

HEAVY-DUTY MECHANICAL FORGING PRESSES.

B. AND S. MASSEY, LIMITED, MANCHESTER.

(For Description, see Page 97.)

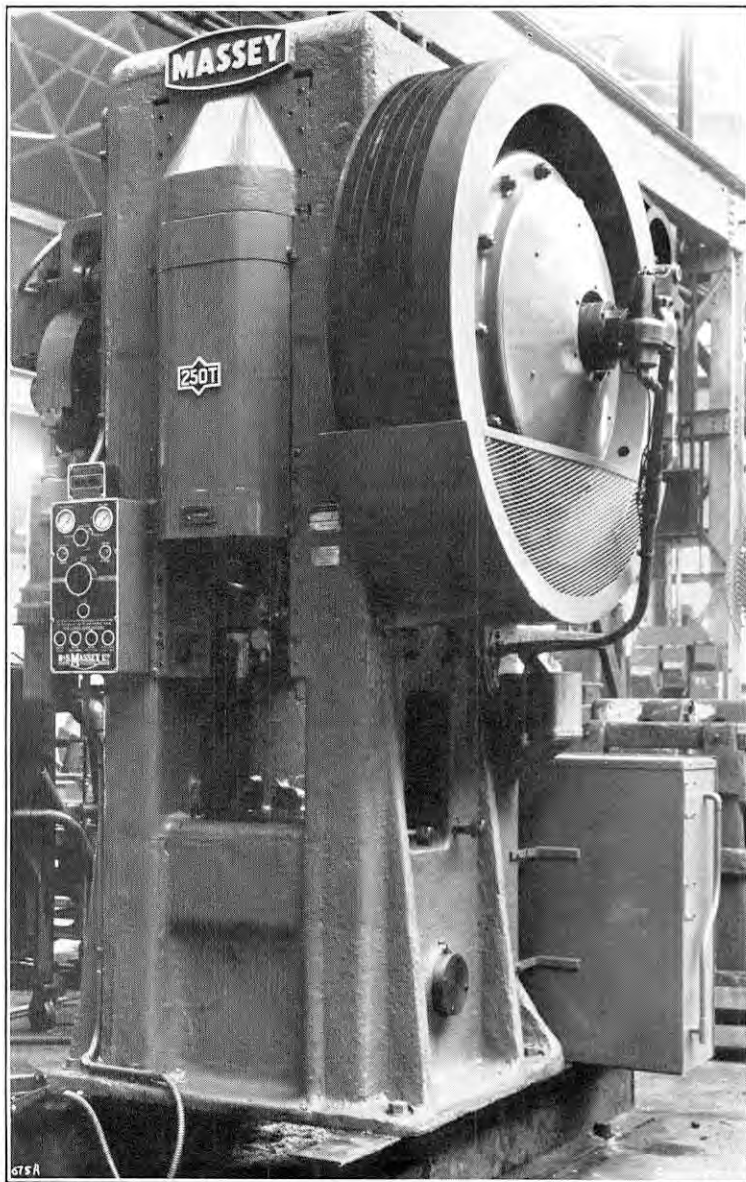


FIG. 1. 250-TON HIGH-SPEED FORGING PRESS.

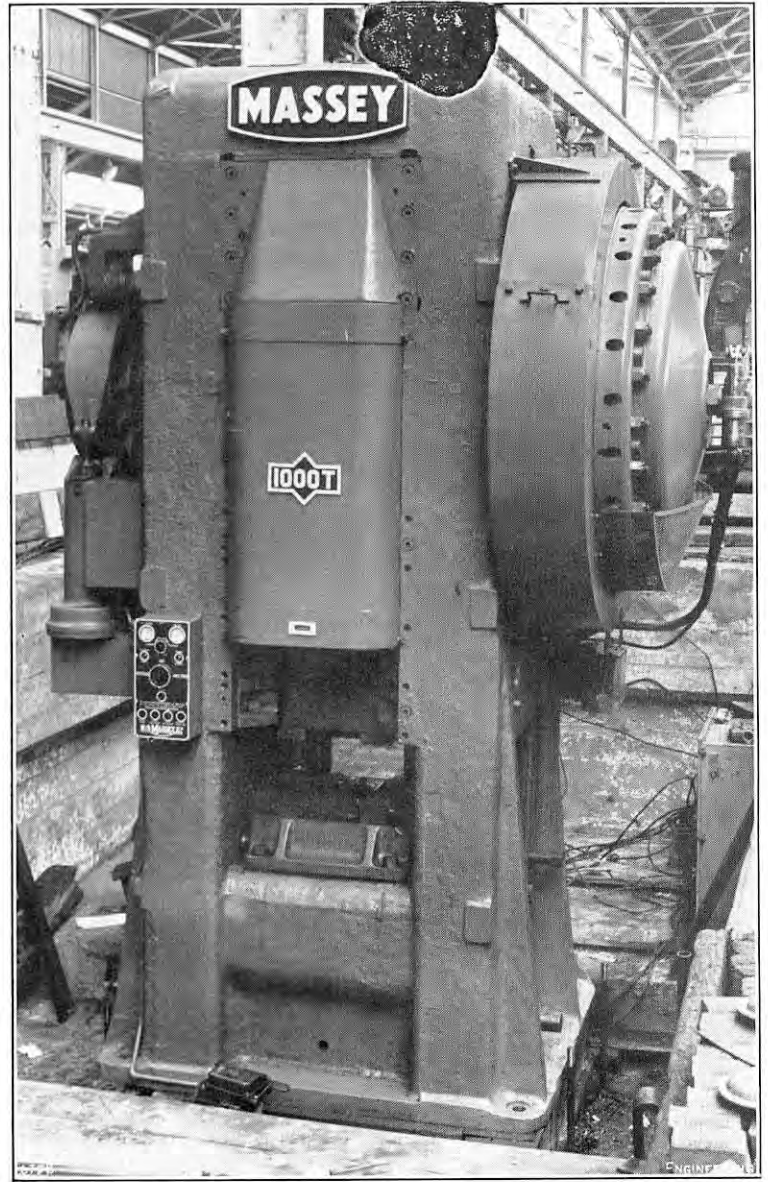


FIG. 2. 1,000-TON FORGING PRESS.

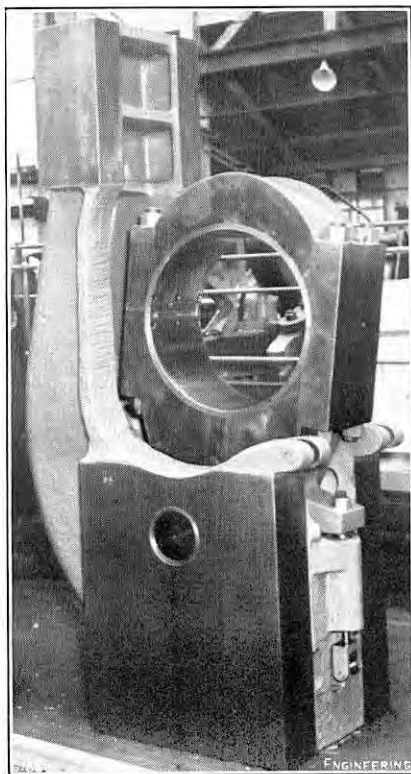


FIG. 3. RAM AND PITMAN ASSEMBLY FOR 1,000-TON PRESS.



FIG. 4. TOP AND BOTTOM SLIDES FOR 1,000-TON PRESS

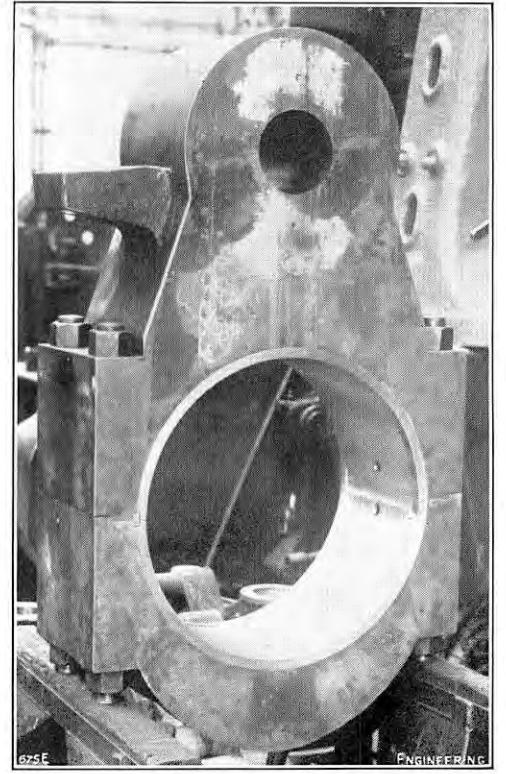


FIG. 5. PITMAN FOR 1,000-TON PRESS.

HEAVY-DUTY MECHANICAL FORGING PRESSES.

It is generally conceded that, for certain classes of die-forging work, there is much to be gained by the use of forging presses in place of the more usual drop hammers, provided the heating facilities and the working and handling conditions enable full advantage to be taken of their higher outputs. Until recent times, such presses have not been manufactured in this country, their development having been left mainly to Germany and America. This state of affairs, however, has now largely been rectified as, since the end of the second World War Messrs. B. and S. Massey, Limited, Openshaw, Manchester, have developed an extensive range of

being sufficiently high to ensure an ample store of energy.

Two typical presses are illustrated in Figs. 1 and 2, on Plate V, Fig. 1 showing a 250-ton machine and Fig. 2 a 1,000-ton machine. Possibly the most outstanding feature of their design is the employment of a cast-steel frame instead of the more usual tie-bolt form of construction. The manufacturers have adopted this method as they claim that, weight for weight, the solid steel frame is stronger and less resilient, the effective part of the solid frame subjected to loading being larger in area but shorter than that of the bolted frame. Furthermore, in bolted designs, the tie bolts contribute little resistance to distortion, other than in the longitudinal direction, whereas in a solid frame the metal taking the place of the tie bolts adds con-

established practice and although the following description applies more specifically to the 1,000-ton machine illustrated in Fig. 2, with certain exceptions it applies equally well to the whole range. The ram is a heavily-ribbed steel casting provided with extensive guiding surfaces. A photograph of this unit is reproduced in Fig. 3, on Plate V, where it is shown with the pitman arm in position. It will be noted that an arm, integral with the ram, extends in the vertical direction, the upper end of which has further guiding surfaces. These work in conjunction with slides installed in the crown of the main frame and it will be appreciated that the provision of both top and bottom guides ensures accurate location of the ram, and prevents "tilting," an important feature when both pre-forming and finishing dies are employed, off-centre work being inevitable in such cases. The slides, which are made from phosphor bronze, extend the full length of travel of the ram and as will be seen from the photograph reproduced in Fig. 4, on Plate V, are liberally provided with oil-distribution channels. The front slides are supported by steel castings bolted into machined recesses in the front of the columns and the rear main slides by substantial abutments cast integrally with the rear of the columns, the latter form of construction being employed to counteract the heavy thrusts set up due to the obliquity of the pitman arm. The ram is counterbalanced by a pneumatic cylinder located at the rear of the frame and, if required, it can be arranged for water cooling.

Like the ram, the pitman arm is a steel casting, the outer surface of the lower end being bedded into a seating formed in the ram. The seating is fitted with a phosphor-bronze liner and the gudgeon pin runs in bearings of the same material. Phosphor-bronze liners are also fitted at each side of the lower end of the pitman to ensure free movement between the ram and pitman. The upper, or big, end of the pitman arm is provided with a phosphor-bronze bearing made in halves to facilitate installation and dismantling and fitted with a key at one of the abutment faces to prevent rotation. The general design of the pitman arm and the big-end bearing will be clear from Fig. 5, on Plate V, which shows the unit with the bearing assembled. The eccentric shaft, a photograph of which is reproduced in Fig. 7, on page 98, is machined from a manganese-molybdenum steel forging, the main bearings being designed so that they support the shaft for almost its full length, coming as close as practicable to each side of the eccentric. This form of construction will be clear from Fig. 4, which shows a machine partly assembled with the eccentric shaft in position. The shaft rotates in split phosphor-bronze bearings, the upper halves of which are fitted directly into the frame and the lower halves into steel housings supported by steel wedges. As in the case of the big-end bearing for the pitman arm, long steel keys are fitted at the abutment faces to prevent rotation of the bearings in their housings.

