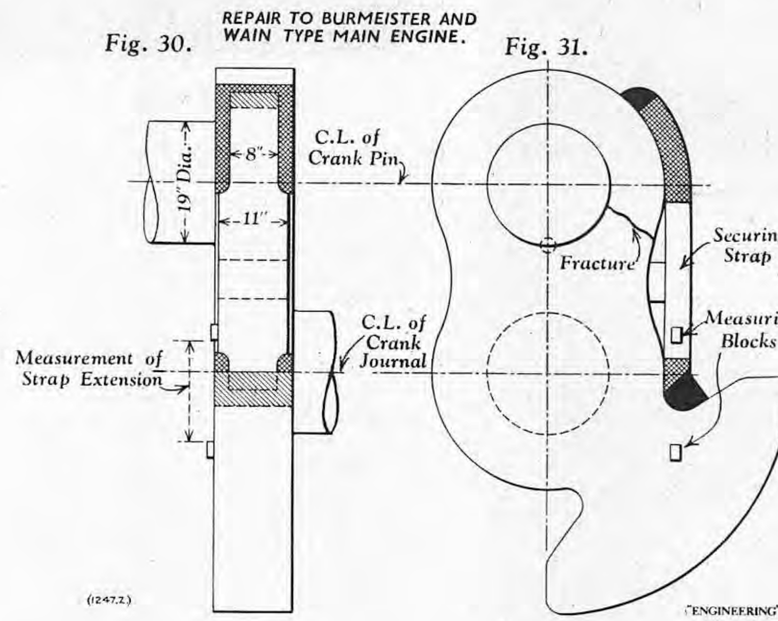


FIG. 27.

FIGS. 26 & 27. REPAIR TO DOXFORD-TYPE CRANKSHAFT.



considerable advantage in the fitting of replace furnaces, particularly for older designs, where the attachment to the combustion-chambers has been of the saddle type. Repairs to boiler shells are relatively infrequent, due to difficulties of stress-relieving and lack of radiography. Such repairs, however, are sometimes unavoidable.

Several instances have been noted where, in double-ended boilers, at the intermediate circumferential riveted seams, the edges of the middle strake of shell plating had, at some time during their service, been indiscriminately sealed with heavy fillet-welds, resulting in an extensive circumferential cracking. These were subsequently repaired by removing the heavy fillets, welding-up the cracks and sealing the plate edges with a light fillet-weld. Cracks in combustion-chambers and furnace flanges in way of rivet holes are commonly repaired by welding. Where, however, these cracks are caused by caustic conditions, it is unwise to attempt repairs before making a very complete examination of all riveted seams. In many cases it has been found that the cracking is so extensive that renewal of the boiler, or large sections of it, is necessary.

Shafting.—In view of the urgent necessities of war, welding has been used to carry out permanent repairs of main screw shafts under carefully controlled conditions, and is accepted by some authorities at the present time. Such repairs are not common in Britain for merchant ships. Temporary repairs to shafting by welding are mostly carried out in places other than the ship's home port, and the delay to the ship in port should therefore be a minimum. Further, facilities for repairs are often limited, and these limitations influence the type of repair to be adopted. Bearing these comments in mind, the following are examples of repairs to crankshafts which have been carried out with success.

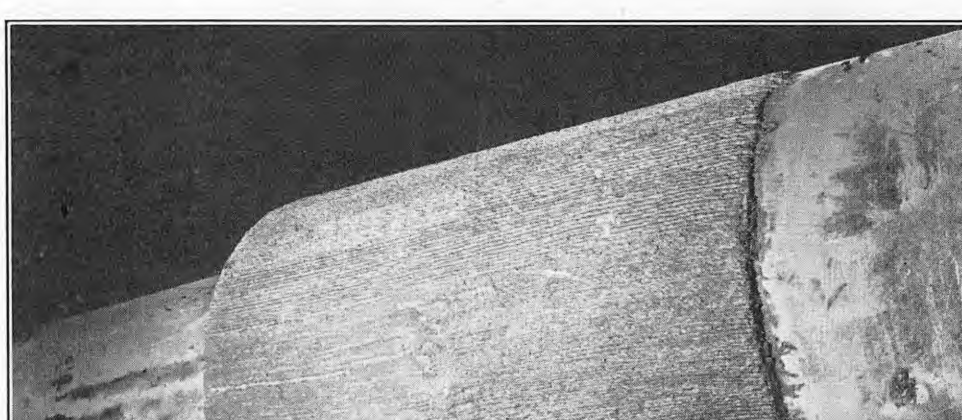


FIG. 32. GEARWHEEL SHAFT BUILT UP BY WELDING.

THE S.55 HELICOPTER.

WESTLAND AIRCRAFT, LIMITED, YEOVIL.

The crankshaft, with a journal 17¼ in. in diameter, for a Doxford main engine was found, on arrival in New Zealand, to be cracked in way of a side crank-pin and the adjacent outer web, and a repair was made as shown in Figs. 26 to 29, opposite. A ring was first mounted over the side crank-pin and mild-steel shaped-blocks were fitted between the outer and inner webs, the entire arrangement then being heavily block-welded and finally secured by means of two stud bolts 4 in. in diameter. On completion of this repair, the ship made a successful voyage from New Zealand to Britain in the latter part of 1952.

Another interesting example of a successful temporary repair to a crank-web by welding is shown in Figs. 30 and 31,* that of a main-engine crankshaft. The repair was carried out in Australia in 1946. A strap of heavy section (11 in. by 4 in.) was laid in place along the crank-web, secured at one end, and heated by a system of electric elements until its extension, measured at the points shown in Fig. 30, equalled the width of the crack, when final welding began. The additional heat generated during welding produced a further slight extension and, when the assembly cooled down on completion of the welding, the crack was effectively closed.

The use of welding dealt with in the preceding paragraphs has been to make good the results of fractures. A further interesting application has been to make good the effects of wear on gear-wheel shafts, a particular example of which is shown in Fig. 32, opposite. The gearwheel was found to be slack on its hub, and, again, to save time, the fitting surface of the shaft was built up by welding under carefully controlled conditions, and, on completion, the shaft was stress-relieved in a non-oxidising furnace. While this particular repair was carried out in the United States, similar repairs have been done in Britain.

So much has been said of the many advantages of welding that it is perhaps prudent to draw attention to the indiscriminate or ill-advised use of welding which, by virtue of its ease of application, is apt to be abused. Though temporary repairs to shafts by welding have been carried out, it will be recognised that the application of welding sets up high local residual-stresses, particularly where relatively small deposits are laid on a larger mass of metal, and these may give rise to incipient cracking in the weld-deposit. There is also the possibility of blow-holes and slag-inclusions, which may act as stress-raisers. The influence of welds in engine forgings subject to dynamic loads requires investigation, and, in the light of present knowledge and experience, such welding cannot be generally accepted.

During the 1939-45 war, an error in the machining of the propeller keyway in a screw-shaft was, without approval of the inspection authorities, built up by electric welding. After a very short period of service the ship lost her propeller, fracture occurring in way of the weld. It is fair to add, however, that in this case the shafting system was affected by critical torsional vibrations. A further example occurred in a ship propelled by Diesel-electric machinery. The crankshaft of one of the main-engine generators fractured, in way of the journal, after approximately six months in service. On investigation it was found that at some time during the manufacture, the surface of the shaft journal where the fracture occurred had, without authority, been welded.

A serious example of the misuse of welding came to light recently, as the result of a disastrous break-down of a new main-engine at sea, which caused the ship on her maiden voyage to be adrift for several days before she was taken in tow. One of the connecting rods of the six-cylinder oil engine broke at full speed and wrecked the engine. The fracture occurred at the fork end of the rod, and investigation by the Research Department of Lloyd's Register disclosed that the rod had been built up by welding, to make good a deficiency in metal which had prevented it from cleaning up properly when it was being machined. The welding had been done without authority and, due to the oxidised surface of the rod, could not be detected by normal visual inspection at the time it passed survey. The fracture originated at the weld, and this case should be regarded as a warning not only of the serious consequences which can follow the indiscriminate use of welding, but also of the doubt which must be associated with the welding of important engine forgings which are subject to alternating stresses in service.

Welding offers a convenient method of repair for broken parts, and parts of engines and boilers which are wasted by corrosion or wear. In many cases the repairs are necessarily of a temporary nature to enable the ship to complete her voyage. Such repairs are frequently carried out in foreign ports where facilities for permanent repairs are not available. Just as welding is a legitimate method of construction when used under proper control and supervision, so it may be applied in effecting permanent repairs under similar conditions. The secret of good welding is good preparation of the parts to be welded. Root gaps, depth of root faces, shape of weld-grooves, close abutment of components to be welded, are factors in welding of equal importance to quality of electrode and correct welding technique. The advantages of radiographic examination as a control of weld quality cannot be too strongly emphasised. In new construction, many manufacturers have found this to be the best means for maintaining a good standard of workmanship.

Many examples of interesting weld repairs could be given. The lecturer is aware of other uses of welding which, for reasons of economy in time and space, must be excluded from this lecture. The repair of steel castings and the bronze welding of propellers are examples.

* Arnold, A. G., *Trans. Inst. Mar. E.*, vol. 62, page 133 (1950).

THE WESTLAND S.55 HELICOPTER.

ON November 12 last, the 10-12-seat Westland-built S.55 helicopter made its first flight. The S.55, which is constructed in the United Kingdom by Westland Aircraft, Limited, Yeovil, Somerset, under licence from the Sikorsky Aircraft Division of United Aircraft Corporation, Bridgeport, Connecticut, U.S.A., has shown itself to be a useful and versatile machine in service with the American forces in Korea, notably for ambulance duties and field medical services and for air/sea rescue work. Other applications for which the S.55 is eminently suitable include the carriage of freight and mail, communications duties, traffic control, crop-spraying, and forestry fire-fighting patrols with their equipment.

The Westland S.55 helicopter, shown in the illustration, is sustained by a single three-blade main rotor, with a two-blade tail rotor for counteracting torque reaction, and for providing directional control by means of a variable-pitch adjustment operated by the pilot's rudder pedals. The blades of the main and tail rotors are of metal. The main rotor, which is mounted with the main gearbox on a pylon of steel tubes above the cabin roof, is driven, through a clutch and freewheel, by a Pratt and Whitney Wasp R.1340 radial air-cooled engine, developing 600 brake horse-power for take-off. Later, the new Alvis Leonides Major 800-h.p. engine, now in an advanced state of development, which is expected to go on test this year, will be available as an alternative power plant.

The engine, clutch and accessories are installed in the fuselage nose, which consists of two large doors giving excellent access for servicing. The drive from the engine is taken through a sloping shaft to the rotor head. The tail rotor is driven through extension shafting from the main rotor drive. Access to the main transmission and the flight controls is provided by removable sound-proofing panels in the cockpit. The collective-pitch and cyclic-pitch control mechanisms of the main rotor are power-assisted by a hydraulic servo system, housed in the rotor pylon. The pilot can trim the aircraft in flight by an adjustable aerofoil surface which can be seen in the illustration beneath the tail.

The fuselage is a semi-monocoque structure, principally in magnesium-alloy sheeting. The passenger cabin, 10 ft. long, 5½ ft. wide and 6 ft. high, is located directly below the main rotor, so that the centre of gravity of the machine is not greatly affected by changes in payload. The cabin can be arranged to accommodate ten to 12 passengers, or six stretchers. The entrance door is on the starboard side. The pilot's cockpit, which is above the forward end of the cabin, contains two pilot's seats with full dual control. Fuel is carried in tanks below the cabin, the normal maximum fuel capacity being 150 Imperial gallons; there is provision for fitting additional tanks for carrying out long-range flights. A four-wheel undercarriage is fitted, each wheel having individual hydraulic shock absorption. A hydraulically-operated winch is provided, which can be used for lowering stretchers or for air/sea rescue, while the helicopter hovers.