The clutch, which is mounted on the eccentric shaft, is of the multiple-plate type and is designed for operation and cooling by air. A flywheel and clutch assembly for a high speed machine is illustrated in Fig. 8, on page 98, and a typical geared installation in Fig. 9, on the same page. To reduce losses, the inertia of those parts to be set in motion and stopped at each stroke, namely, the driven plates and splined hub on which they operate, has been kept as low as possible. The heavier clutch components such as the air cylinder and piston, splined housing and outer plates, rotate with the flywheel, or, in the case of a gear-driven machine, with the gear ring, thereby adding to the kinetic energy. All clutch plates are made from manganese steel and the driven plates are faced with friction material in the normal manner. As previously mentioned, the clutch is air operated, air being admitted under pressure to a cylinder fitted with a piston which acts against strong springs. When the air is exhausted from the clutch cylinder, these springs move the piston, together with the end plate and outer, or driven, clutch plates, against cone-shaped seatings formed in the inner periphery of the housing, thereby preventing "chatter" and increasing the life of the splines. To facilitate maintenance, the plungers associated with the return

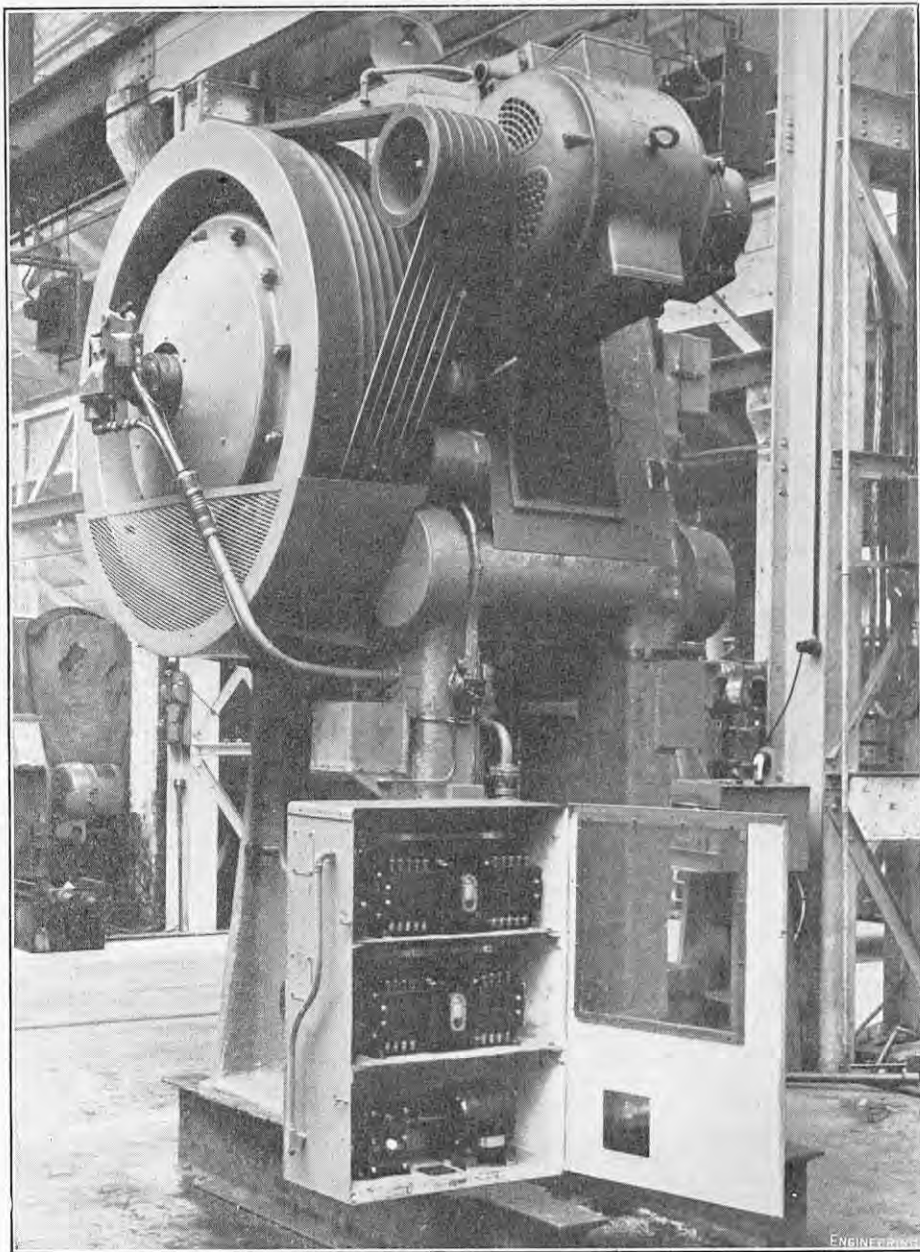


FIG. 6. REAR VIEW OF 250-TON PRESS.

forging presses. Both high-speed and slow-speed machines are included in the range, the former being used when it is required to keep the dwell period as short as possible and thus minimise the chilling effect on the forgings, and the latter where extrusion is involved in the forging process; in such cases, high speeds of operation lead to excessive rates of flow of the material and cause serious abrasion of the die surfaces. The high-speed presses are designated type H and the slow-speed presses type L, the former being made in sizes ranging from 250 tons to 3,000 tons and the latter in sizes ranging from 250 tons to 1,000 tons. Up to, and including, the 1,000-ton size, type H presses are not geared but all other presses are gear-driven. In all cases, however, the flywheel is mounted through roller bearings directly on the eccentric shaft, the speed

siderably to the structural rigidity. The frame castings are stress-relieved and, to give extra resistance to distortion, the sides are extended towards the back of the machine. These extensions are of box section and are fitted with covers to enable the chambers so formed to be used as air receivers. Tapped holes are provided in the bed for securing the lower bolster assembly in position. The bolster is supported by a heavy steel wedge in the normal manner, the angle of which is such that, in addition to providing a ready means of adjustment for the die, it also acts as a safety release in the event of jamming. To enable easy and accurate setting to be made to the die space, the machine is equipped with a micrometer-type indicator.

In general, the design of the presses follows

springs are arranged so that they are flush with the ends of the spring covers when the clutch plates are new and in the engaged position, the subsequent wear of the friction surfaces being assessed at any time by admitting air to the clutch when the machine is not in use and measuring the projection of the plungers beyond the spring covers. To give a constant torque, the air used for operating the clutch is maintained by means of a regulating valve at a steady value of 70 lb. per square inch; this arrangement has the added advantage of protecting the press against damage caused by overloads as the torque transmitted by the clutch is a function of the air pressure. A diaphragm type of air seal is incorporated in the clutch to prevent leakage from the piston assembly, thus permitting air-line lubrication of the working parts to be employed without the danger of oil reaching the friction facings of the driving and driven clutch plates. Internal fins and passages are incorporated in the clutch so that, when it is rotating, a considerable quantity of cooling air is drawn past the friction plates, etc., the air being admitted through an annular space in the cowl and escaping from the periphery of the clutch.

A hand-type main brake is employed; this is applied by a powerful spring and released by a compressed-air cylinder-and-piston assembly, a time-lag mechanism ensuring that the clutch is released before brake application. To obtain maximum clearance between the top and bottom dies when the machine is at rest, the controlling gear is designed to arrest the ram at top dead centre, a device being incorporated whereby adjustments to compensate for over or under running can be effected merely by turning a knob on the control panel. The brake drum is keyed and bolted to the end of the eccentric shaft and is provided with a number of radial fins to promote cooling; it is shown in position on the end of the shaft in Fig. 7. To prevent coasting of the flywheel when the power is shut down, an auxiliary brake controlled by an independent push-button is provided. This comprises a brake shoe arranged to make contact with the rim of the flywheel and operated by an air-cylinder unit, an interlock being installed in such a manner that the starter is automatically tripped when the brake is applied.

Lubrication of the major working parts is effected by mechanical sight-feed lubricators driven by an independent electric motor, those parts not requiring frequent lubrication being provided with grease nipples. A photograph showing the sight-feed lubricators for a 250-ton machine is reproduced in Fig. 6, on page 97, from which it will be seen that there are two separate units arranged one above the other with the driving motor below, the whole being contained in a steel cabinet. Electrical interlocks ensure that the lubrication system is started before the press is set in motion; conversely, the machine is halted automatically should the motor driving the lubricators stop for any reason. The oil feeds to the three main bearings are duplicated, additional sight-feed lubricators being mounted adjacent to the control panel in a position where they are constantly under the observation of the operator.

The machine is controlled from a panel containing a main isolating switch and a number of subsidiary switches, warning lights, etc. In addition to acting as an isolator, the switch provides three alternative methods of operation, namely, continuous, single-stroke and inching. Continuous and single-stroke operation are obtained by using a foot-operated switch and inching by separate forward and reverse inching buttons. In the continuous position, the press runs as long as the foot switch is depressed, the ram automatically coming to rest at the top of its stroke when the switch is released. It is possible to fit another control mechanism which enables a predetermined number of continuous strokes to be obtained each time the foot switch is depressed; a useful feature in cases where forgings require pre-forming or "rolling." Other items installed on the panel include: two air-pressure gauges which indicate the pressure in the air receivers and supply line respectively; two indicator lamps, one of which shows whether current is available at the automatic starter and the other when the driving motor has reached operating speed; a control

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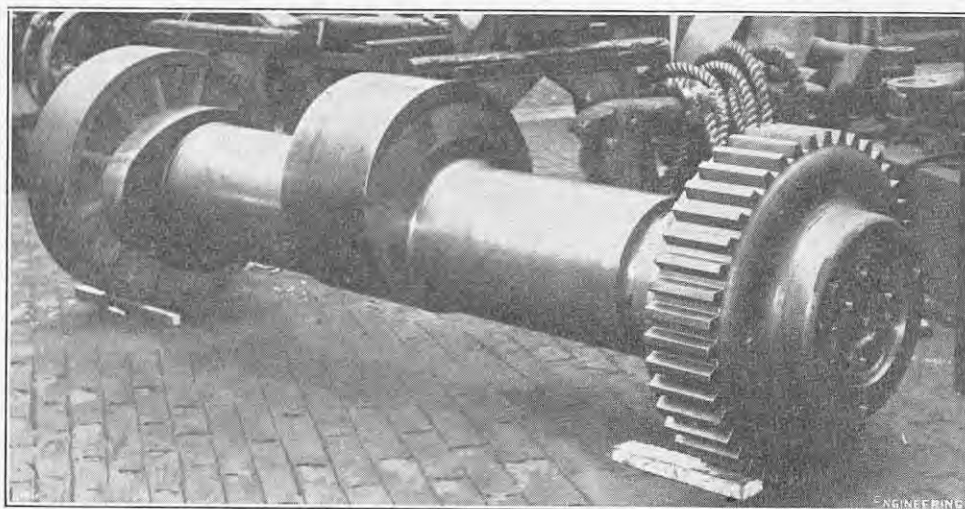


FIG. 7. ECCENTRIC SHAFT FOR 1,000-TON PRESS.



FIG. 8. FLYWHEEL AND CLUTCH ASSEMBLY FOR 1,000-TON HIGH-SPEED PRESS.

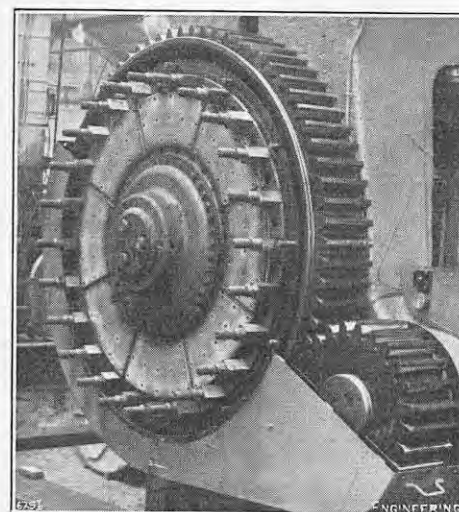


FIG. 9. CLUTCH FOR GEAR-DRIVEN MACHINE WITH OUTER PLATE REMOVED.

knob for correcting over-run or under-run of the eccentric at top dead centre, reference to which has already been made; the push-buttons for starting and stopping the main driving motor; and a push-button for applying the flywheel brake.