The overall dimensions of the fuselage are: length, 41 ft. 8½ in.; width, 5 ft. 11 in.; and height, 14 ft. 8 in. The diameter of the main rotor is 53 ft. and that of the tail rotor 8 ft. 10¾ in. The main-rotor blades are arranged to fold back for transport and storage. The all-up weight of the S.55 is 6,800 lb. The sea-level performance of the machine is as follows: specific range in still air, at the maximum-range speed of 74 m.p.h., 2·88 miles per gallon, corresponding to a maximum still-air range (with no allowances for fuel reserves) of about 430 miles; maximum endurance, at a forward speed of 60 m.p.h., 6 hours 25 minutes; maximum continuous speed, 106 m.p.h.; maximum weak-mixture cruising speed, 86 m.p.h.; vertical rate of climb at take-off power, 400 ft. per minute; maximum rate of climb at continuous-power rating, 880 ft. per minute. The Westland S.55 helicopter has a service ceiling of 13,000 ft., and a hovering ceiling, without allowing for ground effect, of 4,900 ft.

THE WENVOE TELEVISION TRANSMITTING STATION.

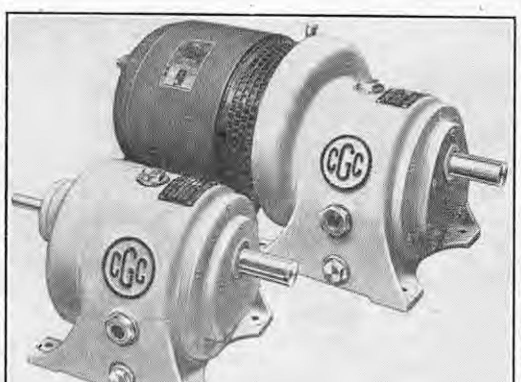
The high-power television transmitting station of the British Broadcasting Corporation at Wenvoe, five miles west of Cardiff, was brought into service on December 20, 1952. On the same date, the medium-power transmitters, which had been in use since the middle of August, reverted to stand-by usage. The Wenvoe station stands on a 30-acre site at a height of 400 ft. above sea level, the transmitting aerial being mounted on the top of a 750-ft. mast. The vision programme is received over a $\frac{3}{8}$-in. tube coaxial cable system from London, and the sound programme over specially equalised telephone circuits. The vision transmitter operates on a frequency of 66·75 megacycles (4·495 m.) and the sound transmitter on 63·25 megacycles (4·745 m.). The vision transmitter, which was constructed by Electric and Musical Industries, Limited, Hayes, Middlesex, is similar to that installed at the Kirk o'Shotts station. Low level modulation is used, thus enabling a considerable reduction in size to be made and the overall efficiency to be increased. The incoming vision signals are fed to a modulation amplifier, consisting of a three-stage direct-current input amplifier, a linearity correction amplifier and a pre-modulation amplifier. The black level is clamped at the input to the pre-modulation amplifier and is maintained constant by feed-back from the transmitter output. The modulation is applied to an earthed grid push-pull modulated amplifier through a pre-modulation radio-frequency amplifier, a frequency multiplier and the crystal oscillator stage, while the modulated amplifier output is, in turn, fed to a chain of three amplifiers which give a final output power of 50 kW. The modulated amplifier is also connected to inter-stage couplings of the wide-band coupled-circuit type, which are tuned so that their pass-band centre frequency is about 0·7 megacycles below the carrier frequency. A filter is used to obtain the final asymetric side-band condition. Finally, a three-stage coupled circuit changes the balanced to an unbalanced load by which the coaxial output transmission line is fed. The high-voltage direct-current supplies for the high-power stages of the transmitter are obtained from the South Wales Electricity Board's system through two 500-kVA transformers and rectifiers. The valves in the earlier stages are air-cooled; in the final stage, distilled water is used for cooling.

The high-power sound transmitter, constructed by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2, is of the well-known Class B modulated type, with a carrier output power of 12 kW. The filaments of the three radio-frequency power amplifier valves and the modulator valves are supplied with heating current from metal rectifiers, equipped with limiting reactances for controlling the starting current. The remaining valve filaments are heated by alternating current. The main high-tension supply for this part of the station is obtained from a 6-kW three-phase full-wave bridge-connected rectifier of the hot-cathode grid-controlled mercury-vapour type. The output of the vision transmitter is passed to a vestigial side-band filter and thence to a combining unit, where it is joined by the output from the sound transmitter. The signals are fed thence to a common aerial at the top of the 750-ft. mast through a coaxial cable. The mast and the aerial are similar in construction to those at Sutton Coldfield, Holme Moss and Kirk o'Shotts.

Cement Production in 1952.—The total output of cement in the United Kingdom during 1952 was 9,147,000 tons, an increase of slightly more than 1,000,000 tons over the previous year. During the year—the first free from price control in the home market—the cement industry was able to lower the price by between 2*s*. and 3*s*. a ton, according to area. A fall in the price of paper permitted further reductions in the price of packed cement. Exports reached a peak figure of 2,055,000 tons. The installation of new plant will increase the capacity of the industry by half a million tons during 1953.

GEARED MOTOR UNIT.

A geared electric motor unit with many possible applications has been added to the range made by the Coventry Gear Company, Foleshill, Coventry, a member firm of the David Brown Group. Suitable for driving conveyors, small compressors, pumps, hoists, textile machinery, etc., it is available either as a double-reduction or triple-reduction unit, with efficiencies of 96 per cent. and 94 to 95 per cent., respectively. With a motor speed of 1,425 r.p.m., there is a choice of six output speeds, from 105 r.p.m. to 345 r.p.m., with corresponding input powers of 3 h.p. to 5 h.p., with the double-reduction unit; and a choice of 11 output speeds, from 25 r.p.m. to 90 r.p.m., and input powers from 1·25 h.p. to 3 h.p. with the triple-reduction unit. Since the height of the unit is only slightly greater than that of the motor alone, it is particularly suitable for installing in a confined space. It can be supplied for mounting in any position, but is not suitable for running with the output shaft extended vertically upward.



Units are supplied with any desired type of motor, provided that the diameter does not exceed 14 in.; alternatively, gear units are available without motors, with coaxial input and output shafts and with modified covers in place of the adaptors. Both types are shown in the accompanying illustration. The precision-cut gears are of heat-treated high-tensile steel, the first reduction stage being helical and the second and third reductions having spur teeth. Splash lubrication is provided and the internal arrangement of the case ensures an adequate flow of oil to the bearings.

For units intended for vertical mounting, a screw pump provides a positive oil feed to the top bearing and gears. All the shafts run in bearings of sufficiently large capacity for carrying the overhung loads normally experienced; the maximum load which can be carried by the output shaft is equivalent to a steady tangential load of 600 lb. at a radius of 1 in. when applied midway along the shaft extension. The casing is of close-grained cast iron, bored and faced at each end to receive the end cover and the motor adaptor, which are secured by Allen screws and fitted with oil-tight and dust-proof joints. There is an oil seal in the output-shaft cover. A combined filling and ventilating plug, a drain plug, and an oil-level indicator are provided in the casing.

The Late Mr. R. C. Pierce.—We regret to record the death of Mr. Robert Cecil Pierce, which occurred at Cambridge on January 10, 1953, at the age of 77. Mr. Pierce, who was prominent in the early days of electricity supply, was educated at Eton and received his engineering training at King's College, London, and with C. A. Parsons & Co., Ltd. After serving as assistant to Mr. A. A. Campbell Swinton in the erection of a number of electricity supply stations, he became general manager and engineer of the Cambridge Electric Supply Co., Ltd., a position he held for many years until his retirement. Mr. Pierce was elected a Member of the Institution of Mechanical Engineers in 1910. He joined the Institution of Electrical Engineers as an associate in 1897, was transferred to the class of associate member in 1909, and to that of member in 1912.

LAUNCHES AND TRIAL TRIPS.

M.S. "Hayling."—Single-screw cargo vessel, built by S. P. Austin and Son, Ltd., Sunderland, for Stephenson Clarke, Ltd., London, E.C.3. Second vessel of two. Main dimensions: 249 ft. by 38 ft. 9 in. by 18 ft. $4\frac{1}{2}$ in.; deadweight capacity, about 2,400 tons on a mean summer draught of 17 ft. Clark-Sulzer eight-cylinder vertical two-stroke single-acting trunk-piston oil engine, developing 1,150 b.h.p. at 225 r.p.m., constructed by George Clark (1938), Ltd., Sunderland. Service speed, $10\frac{1}{2}$ knots. Launch, November 4.

S.S. "Evgenia."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Mr. N. G. Livanos, Piræus, Greece. Second vessel of five. Main dimensions: 457 ft. 6 in. overall by 57 ft. $8\frac{1}{2}$ in. by 38 ft. 3 in. to shelter deck; deadweight capacity, 11,235 tons on a draught of 28 ft. $6\frac{3}{4}$ in. Triple-expansion steam engine, with a Bauer-Wach exhaust turbine, and three oil-fired boilers. Service speed, $11\frac{1}{2}$ knots. Trial trip, November 21.

M.S. "Raeburn."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Lamport and Holt Line, Ltd., Liverpool. Main dimensions: 470 ft. overall by 63 ft. by 39 ft. 6 in. to shelter deck; gross tonnage, 8,311. Harland-B. and W. seven-cylinder two-stroke opposed-piston heavy-oil engine. Trial trip, November 27 and 28.

S.S. "Hallindene."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Gray & Co., Ltd., West Hartlepool, for the Dene Shipping Co., Ltd., London, E.C.3. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 36 ft. $4\frac{1}{2}$ in. to shelter deck; deadweight capacity, 8,870 tons on a draught of 24 ft. $11\frac{1}{2}$ in. Triple-expansion steam engine and Bauer-Wach exhaust turbine, and two oil-fired boilers. Service speed, $10\frac{1}{2}$ knots. Trial trip, November 28.

S.S. "Tosca."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for Rederi A/B Soya, Stockholm. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 40 ft. 2 in.; deadweight capacity, about 10,350 tons on a draught of 27 ft. Triple-expansion reheat reciprocating steam engine, developing 3,900 i.h.p. in service, and three multitubular oil-burning boilers, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Speed, about $12\frac{1}{2}$ knots. Launch, December 1.

M.S. "Master Nicos."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for Motores Maritimos Compania Ltda., Costa Rica. Main dimensions: 435 ft. between perpendiculars by 62 ft. by 38 ft. 3 in. to shelter deck; deadweight capacity, 12,550 tons on a draught of 29 ft.; gross tonnage, 8,453. Six-cylinder two-stroke Diesel engine, developing 3,940 b.h.p. at 121 r.p.m., constructed by Sulzer Bros., Ltd., Winterthur, Switzerland, and installed by the shipbuilders. Trial trip, December 19.

M.S. "Governor."—Single-screw cargo vessel, built and engined by William Doxford & Sons, Ltd., Sunderland, for the Charente Steam Ship Co., Ltd. (Managers: Thos. and Jas. Harrison, Ltd.), Liverpool. First vessel of an order for four. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 28 ft. 8 in.; deadweight capacity, 9,140 tons on a draught of about 26 ft. Four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 108 r.p.m. Service speed, $13\frac{1}{2}$ knots. Trial trip, December 24.

M.S. "Africa Palm."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the West African trade of Palm Line, Ltd., London, E.C.4. Main dimensions: 425 ft. between perpendiculars by 57 ft. 9 in. by 37 ft. 2 in. to shelter deck; deadweight capacity, about 8,516 tons on a summer draught of 23 ft. $9\frac{1}{2}$ in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 3,000 b.h.p. at 122 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Trial trip, December 29.