As previously mentioned, the presses are driven by multiple V-ropes either directly or through plain spur gearing. The driving motors are of the screen-protected wound-rotor slip-ring type with external slip resistance arranged to give a high degree of slip, and the starter is of the automatic stator and rotor type. Accessories provided with each machine include top and bottom ejectors and a stroke counter. The top and bottom ejectors are of the mechanical type, arranged so that ejection occurs at the earliest possible moment, but provision is made for the addition of air-operated ejection equipment for use when delayed or long-stroke ejection is required.

UNDERWATER TELEVISION.—Marconi's Wireless Telegraph Co. Ltd., Chelmsford, have been investigating the possibilities of underwater television, especially for purposes for which it would be dangerous to employ a diver. Such applications include the study of wrecks and the examination of the sea bed, as well as engineering operations like the inspection of dock gates and of ships below the water line. A television camera can be used at depths exceeding 1,000 ft. and enables the underwater conditions to be viewed by experts on the surface and, if necessary, photographed. For this work no modification in the Image Orthicon camera is necessary, although remote control and indicating devices, and sometimes a lighting system, have to be added. For the majority of cases the camera can work for far longer periods than a diver and to greater accuracy.

LITERATURE.

Theory of the Interior Ballistics of Guns.

By J. CORNER, M.A., Ph.D. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 8 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 64s. net.]

Internal Ballistics.

Published for the Ministry of Supply by H.M. Stationery Office, Kingsway, London, W.C.2. [Price 25s. net.]

"I, who was above at the battery . . . began to deliberate how I might lay him flat. I took my swivel . . . turned it round, and charging it with a good quantity of fine and coarse powder mixed . . . because it could not be expected that such a piece should carry so far—I fired—and hit the man exactly in the middle." Benvenuto Cellini, in 1527, knew the value of a high loading density. During the next 300 years, comparatively little was added to knowledge of "what happens in the gun and why," though the steady progress made in the parallel field of external ballistics is evident from the reports of the extensive and well-conducted field trials of the Ordnance Commission of Metz in 1840, the culmination of the primitive phase of development. During the past hundred years the tempo of progress has been of an entirely different order. The leisurely jog-trot of the five centuries which followed the first effective use of ordnance at the battle of Crécy has been replaced by express speed. The chemist, the metallurgist, the physicist, and the mathematician have provided

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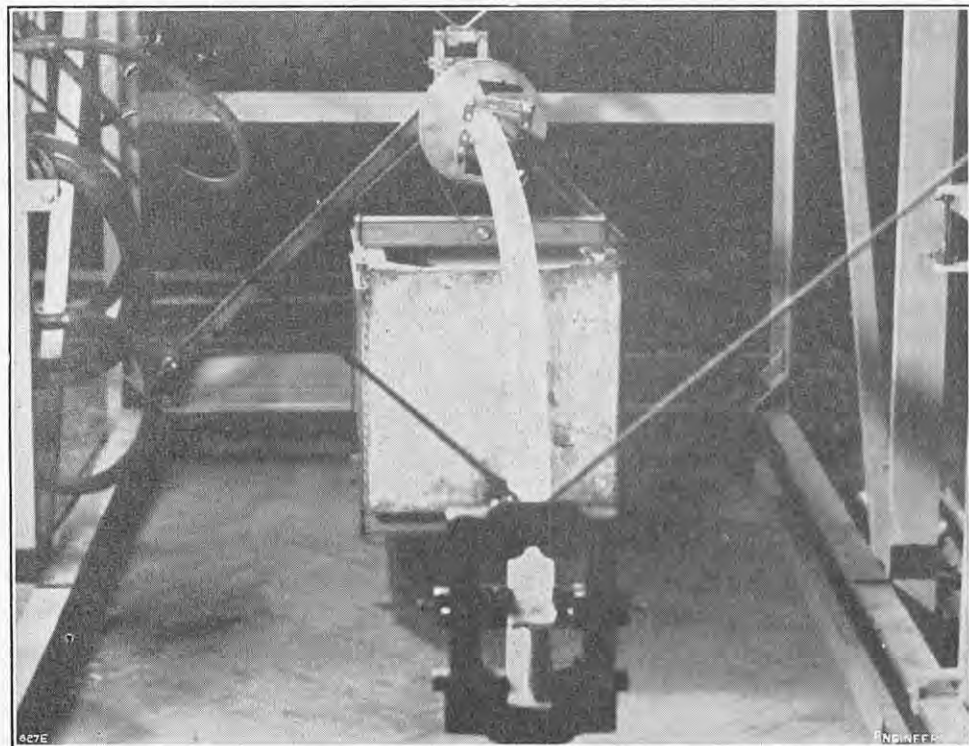
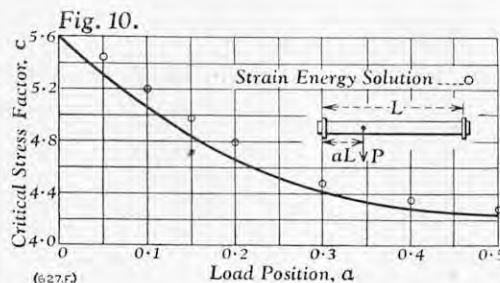


FIG. 9. BEAM FAILED FROM LATERAL INSTABILITY.

the ballisticians and the armament engineer with the means, in big guns, of "projecting a shell the weight of a motor car from London to St. Albans," and in automatic weapons of delivering muzzle energy with an efficiency, in terms of horse-power for equipment weight, far higher than that of the internal-combustion aircraft engine. Such results have been made possible by the discovery of nitrocellulose propellants, improved gun steels, scientific instruments applied to experimental observation, and more advanced analytical methods.

The two volumes under notice both aim to give an up-to-date fully-documented account of modern theory and "know-how," with special emphasis on the more recent developments, which the author of the one and the contributors of the other are uncommonly well qualified to present, by reason of their own outstanding contributions to this highly specialised science. *Internal Ballistics*, an official publication, introduced by Sir John Lennard-Jones, F.R.S., chairman of the Scientific Advisory Council, Ministry of Supply, has been prepared by an editorial panel of four—Colonel F. R. W. Hunt, Brigadier G. H. Hinds, Dr. C. A. Clemmow and Professor C. J. Tranter—each of whom has made his own contribution. One of eleven other contributors is Dr. Corner, whose own book, with the American title *Interior Ballistics* and internal evidence of transatlantic publication, has appeared contemporaneously. If there are any hairs to be split, Dr. Corner's book has the priority by a few months. Apart from the publishers' dates, this fact is made plain by the author's statement that, though his text had been passed by the Ministry of Supply, the restrictions on publication had indirectly influenced his treatment, in that, while he had been able to refer to the recent work of his colleagues in the Ministry, he could not include detailed references. Dr. Corner's book, *Internal Ballistics*, contains all these references in full. This, however, is a small point to set against the fact that so much hitherto highly-classified material has been released for open publication. Security, it may be surmised, can be invoked either as the veil of information or the cloak of ignorance, and these two volumes will dispose of any possible suspicion that the British armament industry has been fed on the crumbs let fall from foreigners' tables. The Ministry of Supply, as these books show, has been able to carry out in its research establishments, and to sponsor, original work of the highest quality on projects which were vital ten years ago. This fact



should give confidence in the ability of the Ministry to cope efficiently with current research problems still on the secret list.

The question may be asked why two separate publications of about the same length and covering much the same ground should be necessary; but the answer is that they are complementary rather than competitive. There is always merit in a monograph, if it be well executed—as Dr. Corner's book most certainly is; it presents an extensive field of knowledge through the mind of a single author. At the same time, the volume which collects the work of a dozen authors, each a specialist in his own narrower compass, may give the more intense illumination. The reader's expectation that the free-lance author will be less inhibited by terms of reference than the official contributors is not disappointed. Dr. Corner, who displays a broad philosophy as well as a pleasing lightness of touch, freely admits that "most of the theoretical work is directly inspired by experimental results . . . at the same time experiment is often held back until a theoretical examination has been made; this respect for theory is due in part, it must be admitted, to the high cost of experiments in this subject." Again, introducing a mathematical discussion of the perennial problem of quality versus quantity, he remarks that "In war time there is a constant urge to speed production by relaxing tolerances. This results in a larger number of [mortar] bombs which, unfortunately, have a bigger dispersion at the target. The net result may or may not be an improvement."

Summing up very briefly, *Interior Ballistics*, with its unity of conception and continuity of treatment and style, may well make a stronger appeal to the layman and to the scientist with related but not identical problems, and *Internal Ballistics* to those concerned with more detailed applications.

THE LATERAL STABILITY OF UNRESTRAINED BEAMS.

By A. R. FLINT, B.Sc., Ph.D.

(Concluded from page 67.)

Unsymmetrical Point Loading.—Further increases in the permissible stress may be allowed in cases where a single point load is applied at some non-central point along the span. Under these conditions, a member may become laterally unstable and fail in the manner shown in Fig. 9, herewith, which illustrates a 3-in. by 1½-in. I beam under point load at a distance 0.175L from a support. The buckled mode is unsymmetrical and the maximum displacements occur between the load point and mid-span. Theoretical solutions to this problem have been derived which include the influence of warping and vertical eccentricity of loading, using both analytical and strain-energy methods. It is again apparent that the stress at which buckling occurs may be determined from the formula

$$F_c = \frac{c}{Z_2 L} \sqrt{\frac{E I_1 G J}{\gamma}} \quad (6)$$

where c is the critical stress factor, governed by load position.

The increase in magnitude of the stress factor for loads applied at a distance aL from a support is indicated in Fig. 10, herewith, from which it is seen that appreciable increases in the critical stress, and considerable increases in buckling load, may be expected as the load point approaches one support. The strain-energy solution is seen to give slightly higher results in all cases owing to error in the assumed form.

It has been found from the results of strain-energy analysis that the influence of warping on buckling loads is practically independent of the load position. In consequence, it may be safely assumed that the modification given by equation (3) may be applied to unsymmetrical loading conditions and we may again put

$$F'_c = F_c \sqrt{1 + \frac{\pi^2 C}{G J L^2}}$$

where F'_c is the true critical stress for a "stocky" member and F_c is given by equation (6). This will yield an estimate of the safe stress which will be slightly in error on the safe side.