M.S. "Harold Sleight."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Singapore Navigation Co., Ltd., Singapore. Main dimensions: 460 ft. between perpendiculars by 61 ft. by 34 ft. 1 in.; deadweight capacity, about 12,600 tons on a draught of about 27 ft. 6 in. Kincaid-Burmeister and Wain six-cylinder single-acting four-stroke Diesel engine, developing 3,600 b.h.p., constructed by John G. Kincaid & Co., Ltd., Greenock. Speed on trial exceeded 13 knots. Trial trip, December 29.

M.S. "Coraggio."—Twin-screw oil tanker, built by the Soc. Per Az. Ansaldo, Genoa, for Achille Lauro, Naples. Main dimensions: 627 ft. 10 in. overall by 82 ft. by 43 ft. 1 in.; oil-carrying capacity, 26,700 metric tons; gross tonnage, 17,050. Two seven-cylinder Diesel engines developing a total of 12,000 h.p., constructed by the Stabilimento Grandi Motori Fiat, Turin. Launch, January 11.

THE INSTITUTE OF METALS.

THE 1953 annual general meeting of the Institute of Metals will be held in London from Monday to Thursday, March 23 to 26. The meeting commences at 6 p.m., on the first day, at the Royal Institution, Albemarle-street, London, W.1, when Sir Christopher Hinton, M.A., M.I.C.E., M.I.Mech.E., will deliver the 43rd annual May Lecture on "The Present and Future Metallurgical Requirements of the Chemical Engineer."

On Tuesday, March 24, at 10.30 a.m., the meeting will be resumed at the Park Lane Hotel, Piccadilly, W.1, where all subsequent technical sessions will be held. The reports of the Council and the honorary treasurer will be submitted and will be followed by the presentation of the Institute of Metals Platinum Medal and other medals and awards, and the induction of the new President, Professor F. C. Thompson. The meeting will adjourn at 12.45 p.m., after the delivery of Professor Thompson's presidential address.

Four papers will be presented at the afternoon session from 2.30 to 5, namely, "The Effect of Certain Solute Elements on the Recrystallisation of Copper," by Dr. V. A. Phillips and Professor A. Phillips; "Segregation of Iron and Phosphorus at the Grain Boundaries in 70 : 30 Brass during Grain Growth," by Professor H. M. Miekk-Oja; "Factors Influencing the Young's Modulus of Solid Solutions," by Mr. A. D. N. Smith; and "The Young's Modulus, Poisson's Ratio and Rigidity Modulus of Some Aluminium Alloys," by Mr. N. Dudzinski. In the evening, at 7 for 7.30, a dinner-dance will be held at the Park Lane Hotel.

On Wednesday, March 25, all-day concurrent scientific and technical sessions will be held, lasting from 9.30 a.m. until 12.45 p.m., and from 2.30 to 5 p.m. Six papers, comprising a symposium on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys," will be presented and discussed before session "A." The first of the six papers is entitled "The Principles of Technical Control in Metallurgical Manufacture," by Dr. A. R. E. Singer. The remaining five papers all deal with the "Control of Quality in the Melting and Casting of Various Alloys." That on "Aluminium Alloys for Working," is by Mr. R. T. Staples and Mr. H. J. Hurst; that on "Copper and High-Conductivity Copper Alloys," by Mr. J. Sykes; that on "Brass" by Dr. Maurice Cook and Mr. C. L. M. Cowley; that on "Magnesium and its Alloys," by Mr. R. G. Wilkinson; and that on "Zinc and Zinc-Alloy Rolling Slabs and Extrusion Billets," by Mr. C. W. Roberts and Mr. B. Walters. The discussion will be continued in the afternoon from 2.30 to 5.

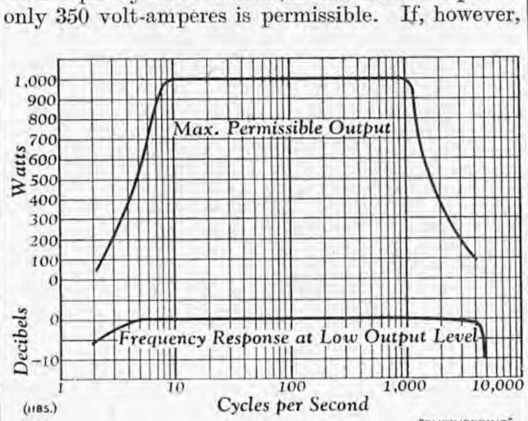
Five papers will be discussed during the morning before session "B," namely, "Effect of Cold Work on the Microstructure and Corrosion Resistance of Aluminium-5 per cent. Magnesium Alloys containing from 0 to 1 per cent. of Zinc," by Dr. P. Brenner and Mr. G. J. Metcalfe; "Atmospheric Corrosion and Stress Corrosion of Aluminium-Copper-Magnesium and Aluminium-Magnesium-Silicon Alloys," by Mr. G. J. Metcalfe; "Intercrystalline Corrosion in Cast Zinc-Aluminium Alloys," by Mr. C. W. Roberts; "High-Temperature Oxidation of Some Cobalt-Base and Nickel-Base Alloys," by Professor A. Preece and Dr. G. Lucas; and "High-Temperature Oxidation Characteristics of a Group of Oxidation-Resistant Copper-Base Alloys," by Dr. J. P. Dennison and Professor A. Preece. A general discussion on the theme of "Creep and Plastic Deformation" will be held in the afternoon at the meeting of session "B." It will be based on 16 papers bearing upon this subject, by Mr. W. A. Rachinger, Dr. W. A. Wood and Mr. J. W. Suiter, Mr. D. McLean, Mr. J. Trotter, Mr. K. E. Puttick and Mr. R. King, Dr. G. B. Greenough and Mrs. C. M. Bateman and Mrs. E. M. Smith, Mr. J. A. Ramsey, Dr. S. Bhattacharya, Dr. W. K. A. Congreve and Professor F. C. Thompson, Dr. A. E. Johnson and Mr. N. E. Frost and Mrs. V. M. Urie and Mr. H. L. Wain.