Where the point load is applied above or below the shear centre, we may again expect the critical load to be modified. The analytical approach to the problem yields a relationship between the vertical eccentricity ratio, η , and the ratio, n , of the critical load to that for zero-eccentricity, for any point of loading on the span. As examples of the effect of this eccentricity, curves are drawn in Fig. 11, on page 100, illustrating these relationships for several points of load application, distant aL from a support. It may be seen from these that loads near mid-span are more sensitive to eccentricity than those applied towards the support. The reduction in critical load should, however, always be estimated where beams are loaded at the top flange or at any other point above the shear centre. Taking a typical range of values of η to lie between 0.1 and -0.1, we may again assume a linear relation to exist between the eccentricity and the critical load

$$n = 1 - m\eta$$

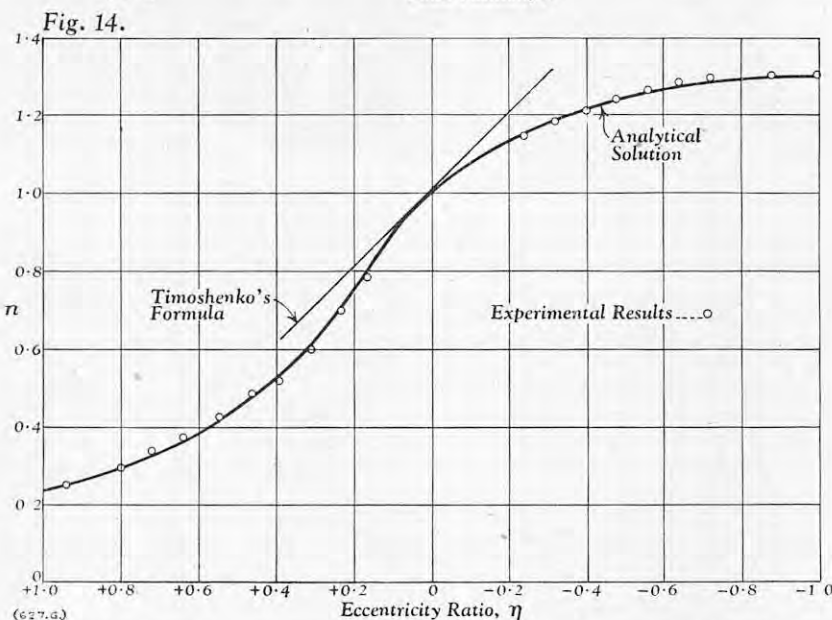
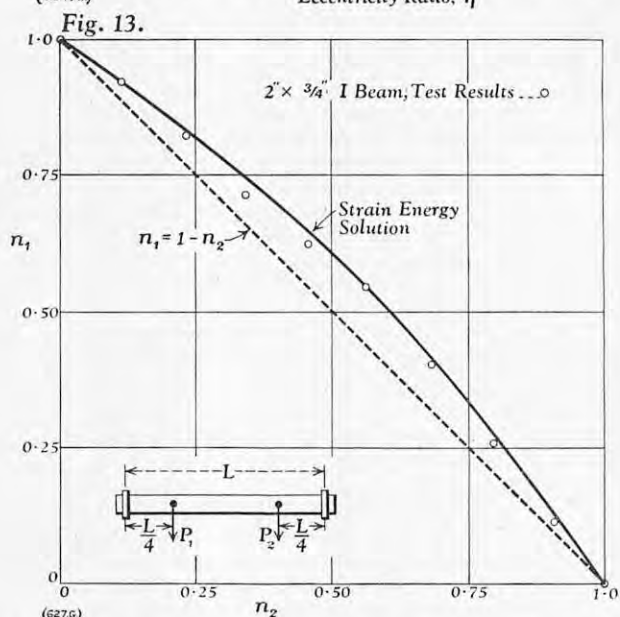
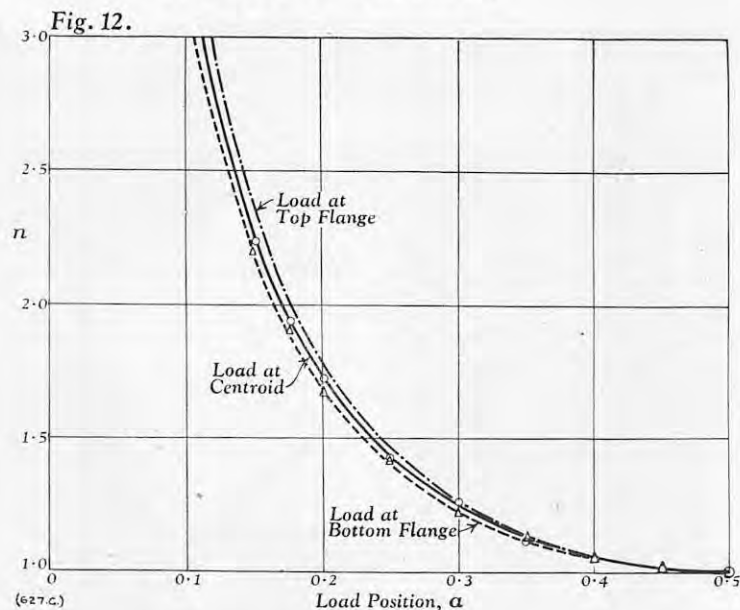
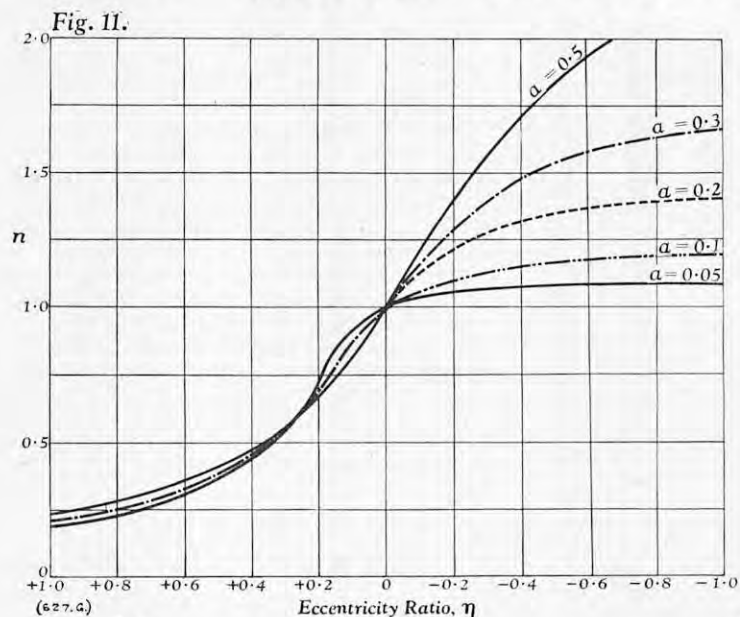
in which the constant, m , depends upon the load position, a . Typical values of this constant are given in Table I, being simply the slopes of the curves shown in Fig. 11, page 100, at the point $\eta = 0$.

TABLE I.

a	0.5	0.4	0.3	0.2	0.1	0.05
m	1.73	1.68	1.61	1.50	0.95	0.53

Tests on both model and light-alloy beams have shown good agreement with the above-mentioned solutions. A number of different beams have been tested to instability under single unsymmetrical point loads with various vertical positions of application. For example, the results of tests on a 3 in. by 1½ in. light-alloy I-beam are shown in Fig. 12, page 100. The observed critical load ratios agreed

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well with theory for two vertical positions of loading, but they were a little low when the load was applied to the top flange, the experimental points coinciding with those for load at the centroid. The range of values of a was limited by the width of the loading tank, which fouled the supports beyond a certain position. Further tests, carried out on channel, T and angle sections, showed similar agreement.

Two Unsymmetrical Loads on Span.—The theoretical solutions to problems of two unsymmetrical point loads, applied on the shear centre axis, cannot be generalised. A simple empirical formula may, however, be derived from consideration of specific cases. Taking, for example, the case of unequal loads P_1 and P_2 applied at the quarter points (Fig. 13, on this page), it has been found that buckling occurs when the ratios of each load to its critical value, were the other zero, n , are related by the curve shown. Thus, when P_1 reaches a load equal to about 0.6 times the critical load for single-point load at that position, a load P_2 , equal to half its independent critical value is required to cause instability ($n_2 = 0.5$). As an approximation, the straight-line relationship $n_1 = 1 - n_2$ may be used for all cases of such unsymmetrical loading. The independent critical loads may be derived from Fig. 10 and the possible combinations of applied loads may be studied.

Tests carried out on a model I beam have verified the safety of this approach, and the results are seen to lie close to the strain-energy solution in Fig. 13. Further tests carried out with one load at mid-span and one at a quarter point have likewise corroborated this approximate solution. The behaviour of a beam under two equal and sym-

metrically placed loads has been illustrated elsewhere.*

Lateral Stability of Cantilevers.—Cantilevers of deep section may become laterally unstable under applied loads in the same manner as previously described for simply supported beams. Owing to the considerable restraints frequently afforded by connecting members, the probability of the occurrence of such failure is small and the problem is one of primarily academic interest. The critical value of a point load applied to the free end of a cantilever may be written as†

$$P_{crit.} = \frac{4}{L^2} \sqrt{\frac{E I_1 G J}{\gamma}} - 0.3 w L, \quad (7)$$

and the corresponding critical stress is

$$F_c = \frac{4}{Z_2 L} \sqrt{\frac{E I_1 G J}{\gamma}} - 0.15 w, \quad (8)$$

where w is the deadweight of the member per unit length.

Vertical eccentricity of application of loads will again influence buckling values, and the relationship between the eccentricity ratio and critical load ratio n is plotted in Fig. 14, herewith. It is seen that considerable reduction in load-carrying capacity is obtained with quite small eccentricities of loading. When load is applied below the shear centre, only a small increase in buckling load is

obtained and, for large eccentricities, the second mode of failure occurs at a load 35 per cent. greater than the fundamental critical load. In this mode, no rotation will occur at the free end. The approximate equation suggested by Timoshenko, $n = 1 - \eta$, is seen to be applicable over a range of values of η between 0.1 and -0.1.

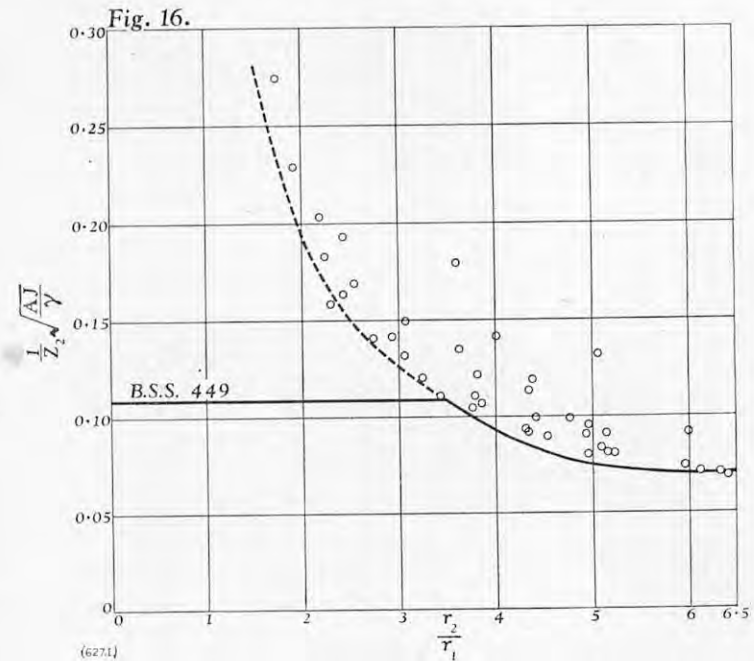
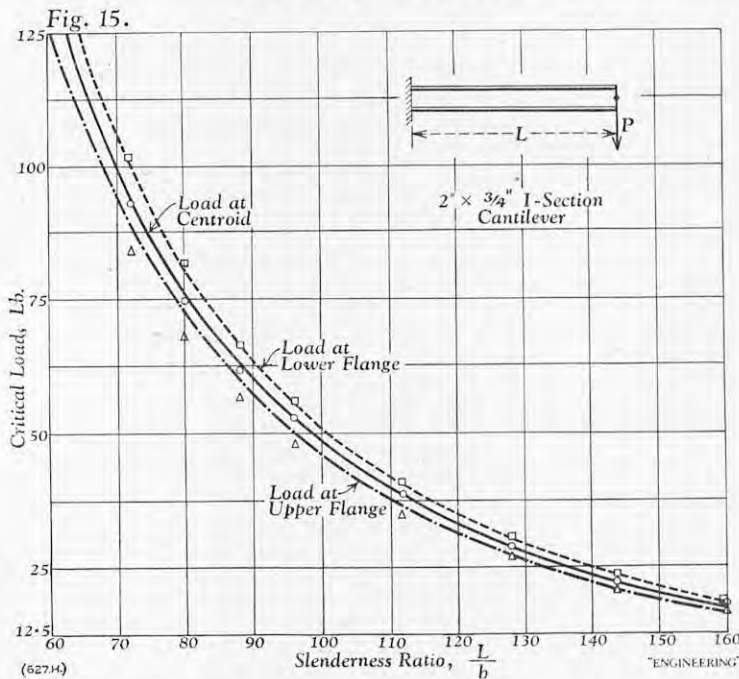
A 2 in. by 3/4 in. I section cantilever was tested under point load over a range of lengths and the experimental results are compared in Fig. 15, opposite, with curves computed from the constants of the member. The theoretical results include the influence of the deadweight of the cantilever on its buckling load. Good agreement was evident between observed and estimated values for all three positions of loading. Tests carried out on two narrow rectangular cantilevers loaded by the system shown in Fig. 7, page 67, ante, verified the effect of eccentricity of loading and the results have been plotted in Fig. 14.

Design Data.—The stresses permissible in the design of structural beams are governed by either the strength of the material or the stability of the members under bending loads. Recently revised Codes of Practice have specified safe stresses which are inversely proportional to the slenderness of the members. These expressions simply represent the critical stresses, divided by a safety factor, for slender beams under uniform bending moment and having ideal conditions of loading and support. Though a considerable improvement on the previous design formulae, and the first attempt to apply theoretical solutions to the problem, these specifications are still extremely conservative in many instances. It is not often that a beam is subjected to uniform

* "The Influence of Restraints on the Stability of Beams," by A. R. Flint. *Jl. Inst. Struct. Engrs.*, vol. 29, No. 9 (1951).

† "The Buckling of Deep Beams," by J. Prescott. *Phil. Mag.*, vol. 36, page 297, and vol. 39, page 195 (1929).

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bending moment without the introduction of end restraints, and the case considered as a design basis is indeed a stringent one. The additional load-carrying capacity of members under non-uniform bending moment should be estimated in border-line cases, and allowance should be made for the increased stiffness due to restraint of warping. The reduction in the working stress when loads are applied at the top flange, suggested primarily for light-alloy beams, should be put on a more rational basis and would, in consequence, be generally less severe.

The modifications to the basic beam formula proposed in B.S. Code of Practice No. 113 on "The Structural Use of Steel in Buildings," necessary for improved design, may be reduced to extremely simple forms. A study of the properties and stability of the most common beam elements has led to a number of semi-empirical relations, based on the foregoing solutions, which may be easily applied. It is assumed that the members are initially perfectly straight and free from twist along their lengths, but, where imperfections or eccentricities of loading are likely to arise, it is necessary to reduce the suggested stresses to allow for the lateral bending which would occur at loads less than the critical values.

Rolled-Steel Joists.—The working stresses specified for rolled-steel joists in B.S.C.P. 113 are limited by a value of

$$F_{bc} = \frac{920 r_1}{L} \times K_1 \text{ tons per sq. in.} \quad (9)$$

where r_1 is the least radius of gyration of the beam section, and K_1 is a factor to be taken as unity except for sections having a ratio $\frac{r_2}{r_1}$ less than 5, r_2 being the maximum radius of gyration. Values of K_1 are tabulated for ratios down to 3.5, below which $K_1 = 1.50$. This stress represents one half of the critical stress for a slender beam under uniform bending moment, and is based upon St. Venant's approximation to the torsion constant for a section.* This approximation invariably provides a low estimate of the constant and, in consequence, the basic buckling stress derived from equation (9) is often in error on the low side.

An analysis of the properties of joists has been made, using the table of torsion constants derived by Cassie and Dobie,† in which the relation between the critical stress and slenderness ratio has been

observed. Taking the critical stress to be

$$F_c = \frac{c}{Z_2 L} \sqrt{\frac{E I_1 G J}{\gamma}} \quad (6a)$$

and putting $E = 2.5G = 13,000$ tons per square inch for mild steel, then

$$F_c = 8220 \left(\frac{r_1}{L} \right) \frac{c}{Z_2} \sqrt{\frac{A J}{\gamma}}, \text{ tons per sq. in.,} \quad (10)$$

and the design stress $F_{bc} = \frac{F_c}{2}$.

The parameter $\frac{1}{Z_2} \sqrt{\frac{A J}{\gamma}}$ has been determined for all sections and its values are shown in Fig. 16, herewith, plotted to a base of the ratio $\frac{r_2}{r_1}$, which represents the "stockiness" of a section, and the design curve corresponding to the Standard Specification is shown for comparison. Though representing a lower limit for values of $\frac{r_2}{r_1}$ greater than 3.5, these specifications are seen to underestimate seriously the stability of all the stockier sections, and over the whole range of sections there are many beams in which the load-carrying capacity would be greater than that predicted from these data. By the inclusion in section tables of values of the torsion constant, J , recourse to such a restricted empirical formula would no longer be necessary, and designers would be able to use equation (10) directly to calculate their safe loads. As an alternative, safe-load tables should be based on this equation rather than on an empirical curve which so unjustly reduces the permissible stresses in beams of certain sections.

It is evident that the table of bending-stress factors given in B.S.C.P. 113 should be extended to give further increases in permissible stress when the ratio, $\frac{r_2}{r_1}$, is less than 3.5 if this formula is to conform more nearly with theory. By using the dotted curve shown in Fig. 16, the factors, K_1 , given in Table II have been obtained, which may be used in equation (9) for the stockier sections. The value of the critical stress factor, c , to be used in equation (10) depends upon the type and position of loading and values of the factor are given in Table III for certain special cases. Values of the factor for unsymmetrical point loads are shown in Fig. 10, on page 99.

Equation (9) may be modified to allow for different types of loading by using the expression

$$F_{bc} = 920 \frac{r_1}{L} \frac{c}{\pi} \times K_1 \text{ tons per sq. in.,}$$

or the critical stress may be more accurately computed from equation (10).

The influence of the restraint of warping, which occurs in all structural beams, may be estimated from equation (3). The modified permissible stress may be written as

$$F'_{bc} = F_{bc} \sqrt{1 + \frac{\alpha \pi^2 C}{G J L^2}}$$

Now

$$\frac{C}{G J L^2} = \frac{E I_F h^2}{2 G J L^2} = \frac{5}{8} \left(\frac{r_1}{L} \right)^2 \frac{A h^2}{J}$$

Values of the parameter $\frac{A h^2}{J}$ have been evaluated for all the standard rolled-steel joists and it has

TABLE II.—Bending Stress Factors for Rolled-Steel Joists.

$\frac{r_2}{r_1}$	K_1
3.5	1.50
3.0	1.75
2.5	2.10
2.0	2.80
1.5	4.00

TABLE III.

Type of Loading.	Critical Stress Factor c .
Uniform bending moment	π
Point load at mid-span	4.23
Symmetrical point loads at one-third points	3.45
Symmetrical point loads at quarter points	3.26
Uniformly distributed load	3.54
Point load on cantilever	4.01
Uniformly loaded cantilever	6.43

been found that the lower limit of these values may be represented by

$$\frac{A h^2}{J} = 40 \left(\frac{r_2}{r_1} \right)^2.$$

Thus we may write

$$F'_{bc} = F_{bc} \sqrt{1 + 250 \alpha \left(\frac{r_2}{L} \right)^2} \quad (11)$$

$$= F_{bc} \left[1 + 125 \alpha \left(\frac{r_2}{L} \right)^2 \right], \quad (12)$$

where $\alpha = 1$ for beams supported with no end restraints, but prevented from twisting at the supports, and $\alpha = 2$ for beams with warping restrained at the ends. Allowance should also be made for the influence of any vertical eccentricity of loading. It has been shown above that the expression for critical stress may be modified by multiplying by a factor, $n = 1 - m\eta$, the values of the constant m being given in Table I, page 99, for different load positions.

* "A Commentary on the Draft Code of Practice for the Structural Use of Steel in Buildings," by J. Mason. *Jl. Inst. Struct. Engrs.*, vol. 24, No. 5, page 245 (1946).

† "The Torsional Stiffness of Structural Sections," by W. Fisher Cassie and W. B. Dobie. *Jl. Inst. Struct. Engrs.*, vol. 26, No. 3, page 154 (1948).

Now $\eta = \frac{d}{L} \sqrt{\frac{E I_1}{G J \gamma}} = \sqrt{\frac{r_1}{L}} \frac{h}{2} \sqrt{\frac{A}{J \gamma}}$ when load is applied to the top flange. It has been found that, for all joists, the parameter $\frac{h}{2} \sqrt{\frac{A}{J \gamma}}$ may be approximately represented by

$$\frac{h}{2} \sqrt{\frac{A}{J \gamma}} = 3.85 \left(\frac{r_2}{r_1} \right)$$

Hence $\eta \approx 6 \left(\frac{r_2}{L} \right)$ and we may put

$$F'_{bc} = F'_{bc} \left(1 - 6m \left(\frac{r_2}{L} \right) \right) \text{ when load is applied}$$

to the top flange, the sign inside the bracket being reversed when load is attached to the lower flange. This expression is only strictly accurate when $\frac{r_2}{L}$ is less than 0.2, the curves shown in Fig. 11 giving a more accurate estimate for higher values. The greatest reduction in working stress occurs under point load at mid-span when $m = 1.73$, and a general expression for the working stress might be safely written as

$$F'_{bc} = F'_{bc} \left(1 - 10 \frac{r_2}{L} \right) \quad (13)$$

Compound Girders.—In the case of compound girders, it has been found that no simple relation exists between the factor K_1 in equation (9) and the ratio $\frac{r_2}{r_1}$. Though the Standard Specifications permit increases in stress for stocky compounds similar to those for plain joists, it would be safer to employ a factor of unity throughout in cases where the basic formula is used. Considerable increases in permissible stress may be obtained for these sections, but these must be calculated directly from equation (10). The lower limit of safe working stress may be represented by

$$F_{bc} = 800 \frac{r_1}{L} \text{ tons per sq. in.}$$

Rolled-Steel Channels.—Provided that a channel beam is to be loaded through its shear centre, the same theoretical solutions may be used in estimating the buckling loads and stresses. Where loads are to be applied directly to the flanges, however, the members must be treated as if under eccentric loading, and the permissible stresses reduced. The lower limit of permissible stress for all rolled-steel channels has been found to be given by $F_{bc} = 920 \frac{r_1}{L}$

tons per square inch, as for joists, for ratios of $\frac{r_2}{r_1}$ in excess of 5. The torsion constant has been assumed to be $\sum \frac{1}{3} b t^3$ for all channels, and, in consequence, will give a slightly low estimate of the critical stress. For stockier sections, this stress may be increased, as

$$F_{bc} = 920 \frac{r_1}{L} \left[1 + 0.2 \left(5 - \frac{r_2}{r_1} \right) \right] \quad (14)$$

This empirical expression replaces the factors given in B.S.C.P. 113, which are not applicable to these sections. A more accurate estimate of the safe stress may again be obtained from equation (10).

The influence of warping restraint on the stiffness of channel beams is more pronounced than for corresponding joists, and considerable increases in the permissible stress may be obtained by modifying equation (14) to allow for this effect.

From analysis of the properties of channel beams it has been found that the modified working stress may be represented by

$$F'_{bc} = F_{bc} \sqrt{\left\{ 1 + 900 \alpha \left(\frac{r_2}{L} \right)^2 \right\}} \quad (15)$$

This expression will apply to all but the two smallest sections. In cases in which load is applied at the level of the top flange, the permissible stress should be reduced to

$$F'_{bc} = F'_{bc} \left[1 - 8m \left(\frac{r_2}{L} \right) \right] \quad (16)$$

$$= F'_{bc} \left[1 - 14 \frac{r_2}{L} \right]$$

Aluminium-Alloy Beams.—The problem of stability becomes more acute in the case of light-alloy members in which the material has high strength but low elastic moduli, and design stresses

are more likely to be based on critical buckling values. The report recently published by the Institution of Structural Engineers on "The Structural Use of Aluminium Alloys in Buildings," includes proposals for limiting compressive stresses in beams in terms of the flange slenderness, and it is stipulated that these stresses should be reduced by 40 per cent. when the load is applied at the top flange. Such proposals are extremely conservative in nearly all cases, and it seems more reasonable to base design stresses on a formula of the type specified for steel joists.

An analysis of the properties of aluminium-alloy sections has been made, in which the relation between critical stress and slenderness ratio was observed. The torsion constants derived by Cullimore and Pugsley* have been used and the section dimensions have been taken from B.S.1161.

By putting $E = 10^7$ lb. per square inch, and $G = 3.8 \times 10^6$ lb. per square inch, in equation (6), we see that the critical stress for alloy beams is given by

$$F_c = 2,750 \left(\frac{r_1}{L} \right) \frac{c}{Z_x} \sqrt{\frac{A J}{\gamma}} \text{ tons per sq. in.} \\ = 2 F_{bc} \quad (17)$$

The parameter $\frac{1}{Z_x} \sqrt{\frac{A J}{\gamma}}$ has been determined for both I and channel beams, and it is found that the lower limit for the working stress, using a safety factor of 2, may be written as

$$F_{bc} = 400 \frac{r_1}{L} \frac{c}{\pi} \quad (18)$$

This expression will give a safe estimate of working stresses, but will prove over conservative in many cases.