At 8 p.m., on Wednesday, March 25, a conversazione and exhibition will be held at 4, Grosvenor-gardens, London, S.W.1.

On Thursday, March 26, from 10 a.m. to 12.30 p.m., an informal discussion on "Liquid Metals," arranged by the Metal Physics Committee of the Institute, will be held. As an alternative, parties of members will leave the Park Lane Hotel at 9.45 a.m., to visit the laboratories of the British Non-Ferrous Metals Research Association, Euston-street, N.W.1, and the works of the Pyrene Company, at Brentford; Hoover, Limited, at Greenford; and Vickers-Armstrongs Limited, Weybridge.

AMPLIFIER FOR VERY LOW FREQUENCIES.

AN amplifier to provide a source of power at frequencies below those possible with standard audio types has been produced by W. Bryan Savage, Limited, Westmoreland-road, London, N.W.9. It consists of a paraphase three-stage voltage amplifier which feeds a grid-driven push-pull triode output stage, 15 decibels of negative feed-back being applied between the cathode of the second stage and the output, so that either highly-inductive or capacitive loads can be connected to the output transformer without disturbing the stability. The output is 1,000 watts at from 10 to 1,000 cycles, with a regulation of 9 per cent. or 0·8 decibels, but, with a purely reactive load, a maximum output of only 350 volt-amperes is permissible. If, however,



this is insufficient to drive the transducer, the power factor of the load can be corrected to unity by the insertion of inductance or capacity and the full output of 1,000 watts utilised. The upper curve on the diagram herewith shows the maximum permissible output of the amplifier into a "matched" resistive load over a range of 2 to 4,000 cycles. The lower curve indicates the inherent frequency response of the amplifier.

The input impedance of the amplifier is 600 ohms free of "earth" and the input sensitivity is 0·05 volt for full output. The apparatus is supplied from the 200 to 250-volt mains, the consumption at full drive being 2·745 kVA. The primary winding of the input transformer has a centre tapping, so that "balanced to earth" working is possible. Alternatively, one side of the primary can be "earthed" and connected to an unbalanced source of input. Again, control is provided ahead of the first stage. The secondary of the output transformer is wound in four sections, which can be connected in series, series-parallel or parallel to match the load impedances of 2·5, 10 or 40 ohms.

All the components, except the output transformer, are mounted on panels, secured to a 78-in. frame, protected by removable side and back covers. The valves are accessible from the front and are protected by quick-release grilles or panels. The output transformer is in a separate cabinet, mounted on wheels and connected to the frame by flexible cables. Control is effected by a main "on/off" switch, at the side of which is a three-position rotary switch enabling the high-tension circuits to be operated either locally or from a distance. A delay circuit ensures that the filaments heat up fully before the high-tension is applied. A selector switch and meter enable the anode currents in the valves of the voltage amplifier to be checked, and anode current meters are connected in the circuits of the output valves. An output level meter is provided and is adjusted to read "Max" at the maximum rated output voltage of the equipment.

NOTES ON NEW BOOKS.

Boiler-House Practice.

By E. PULL, R.N.R., M.I.Mech.E., M.I.Mar.E. Third edition, revised and enlarged. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 12s. 6d. net.]

FIRST published in 1937, this book is intended as a guide to the selection, operation and maintenance of steam boilers of an evaporative capacity up to 12,000 lb. per hour, together with their associated equipment. It deals principally with shell-type land boilers and contains much practical information of use to those concerned with the small boiler house. The author illustrates with many worked examples the process of steam generation and the various means of increasing plant efficiency, by the employment of waste-heat recovery, mechanical stoking, automatic control, etc., with comments on the comparative economics of the various types of equipment. The illustrations, however, are confined to nine sectional arrangements of typical boilers, which seems hardly enough for a book of this type. Suitable diagrams would have assisted greatly to explain some of the descriptive matter.

Identification of Hardwoods—A Lens Key.

H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 5s. net.]

THIS booklet is prepared by the Department of Scientific and Industrial Research, and constitutes the Forest Products Research Laboratory Bulletin No. 25. It contains descriptions of anatomical and other easily observed diagnostic features of nearly 400 timbers, set out in a form convenient for recording on marginally perforated index cards, which are obtainable at 2*l*. 11*s*. 4*d*. per 500, post free, from H.M. Stationery Office. The booklet defines 87 features, according to which specimens can be identified. Many of the features are concerned with pore count and formation, to which end a celluloid scale is supplied with the booklet. By superimposing this scale on a sample to be identified, the size and number of pores may be assessed as part of the determination of identifying features. Any 20 or so features is sufficient to identify positively even the less familiar timbers which, in recent years, have come into the market in the United Kingdom. It has to be noted, however, that the system as a whole, and the operation of the key, requires a sound general knowledge of wood structures.

Fire Grading of Buildings.

By a Joint Committee of the Building Research Board of the Department of Scientific and Industrial Research and of the Fire Officers' Committee. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Prices: Part I, 1s. 6d. net; Parts II to IV (in one volume), 4s. 6d. net.]

IN these Post-War Building Studies the term "fire-grading" is taken as meaning the investigation and assigning of suitable fire precautions of any kind to attain an adequate standard of safety, according to the fire hazard of the building under consideration. In Part I (published in 1946), the various fire hazards are examined under the headings of Personal, Damage and Exposure, and numerous recommendations are made, which, the Committee point out, can form the basis for the framing of rules and regulations by bodies charged with that responsibility, and after taking into consideration the various legal, insurance, and practical standpoints. Parts II, III and IV (published in late 1952) deal with Fire Fighting Equipment, Personal Safety, and Chimneys and Flues. In the matter of equipment, considerable attention is paid to the necessity of having sufficient room in which to manœuvre turntable ladders, and the dimensioned diagrams illustrating certain maximum and minimum distances required to permit a ladder to operate at any length within its total range, are a useful contribution. In the section dealing with Personal Safety, buildings are classified into the groups of Assembly (including cinemas, dance halls, and restaurants), Trade, Commercial and Industrial, and, lastly, Residential and Institutional, and are then examined with reference to minimising the spread of flame, smoke and hot gases, and the spread of fire. Recommendations are made in regard to escape routes, with particular reference to the sizes and numbers of openings and the widths of staircases. In the section on Chimneys and Flues the study is limited to the consideration of appropriate fire-resisting properties of materials suitable for chimney construction and to preventing the ignition of combustible material adjacent to the chimney.

Overseas Economic Surveys: Libya.

By H. J. LEGG, M.C., H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 9*d.* net.]

THE author of this survey, which is published for the Commercial Relations and Exports Department of the Board of Trade, was formerly the First Secretary (Commercial) to Her Majesty's Legation in Libya. After explaining how the new United Kingdom of Libya, comprising the three territories of Cyrenaica, Tripolitania and the Fezzan, is constituted and administered, the booklet gives, as at June, 1952, the "Present Position and Future Prospects for Imports" with reference to a variety of classes of goods such as textiles, chemicals, and pharmaceutical products. Other chapters deal with agriculture, livestock, handicrafts and communications, among others, all of which throw light on the economic condition of this newly constituted country and its potentialities as an export market. Numerous trade statistics are tabulated. The booklet concludes with some useful information for prospective visitors, concerning such matters as suitable clothing, the best season of the year in which to visit Libya, and the currency in use.

The Basis of Mine Surveying.

By M. H. HADDOCK. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 30*s.* net.]

THOUGH geometry and trigonometry may be justifiably regarded as the basis of surveying, it is somewhat surprising to find that this book is essentially a collection of mathematical wranglings in which, according to the author himself, no attempt is made to invade the realm of practical surveying except where it appears to be unavoidable. The geometrical and trigonometrical notes forming the opening chapters on the triangle, the polygon and the circle will be of little use to the student of surveying who wishes to learn the elements of his subject, though, in later years, he may find therein the solution to some abstruse problem. The same remarks can be made about the succeeding chapter on the sub-division of areas, since few surveyors will ever be called upon to undertake such work as making a curvilinear sub-division of a circular lease or apportioning a hyperbolic section. Problems on resection and counter-section are ideal subjects for mathematical investigations and these are dealt with in considerable detail, while the solid-geometry problems on drifting and cross-cutting are reminiscent of the author's previous and more practical book on disrupted strata. Some sections of this new book are modified forms of articles which Mr. Haddock has contributed to various mining journals, but mine surveyors who are already familiar with his mathematical ingenuity will find in this volume many diverse surveying applications of fundamental principles of geometry and trigonometry.

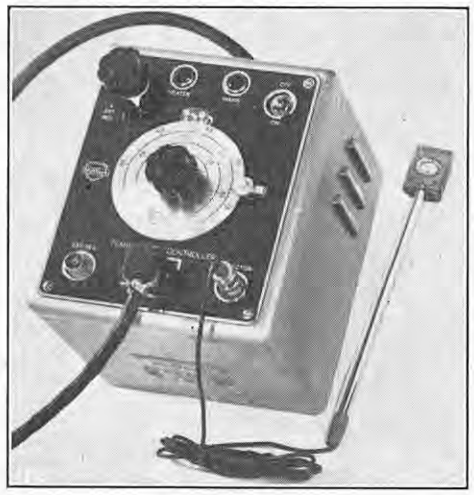
Callender-Hamilton Bridge Handbook: Highway Bridges, Type "B."

By G. D. WHITE-PARSONS, A.C.S.E., A.M.I.C.E. British Insulated Callender's Construction Company, Limited, 21, Bloomsbury-street, London, W.C.1. [Price 21*s.* net.]

THE Callender-Hamilton type "B" bridge is of the Warren arrangement with variable-section trusses constructed, in multiples of 10 ft. in length, from a set of standard parts, and this handbook presents in a useful and convenient form data relating to such highway bridges. The design employs only commercial sections, with no special fittings or intricate welding, and the handbook gives designs for three different loading specifications, together with schedules of materials, for complete ranges of spans of up to 180 ft. for single-lane and 140 ft. for double-lane traffic, in terms of the Ministry of Transport loading.

ELECTRONIC TEMPERATURE CONTROLLER.

THE accompanying illustration shows an electronic temperature controller which has been designed by Mullard, Limited, Shaftesbury-avenue, London, W.C.2, for measuring and controlling the temperature of water baths and similar apparatus within fine limits. It is intended especially for use in connection with chemical analysis and for polarographic, conductivity, viscosity and refractive-index work. The instrument consists of a temperature-sensitive resistor, which has been designed so that it can be immersed in the fluid, the temperature of which is to be controlled. This resistor forms one arm of an alternating-current bridge network the output from which is amplified and used to control a phase-sensitive circuit which operates a relay. This relay is of the single-pole double-throw



type and can deal with currents up to 1 ampere at 230 volts. It has a quick action, as the phase of the bridge output changes very rapidly at the point of balance. The temperature range is 15 to 75 deg. C., which is covered in three steps and, as will be seen, a large dial is provided so that the setting point can be precisely located and locked in position. The calibrated accuracy of the scale is $\pm$ 1 deg. C., but it is possible to control the temperature to within $\pm$ 0·02 deg. C. about the working point.

The instrument is provided with a four-position switch, which enables the value of the resistance in the fixed or standard arm of the bridge circuit to be altered. The adjacent arm of the bridge contains the temperature-sensitive element, while the other two arms are provided by the potentiometer balance control. When the surge switch is in its fourth position, the bridge is connected to a socket on the front panel of the instrument, thus enabling a precision external resistor to be incorporated in the circuit in place of the internal standard resistor. Greater accuracy of control can be obtained by keeping this external resistor at a constant temperature, and, by choosing its value, the range of the instrument can be extended to cover temperatures between $-$ 50 deg. C. and $+$ 80 deg. C. At the lower position, however, the range covered by the fine control will be only 10 deg. C.