The influence of warping should again be included in design, and by application of the foregoing solutions a semi-empirical correction may be obtained. In the case of alloy I beams, the safe stress may be modified to give

$$F'_{bc} = F_{bc} \sqrt{\left(1 + 180 \alpha \left(\frac{r_2}{L} \right)^2 \right)} \quad (19)$$

for small sections, up to 7 in. by 4 in., or

$$F_{bc} = F_{bc} \sqrt{\left(1 + 375 \alpha \left(\frac{r_2}{L} \right)^2 \right)}$$

for larger sections. Similarly, for all alloy channels, the modified stress becomes

$$F'_{bc} = F_{bc} \sqrt{\left[1 + 625 \alpha \left(\frac{r_2}{L} \right)^2 \right]} \quad (20)$$

where $\alpha = 1$ for unrestrained ends, as before.

The decrease in the design stress when point load is applied at the top flange, specified in the report on "The Structural Use of Aluminium Alloys in Buildings," is independent of the span, the basic stress being simply multiplied by 0.6. This reduction will frequently be over-stringent and the modified working stress should again be put on a more logical basis. The above solutions to this problem may be applied to give a modified safe stress, based on the worst case of point load on the top flange at mid-span. It is found that, for all aluminium-alloy I beams, the design stress under these conditions may be written as

$$F'_{bc} \approx F'_{bc} \left(1 - 8m \frac{r_2}{L} \right) \approx F'_{bc} \left(1 - 14 \frac{r_2}{L} \right) \quad (21)$$

and similarly, for channels,

$$F'_{bc} \approx F'_{bc} \left(1 - 10m \frac{r_2}{L} \right) \approx F'_{bc} \left(1 - 17 \frac{r_2}{L} \right) \quad (22)$$

Tests carried out on a number of model and small standard beams have verified existing and extended theoretical solutions to the problems of lateral instability of members under point loads. It has been shown that existing design rules, based on results for members under uniform bending moment, are extremely conservative when applied to cases of point loading. The influence of the restraint of warping, inherent in all cases of loading, may be of considerable importance when considering joists and channels, but is negligible in the case of T

sections. In addition, a reduction in working stress may be necessary where the load is applied at the top flange. This reduction is again negligible for T sections.

The suggested design formulae, based upon theoretical solutions and derived from analysis of the properties of standard sections, should be used wherever detailed design is necessary. The formulae given in B.S.C.P. 113 and B.S.S. 449 will prove sufficient to indicate whether or not the working stress should be reduced below 9 tons per square inch, but are not adequate in detailed design.

THE ENGINEERING OUTLOOK.

IV.—THE AGRICULTURAL MACHINERY INDUSTRY.

THE agricultural machinery industry has an essential part to play in maintaining the country's food supply and hence is indirectly of the utmost importance to defence. It does not, however, rank as a defence industry and, therefore, must expect to encounter difficulties in maintaining output as the re-armament programme makes increasing claims on steel and raw materials. To some extent, manufacturers can claim preferential treatment because of the high level of exports, but, even so, output in 1952 is likely to fall. In 1951, the impact of re-armament had not been felt, and output and exports were considerably higher than in 1950. Table I, opposite, taken from the *Monthly Digest of Statistics*, shows that the output of the industry as a whole in the first nine months of 1951—78.9% millions—was nearly 30 per cent. higher than in the corresponding period of 1950, and the output for export—42.1% millions—was more than 40 per cent. higher. Much of this increase was accounted for by the rise in agricultural tractor output, from 86,200 to 105,500 in the respective periods, and in the output of horticultural tractors from 22,600 to 28,100. Tractors, the output of which is given in Table II, also from the *Monthly Digest of Statistics*, now account for 57 per cent. of the total value of agricultural machinery, compared with 55 per cent. in 1950 and 48 per cent. in 1949.

While the prospects of maintaining the output of agricultural machinery over the next year or so are not good, the course of demand is most uncertain. At home, purchases of agricultural machinery are financed very largely by bank credits and the Government's credit restriction policy is likely to reduce them. Apart from this, there is a strong possibility of a decline in demand unless machinery can be used more profitably than at present. Some agricultural economists and farmers have argued that British farms are already over-capitalised and that the present rate of expenditure on new equipment—50% millions per annum—is unduly high. It is certainly true that, while the number of tractors on farms in England and Wales is now well in excess of 300,000, compared with 50,000 in 1938, there is little concrete evidence of greatly improved productivity per farm worker compared with the 1930s. This does not imply, of course, that there is no further scope for mechanisation. Mr. G. R. Nugent, Parliamentary Secretary of the Ministry of Agriculture, speaking at the dinner of the Oxford Farm Conference on January 7, pointed out that, on many farms, a tractor has been acquired to replace a pair of horses and was still doing no more than the horses did before. Not enough thought has been given to methods of getting increased production with the additional mechanisation, or, alternatively, how to use the time that is saved by machinery to develop other profitable lines.

This view is endorsed by the report on "Productivity in Farming," published in September by the Anglo-American Council on Productivity. The productivity team who visited the United States during the summer say that mechanisation on British farms is still at an early stage and relatively unproductive. Both in Britain and the United States, the first phase of mechanisation has been characterised by a substitution of mechanical power for animal power, unaccompanied by any fundamental changes in the methods and practices of farming. In the United States, however, this phase is now completed; the second phase, which is already well

* "The Torsion of Aluminium-Alloy Structural Members," by M. S. G. Cullimore and A. G. Pugsley. A.D.A. Research Rept. No. 9, 1951.

begun, is characterised by the development of new equipment, involving considerable changes in the established methods of farming. The Team perhaps overstate their case, for they cite as examples of second-phase mechanisation "the increasing uses of the baler, the limited but increasing interest in the field chopper in the hayfield, the developing popularity of yard-and-parlour milking systems and the development of self-feeding methods in the case of livestock." None of these is particularly new or so very uncommon in the United Kingdom. It is perhaps true, however, that the American farmer sees better than his British counterpart the necessity for reorganising the farm business in order to make the farm fit the available machines; but there are many material circumstances which help to explain why the American farmer makes better use of mechanisation than the British. The great uniformity of farming systems alone, and their com-

less mechanisation in Britain. It is probably true to say that, with existing farming methods, some farms are already over-capitalised. Changes in method could reduce the range of machinery and the amount of capital investment required per unit of output. In the long run, this would increase productivity and the overall demand for agricultural machinery. This would correspond to the Team's second phase of mechanisation, the attainment of which brings far-reaching consequences of its own; for, as the use of more and more highly specialised machinery, often beyond the range of one farmer's purse, becomes possible, there must be a tendency towards amalgamation of farms into larger units, or, at least, to greater co-operation among farmers for the purchase and operation of machinery.

In the matter of electrical equipment in and around the farm buildings, farmers in the United Kingdom are certainly not over-mechanised.

the farm. Manufacturers in the United States rely on the local machinery dealers to keep them in touch with the farmer. Dealers are generally required to submit regular and systematic reports to area supervisors and to company headquarters. By supplementing these with regional conferences and discussions, farmers' ideas and requirements are rapidly transmitted to development and production engineers. American manufacturers say that their main task is not inventing new machinery, but developing farmers' ideas. The organisation of the agricultural machinery industry in the United States is strikingly different from that in the United Kingdom, which is composed of a large number of small concerns, all producing a wide range of machines with little attempt at standardisation. In the United States, the manufacture of agricultural machinery is highly competitive, but it is concentrated in the hands of a few large concerns.

TABLE I.—UNITED KINGDOM: PRODUCTION OF AGRICULTURAL MACHINERY.

—	Tractors.		Mouldboard Ploughs.		Disc Harrows.	Corn Drills.*	Mowers.	Potato Spinners.	Threshing Machines.	Combine Harvesters.	Milking Machines.	Total.†	For Export.†
	Agri-cultural Types.	Market-garden Types.	Tractor-drawn.	Horse-drawn.									
	Number.												
1937.. ..	17,949	461	6,054	14,695	1,323	398	4,436	1,767	518	—	—	—	—
1938.. ..	10,029	650	5,156	7,424	1,260	352	4,641	1,496	486	—	—	—	—
1948.. ..	117,038	33,654	66,156	20,793	18,663	3,108	16,901	8,344	1,226	828	10,869	69.2	28.2
1949.. ..	90,411	25,235	51,572	20,196	11,819	3,533	26,033	6,969	807	1,963	15,020	63.9	26.1
1950.. ..	120,211	30,277	52,080	3,410	12,362	6,469	27,076	6,473	758	4,325	19,447	84.7	42.8
1949—3rd Qr. .	17,194	5,959	10,672	7,795	2,874	918	4,607	4,368	192	678	4,049	14.3	5.4
4th Qr. .	21,763	4,827	13,957	1,519	2,805	1,062	2,495	984	244	318	3,708	15.9	7.2
1950—1st Qr. .	25,989	6,120	15,920	1,427	3,073	2,497	6,621	266	196	890	3,959	19.3	9.0
2nd Qr. .	30,412	8,706	11,465	337	4,017	1,029	10,553	2,183	159	1,445	5,474	22.0	10.2
3rd Qr. .	29,800	7,744	11,346	295	2,821	1,167	6,430	3,333	184	903	5,173	20.6	10.4
4th Qr. .	34,010	7,707	13,349	1,351	2,451	1,776	3,472	691	219	1,087	4,841	22.8	13.2
1951—1st Qr. .	36,208	8,729	15,080	1,171	3,627	1,938	7,892	303	137	949	4,341	24.5	12.8
2nd Qr. .	37,699	10,039	14,018	1,265	2,849	1,011	10,952	2,007	149	1,414	3,635	27.9	14.8
3rd Qr. .	31,552	9,365	14,866	1,091	2,547	1,882	4,537	2,202	137	2,032	3,840	26.5	14.5

* Including combined seed and fertiliser drills.

† Including value of items not shown separately in preceding columns, and also parts and accessories.

TABLE II.—UNITED KINGDOM: PRODUCTION OF TRACTORS.*

	Wheeled.†			Track-laying.		
	Total.	For Export.	Total Value.‡	Total.	For Export.	Total Value.‡
	Number.			Number.		
1948	9,669	6,048	2,747	154	88	164
1949	7,358	4,543	2,335	222	144	239
1950	9,788	6,877	3,673	240	178	264
1950—October ..	11,061	8,123	4,209	288	221	331
November ..						
December ..						
1951—January ..	11,796	8,652	4,328	289	219	386
February ..						
March ..						
April ..	12,227	9,149	4,860	351	269	455
May ..						
June ..						
July ..	10,413	8,611	4,891	319	215	469
August ..						
September ..						

* Tractors of 10 h.p. and over for agricultural and industrial uses.

† Including half-track vehicles.

‡ Value figures relate to deliveries, and include parts and accessories.

Moreover, because of the uniformity of farming over wide areas, the United States home market for any particular type of equipment is very big, and, because of their size, companies are able to apply large sums to basic research and development.

These advantages are so considerable that the agricultural machinery industry in the United States might have been expected to outstrip its competitors. Fortunately, however, farming conditions throughout the world rarely conform to the American pattern, and the large special-purpose machines designed for the domestic market are often unsuitable for export. The British agricultural machinery industry, on the other hand, can adapt its products to meet conditions anywhere in the world. In some cases, British designed machinery has been adopted in the American market. The "three-link" hitch used by the principal British manufacturers of medium-sized wheeled tractors, for example, is now being utilised on an ever-increasing scale by American farmers and manufacturers of agricultural machinery. United States tractor manufacturers have little advantage in bulk production and there is already evidence of a much larger market, mainly in the undeveloped countries, for the British medium and small types than for the larger American machines.

It is now, more than ever, of vital importance that the British makers of agricultural machinery should study closely the requirements of overseas markets, since they must be prepared to meet intensive competition from other countries. The *General Survey of The European Engineering Industry*, published by the United Nations Economic Commission for Europe, points out that some considerable surplus capacity for the manufacture of agricultural machinery has been growing over the past few years. Increased defence production, however, has tended to mask this and to conceal the underlying weakness of demand. The surplus is particularly apparent in the case of tractors. As the reports points out, the capacity available in 1950 could, if necessary, have permitted an output one-third greater than was actually achieved. On the basis of estimated European production and consumption, and assuming that there was no increase in exports to the

parative simplicity, makes it easier for the American farmer to think in terms of labour-saving devices. Land is more plentiful and there is a much greater opportunity to obtain high output by using large machinery on an extensive basis rather than by the intensive application of labour to smaller areas. It seems illogical to point out that the number of separate enterprises and individual farms in the United States is fewer than in the case of mixed farming in Britain, and, at the same time, to compare the British farmer unfavourably with the Americans in the readiness with which he undertakes new enterprises as mechanisation of existing processes permits. It would seem, indeed, that, if the British farmer is to benefit from mechanisation, he may have to reduce the range of his activities. He may find that the best way to increase productivity is to increase the yield of existing crops and enterprises. Increased diversification may only produce diminishing returns.

There is no easy answer to the problem of more or

Whereas, in the United States, 85 per cent. of farms have mains electricity, the proportion in the United Kingdom is only about 40 per cent. As with the mechanisation of field work, the intensive development of rural electrification in the United States is of very recent date. In 1935, only 10 per cent. of farms had electricity, but thereafter progress was rapid, largely because of the readiness with which the Rural Electrification Administration granted loans to farmers' co-operative organisations, municipalities and private companies. Electrification, which has made possible the use of hoists and elevators and other labour-saving devices of all descriptions, has taken much of the physical toil and strain out of farming in the United States and has made the last hour of the farm worker's day as effective as the first.

While farmers have something to learn in the United Kingdom about adapting the farm to machinery, manufacturers of machinery may profit from American methods of adapting machinery to

rest of the world, the surplus capacity would be at least as great as in 1952. The world production of tractors reached 951,000 in 1950, compared with 884,000 in 1949 and 303,000 in 1937. European production has been accounting for an increasing proportion of the total: 14 per cent. in 1937, 17 per cent. in 1949, and 23 per cent. in 1950. North American production increased from 175,000 in 1937 to 600,000 in 1950. In Russia, the increase in engineering production generally kept pace with the Western world, but, surprisingly, not in the case of tractors; the production in 1950 was only 112,000, compared with 80,000 in 1937. The most striking increase in tractor production has taken place in the United Kingdom, which accounts for well over half of the total European production, from 18,000 in 1937 to 116,000 in 1950. Western Germany, the second largest European producer, produced 52,000 in 1950, compared with 12,000 in 1937. Many of the other Western European countries which produced few or no tractors before the war have considerably developed their production facilities. Austria produced 5,300 tractors in 1950, Sweden 7,000, and Italy 6,000. Dispersal of tractor production in this manner throughout Europe is certainly not economic, but it may have serious consequences for British manufacturers.

The United Nations Report contains a suggestion that the solution may be to stimulate the demand in less developed areas, and that attention should be focused to an increasing extent "on the suitability of tractors in relation to the needs of individual countries, of, for example, available fuels, repair facilities, and type of land available; and the reduction of initial cost and cost of operation." It is by paying close attention to these factors that British manufacturers have succeeded in increasing their exports of tractors in the face of increasing competition. From Tables III and IV, herewith,

TABLE III.—United Kingdom: Exports of Agricultural Machinery, January to November. (1,000 cwt.)

	1949.	1950.	1951.
Types other than Tractors:			
Ploughs	277	306	327
Hay and Grass Mowers ..	46	61	65
Reapers, Binders and Threshers	23	24	23
Reaper-thresher Combines	—	—	113
Sheep Shearers and Clipping Machines	5	5	5
Other	379	530	568
Total	730	926	1,101
Tractors	189	237	303
Grand Total	919	1,163	1,404

Value (1,000L.).

Types other than Tractors:			
Ploughs	1,745	2,278	2,817
Hay and Grass Mowers ..	554	764	849
Reapers, Binders and Threshers	216	211	241
Reaper-thresher Combines	—	—	1,747
Sheep Shearers and Clipping Machines	196	258	266
Other	3,095	5,158	6,473
Total	5,806	12,393	15,111
Tractors	17,717	25,633	38,001
Grand Total	23,523	38,026	53,112

taken from the *Trade and Navigation Accounts of the United Kingdom*, it will be seen that the value of tractors exported, 38l. millions, in the first eleven months of 1951, was more than twice as great as in the corresponding period of 1949, and the number, 104,175, was nearly twice as great. The principal markets are the Commonwealth countries, which together accounted for half the number of tractors exported from the United Kingdom. The largest single markets, South Africa and Australia, are not, however, the most undeveloped countries. The market for tractors has not been saturated in either country, but the rate of increase in exports may slow up in the near future. Exports to Australia totalled 20,000 tractors in the first eleven months of 1951, an increase of only 5 per cent. on the number exported during the corresponding period of 1950, whereas the total British exports of tractors increased by 38 per cent. Exports to New Zealand, formerly the second largest market for British tractors, actually declined in 1951. United States manufacturers have secured a footing in the Dominion markets, and, but for the emergency, might have made considerable gains. The International

Harvester Company have set up a factory in Australia, in which it was planned to produce 8,500 tractors in 1951. In South Africa, the Massey-Harris Company have taken over a local firm making tractors and implements, whose business is expanding rapidly.

A hopeful sign for future British exports is their dispersion throughout the world, which indicates that British tractors are adaptable to most conditions. In 1950, there was only one country to which the exports in the first eleven months exceeded 7,000; in 1951 there were five. Two of these, Sweden and Denmark, are highly developed countries, but in a third, Turkey, farming is often carried on by very primitive methods. Little can be inferred, however, from the opening up of the Turkish market; the progress of exports to relatively backward (and often to more advanced)

annual market review that Indian exchange resources are inadequate to bring in goods that are essential for the development of the country. Inflationary pressure has been increasing, and production has not increased appreciably over the past year or two. Some attempt has been made to increase the output of food grains as well as of jute and cotton, but little has been achieved. While heavy food imports are necessary to ward off famine, agricultural and industrial equipment alike must be excluded. Industrial profits have been falling, the aggregate savings of the community are low, and there has been little capital formation. In these circumstances, foreign aid would have to be on a very liberal scale indeed to stimulate capital formation. President Truman's programme of aid to the backward countries is a step in the right direction, but no large or immediate returns should

TABLE IV.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL TRACTORS, BY COUNTRY OF DESTINATION (JANUARY TO NOVEMBER).

	1949.		1950.		1951.	
	No.	Value (£1,000).	No.	Value (£1,000).	No.	Value (£1,000)
Union of South Africa	4,589	1,376	6,096	1,900	11,006	3,900
Southern Rhodesia	852	309	769	287	1,366	575
British East Africa	867	392	853	427	955	439
India	954	401	2,586	1,021	5,160	2,026
Australia	16,461	4,993	19,010	6,451	20,029	6,610
New Zealand	4,263	1,249	6,577	2,271	6,106	2,187
Canada	1,168	309	4,620	1,738	6,938	2,225
Other Commonwealth Countries	731	264	970	389	1,802	718
Irish Republic	744	215	1,606	472	3,155	1,020
Finland	1,979	610	1,185	427	3,055	1,137
Sweden	3,943	1,192	6,132	1,092	7,244	2,629
Norway	1,195	338	925	302	2,805	889
Denmark	3,646	1,010	4,667	1,401	7,089	2,331
Netherlands	724	243	1,343	421	2,097	725
Belgium	523	165	1,087	377	1,328	500
France	3,195	888	3,454	1,165	3,622	1,432
Spain	516	148	570	224	1,230	591
Italy	437	122	1,175	426	1,455	622
Greece	403	355	281	181	352	193
Turkey	347	103	760	273	7,381	3,527
Algeria	703	280	1,020	366	556	259
Egypt	667	146	948	260	2,309	713
United States of America ..	6,605	1,478	3,719	847	1,013	118
Brazil	512	187	455	216	1,638	761
Uruguay	658	217	933	420	466	198
Argentine Republic	294	100	567	321	99	40
Other Foreign Countries ..	1,998	627	3,098	1,058	3,820	1,636
Total	58,974	17,717	75,406	25,633	104,175	38,001

TABLE V.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL MACHINERY OTHER THAN TRACTORS, BY COUNTRIES OF DESTINATION (JANUARY TO NOVEMBER).

	1949.		1950.		1951.	
	Quantity (1,000 cwt.).	Value (£1,000).	Quantity (1,000 cwt.).	Value (£1,000).	Quantity (1,000 cwt.).	Value (£1,000).
Union of South Africa	73	518	78	584	85	814
British East Africa	47	355	28	291	28	337
India	40	257	107	807	73	714
Australia	44	498	95	1,061	185	2,322
New Zealand	44	359	66	654	62	699
Other Commonwealth Countries	62	540	79	731	76	941
Irish Republic	66	487	74	590	108	968
Sweden	20	199	21	222	30	330
Norway	18	169	9	111	14	171
Denmark	20	168	25	261	39	426
Netherlands	42	260	47	341	35	313
France	43	342	18	203	53	751
Greece	6	63	18	151	7	93
Egypt	21	130	18	149	21	172
Uruguay	28	203	39	364	9	83
Argentine Republic	33	243	76	824	14	148
Other Foreign Countries ..	123	1,015	128	1,325	262	3,111
Total	730	5,806	926	8,669	1,101	12,393

countries in the past few years has been notoriously unstable. The national income has often been inadequate to carry out the planned level of investment, and, as a result, imports have often had to be reduced with little warning. Perhaps the largest potential market is India, to which twice as many tractors were exported in 1951 as in 1950, but the total number exported in the first eleven months of 1951, 5,160 is minute in relation to the huge population and the vast agricultural area. Before the demand in India can be made actual, sweeping social changes may be necessary as well as a considerable increase in the national income. As in many backward countries where the pattern of community life is based on small landholdings, the problem of adapting the farm to the machinery is much more difficult than in Europe.

In India, the prospect of any rapid increase in the national income is small. Messrs. Premchand, Roychad and Sons, of Bombay, point out in their

be expected by the Western World in the way of an increased demand for engineering products, whether agricultural or industrial.

British manufacturers are succeeding remarkably well in adapting their products to the conditions prevailing in various markets. A recent example of this is the Ford Motor Company's new tractor design, the Fordson Major, which, though basically standard, is suitable for widely varying soils, terrains and climates. This tractor can be fitted with a Diesel, vaporising-oil or petrol engine, according to local preferences. Considerable economies are said to have been achieved in this new tractor from a higher degree of standardisation, particularly of engine components. The three types of engines can be made on a single production line, and differences in the fuel system have been greatly reduced by giving the Diesel and vaporising-oil engines the same bore and stroke as the petrol version. The production of a Diesel engine is a

new venture for the Ford Motor Company, their Diesel-powered tractors having been fitted hitherto with a Perkins engine. The new Diesel-engined tractor, without power take-off and headlamps, is priced at 552*l.*, 100*l.* cheaper than the old model. The petrol and vaporising-oil versions are 20*l.* dearer, but they are more powerful than the corresponding old models. Unfortunately, the shortage of materials has reduced the production economies likely to accrue from the new design; the output at Dagenham is now 20 per cent. below the planned level.

British exports of other agricultural machinery have not expanded quite so spectacularly as have the exports of tractors. The increase in quantity in the first eleven months of 1951, compared with the corresponding period of 1940, was 19 per cent., however, and the increase in value 43 per cent. The large increase in value is partly due to the start of an export trade in combine harvesters. In 1951, these already accounted for 14 per cent. of exports of agricultural machinery other than tractors. Until 1950, the British production of combines fell far short of home requirements; starting at 828 in 1948, production grew to 4,300 in 1950, and, in the first three quarters of 1951, 4,400 were produced, compared with 3,200 in the corresponding period of 1950. The principal markets for agricultural machinery, as may be seen from Table V, herewith, taken from the *Trade and Navigation Accounts*, are roughly the same as for tractors, but, as might be expected, they are even more widely dispersed throughout the world. The degree of dispersion, moreover, is increasing. In the first eleven months of 1951, exports to "other countries," i.e., markets individually too small to be designated separately, were valued at 3.17 millions (26 per cent. of the total), compared with 1.3*l.* millions or 12 per cent. in the corresponding period of 1950. Some types of agricultural machinery have been selling well in the United States. Rotary Hoes, Limited, reported in June that the sales of their machines in that country were at double the rate of 1950, and claimed that their order book is such that they could place the whole of the production in dollar, Dominion, and hard-currency markets.