The controller, which has a power consumption of 25 watts, can be operated from either the 110 to 120-volt or 200 to 250-volt supply. The instrument can be used with any apparatus in which a water or oil bath is incorporated, but, to take full advantage of its accuracy, adequate stirring arrangements must be provided.

EXCEPTIONAL LOADS ON LONDON MIDLAND REGION, BRITISH RAILWAYS.—During 1952, 8,948 out-of-gauge loads were carried by the London Midland Region, British Railways, an increase of 750 over the figure for 1951. The movement of such exceptional loads may involve special routing, moving signals, lineside huts and/or crossing gates, and, on occasions, moving the load on its wagon to avoid obstructions. The heaviest load carried was an electric transformer weighing 119 tons and the longest haul was one of 300 miles from Stafford to Dunfermline.

BOOKS RECEIVED.

Visual Lines for Spectrographic Analysis. By D. M. SMITH. Hilger and Watts, Limited, 98, St. Pancras-way, Camden-road, London, N.W.1. [Price 16*s.* net.]

Portugal. Ministério das Obras Públicas. Laboratório Nacional de Engenharia Civil. Publication No. 27. *Estudo das Condições de Afogamento de Uma Galeria de Desvio.* By ARMANDO COUTINHO LENCASTRE. No. 28. *A Divisão de Hidráulica do Laboratório Nacional de Engenharia Civil.* By FERNANDO MANZANARES ABECASIS. Laboratório Nacional de Engenharia Civil, Avenida do Brasil, Lisbon, Portugal.

The Canadian Standards Association Approvals System. Information for U.K. Manufacturers Exporting Electrically-Operated Equipment to Canada. British Standards Institution, 24, Victoria-street, London, S.W.1. [Price 3*s.* 6*d.* net.]

National Physical Laboratory. Notes on Applied Science, No. 3. The Properties of Electrical Insulating Materials and Methods of Test. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

Painting Practice for Aluminium. Information Bulletin No. 20. The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 2*s.*]

Acta Polytechnica. Chemistry, including Metallurgy, Series. Vol. 3, No. 1. *Wet Combustion. A Process for the Utilization of Peat.* By K. N. CEDERQUIST and P. BERING. [Price 6.50 Swedish kroner.] No. 4. *An Investigation of the Reaction* $2CaCO_3 + SiO_2$ *at High Temperatures.* By J. A. HEDVALL and B. LILJEGREN. [Price 2.50 Swedish kroner.] Acta Polytechnica, P.O. Box 5073, Stockholm 5, Sweden.

Acta Polytechnica. Electrical Engineering Series. Vol. 4, No. 5. *High Frequency Heating and Temperature Distribution in Surface Hardening of Steel.* By L. A. DREYFUS. Acta Polytechnica, P.O. Box 5073, Stockholm 5, Sweden. [Price 18 Swedish kroner.]

United States Bureau of Mines. Bulletin No. 509. *Injury Experience in Coal Mining, 1948.* By FORREST T. MOYER, G. D. JONES, and V. E. WRENN. The Superintendent of Documents, U.S. Government Printing Office, Washington, 25, D.C., U.S.A. [Price 45 cents.]

Illinois State Water Survey. Bulletin No. 41. *Proceedings of the Conference on Water Resources.* October 1, 2 and 3, 1951. Division of the State Water Survey, Urbana, Illinois, U.S.A.

Stauchen und Pressen. By DIPL.-ING. J. BILLIGMANN. Carl Hansen-Verlag, Leonhard-Ech-Strasse 7, Munich 27, Germany. [Price 25 D.M. in cardboard covers, 28.50 D.M. bound.]

The Creative Process: A Symposium. Compiled by BREWSTER GHISELIN. University of California Press, Berkeley 4, California, U.S.A. [Price 6·50 dols.]; and Cambridge University Press, 200, Euston-road, London, N.W.1. [Price 49*s.*]

A History of Civil Engineering. By HANS STRAUB. English translation by ERWIN ROCKWELL. Leonard Hill, Limited, 9, Eden-street, London, N.W.1. [Price 25*s.* net.]

National Building Studies. Research Paper No. 15. Reactions between Aggregates and Cement. Part II. Alkali-Aggregate Interaction: British Portland Cements and British Aggregates. By DR. F. E. JONES. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 1*s.* net.]

TRADE PUBLICATIONS.

Industrial Electric Furnaces.—A leaflet describing their electric bale-out type, hooded, tilting and die-casting electric furnaces has been published by Funditor Ltd., Woodbridge House, 3, Woodbridge-street, London, E.C.1. Particulars of solder and tinning baths and automatic temperature-control device are also included.

Refractory Bricks.—General Refractories Ltd., Genefax House, Sheffield, 10, have sent us a leaflet describing their G.R. "Sillmax" aluminous refractory bricks, made to withstand severe operating conditions in modern oil-firing and other installations.

Flexible Tubing.—We have received two illustrated leaflets from the Plant Engineering Co., Ltd., 90-91, Cox-street West, Birmingham, 12, one of which gives particulars of their "Planteco Preshaflex" flexible metallic tubing with asbestos thread line, and cable armouring which can be supplied with or without asbestos lining. The other leaflet deals with galvanised-steel cable armouring, chromium-plated shampoo tubes, and various accessories.

Portable Pumps.—Goodenough Contractors' Machinery, Ltd., 70-72, London-road, Twickenham, Middlesex, have issued an illustrated brochure giving particulars of their portable automatic self-priming centrifugal pumps, which are available with Diesel or petrol/paraffin engines, in capacities ranging from 4,000 gallons to 30,000 gallons per hour.

Water-Sealed Stokers.—We have received from Nu-Way Heating Plants, Ltd., Vines-lane, Droitwich, an illustrated catalogue describing their three types of water-sealed furnace stokers.