As mechanisation advances, the demand for some of the old staple lines of equipment inevitably falls off. Horse-drawn ploughs are, of course, a most striking example; conventional threshing machines are another. The production of potato spinners has also fallen, from 8,300 in 1948 to 6,500 in 1950, and in the first three quarters of 1951 only 4,500 were produced (compared with 5,600 in the corresponding period of 1950). British agricultural-machinery manufacturers have, however, taken the lead in the development of harvesters which will deliver the potatoes into bags or into the clamp, and several hundreds are already in use. A machine has not yet been evolved which gives a completely satisfactory performance where the soil is very wet or sticky or where there are many stones and clods, but considerable progress has been made. The production of milking machines, which has increased steadily since the war, received a set-back in 1951. In 1950, 19,400 were produced, compared with 15,000 in 1949, but in the first nine months of 1951 only 11,000, compared with 14,600 in the corresponding period of 1950. The demand may be expected to continue to increase, however; it has been found that their use can be justified with very small herds, and some are now being used successfully with herds of fewer than ten cows.

Makers of dairy plant have perhaps been more severely hit by the steel shortage than other sections of the agricultural-machinery industry and will be in a worse position in 1952. They have been informed that, from February 4, their supplies of stainless steel will be cut by 80 per cent. and of carbon steel by 70 per cent. This is particularly serious for the milk industry, which is now very largely committed to mechanical processing, about 90 per cent. of the country's milk being pasteurised. The cuts in the steel supply will not only severely restrict new production, but will make it very difficult for manufacturers to furnish spare parts. The demand for mowers showed signs of levelling off in 1950, and, in the first three quarters of 1951, 23,400 were produced, compared with 23,600 in the

corresponding period of 1950. The drop in production, however, occurred in the third quarter of 1951, and is due to the steel shortage and not to a deterioration in demand.

The agricultural-machinery industry enters 1952 with considerable uncertainty. The main pre-occupation, of course, will be the steel shortage, but the question of future demand should be given careful attention. Both at home and abroad there is undoubtedly a high potential demand for tractors and many types of specialised machinery. Potential demand, however, may not be quickly transformed into actual demand. At home, farmers are not likely to undertake further capital outlays unless these can be justified in terms of increased productivity. It is only by paying close attention to their requirements and by undertaking intensive research and development that makers of agricultural machinery will be able to offer their products at prices which the farmers will accept. Abroad, they can hope to sell in the face of increasing competition only by close attention to the requirements of individual markets.

SHIP RESEARCH.*

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

THE value of scientific research applied to the needs and problems of an industry, however long-established, is now universally admitted. In Great Britain, a large amount of research work on shipbuilding and marine engineering is sponsored by the Admiralty, the British Shipbuilding Research Association and other similar research associations, the Department of Scientific and Industrial Research, Lloyd's Register, various individual firms and associations of firms, and certain of the universities. In other countries, the state of affairs is similar, though the extent of co-operative research by industry is perhaps greater in Britain than elsewhere. In the United States, an extraordinarily large amount of research work devoted to shipbuilding problems is carried out in both State and private institutions. On the Continent of Europe, varying amounts of research are in progress in Belgium, Denmark, France, Holland, Norway, Spain, and Sweden.

The ship has many problems in common with other vehicles of transport. For example, it has to be strong enough to carry its loads safely, and it has to be propelled. The fundamental difference is that the ship has to float, and to move through a medium that exerts considerably greater resistance to motion than air at comparable sizes and speeds. It is not surprising that the early investigators, among them Newton and Euler, concentrated on solving the problems associated with resistance. Even in this field, however, the true scientific approach did not come until 1867, when William Froude began towing models on the River Dart and investigated the resistance of ships in a scientific manner. About two years afterwards he built the first experiment tank at Torquay, and, at last, testing of ship models for resistance and propulsion was given a scientific basis. Froude's work was soon applied in practice by Scott Russell, Edward Reed, and William Denny. It was thus a combination of scientists, experimenters, and practical shipbuilders which enabled the science of ship model testing to be firmly established and finally applied in practical shipbuilding. To-day, a number of shipbuilding firms in Great Britain have experiment tanks of their own, which, except in improved mechanical detail, differ little from the first tank built by William Froude. In addition, there are two large tanks at the National Physical Laboratory at Teddington, of which extensive use is made by many shipbuilding firms in Great Britain. The Admiralty have their own tanks.

Naval architecture and marine engineering embrace a wide range of interests, and the research field can be truly described as enormous. Fig. 1, on page 106, shows this field. The Admiralty has its own research organisation, and much of its work must be kept secret because of security considerations. There are, however, many problems common to naval and merchant ships, and the Admiralty and the shipbuilding research organisations in Great Britain work closely together on many matters. With warships, however, the maximum speed and endurance combined with the maximum protection and carriage of offensive weapons is required. For merchant ships, the shipbuilder fulfils his contract by producing a vessel capable of carrying a stated deadweight with a certain cubic capacity and accommodation, to attain a specified speed either on trial or on service.

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

For many years, the responsibility for adequate structural strength in merchant ships has been borne almost entirely by the classification societies. There have been relatively few serious structural failures in British ships, and these have been confined to cases which can only be described as exceptional; that is, the conditions of loading, etc., have been far removed from the average conditions postulated by the societies in compiling their rules. The structural design of most classes of merchant ships has now reached a stage of effectiveness where the stress induced in the main structure, when among waves of the lengths and heights usually encountered in service, is seldom responsible for damage to the hull structure. It should not be inferred from this statement that further progress is considered unlikely or that the existing knowledge of the behaviour of ships' structures under load is adequate. This is still far from true, despite the considerable amount of full-scale work carried out during recent years.

An entirely satisfactory method of dealing with the strength of ships ought to provide means for the accurate determination of the principal stresses in all parts of the structure. Some method of estimating ship strength must be adopted, even if mathematically exact solutions may not be possible. The forces due to gravity and the statical pressure of water are easily determined quantitatively. The intensity of impact from waves, the effect of variations in pressures due to the motions of the ship on the water, and the rolling, pitching, and heaving reactions can only be determined by the results of experience with actual ships' structures or by experiments. It is surprising that so little reliable information on this subject—comparatively easy to obtain—has been published until the last few years.

First attempts at rational estimates of the strength of ships were directed towards the determination of the stress on a cross-section, assuming the vessel to bend as a whole owing to the unequal distribution of weight and support in a fore and aft direction. That particular problem was solved for practical purposes many years ago and has become known as the girder theory. Reference to the strength of a ship has nearly always meant the strength required to resist longitudinal bending. This is not entirely satisfactory since, after all, a ship that will not deflect appreciably in a certain direction can scarcely be regarded as satisfactory if it is weak in other respects.

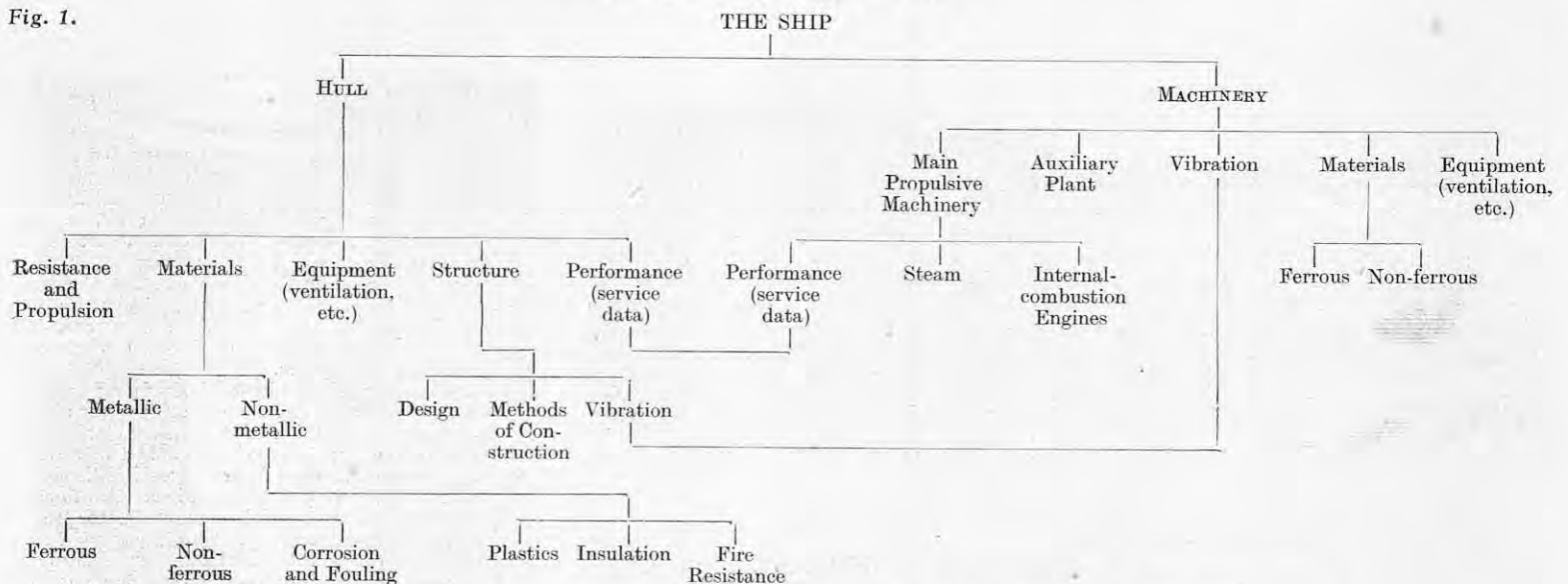
The essential difference between longitudinal and transverse strength is that, for the former, rational and reasonable calculations can be made by statical methods, whereas, for the latter, the structure is of a redundant nature and the stresses are indeterminate by ordinary methods. Clearly, measurements of strain on full-size vessels are essential to enlarge knowledge and understanding of structural behaviour. Where comparative methods of calculation are to be considered, the use of structural models offers attractive possibilities.

While calculations of longitudinal strength are comparatively straightforward, though tedious, calculations of transverse strength are less simple and even more tedious. The loads acting upon a ship are both static and dynamic, and no theory has yet been propounded which deals comprehensively with the many and varied effects such as the interaction between longitudinal and transverse strains, the effect of shear deformations, etc. For these and other reasons too numerous to mention in detail, the British Shipbuilding Research Association (B.S.R.A.) has sponsored fundamental investigations on model structural elements, where the loads to be applied and the principal stresses can be determined under controlled conditions by various methods, including photo-elasticity. The experimental results can then be compared with calculated results, using such modern methods of structural analysis as moment distribution, column analogy, relaxation methods, etc. From tests on structural elements it is proposed to proceed to similar tests on larger sections of the hull on the model scale. Only by such means does it appear possible to explore, for example, the interaction of longitudinal and transverse strength. All this work is closely related to strain measurements on actual ships.

Structural components are being tested in the well-known machine at Gleggarnock (Figs. 2 and 3). In this machine, which now belongs to the British Shipbuilding Research Association, typical ship girders such as bulkhead stiffeners can be tested under lateral loads up to 180 tons. The results of these experiments have found useful practical application in shipbuilding and have led to important economies in steel. The findings are given in a series of important papers. It has been found, for example, from the comparison of riveted stiffeners with their welded counterparts, that the removal of the faying flange does not reduce the section modulus. Weight saving is then possible without reduction either in strength or in stiffness. It has been accepted by the appropriate authorities that the substitution of welded for riveted stiffeners

SHIP RESEARCH.

Fig. 1.



MACHINE FOR TESTING SHIPS' STRUCTURAL MEMBERS.

Fig. 2. OUTLINE ELEVATION.

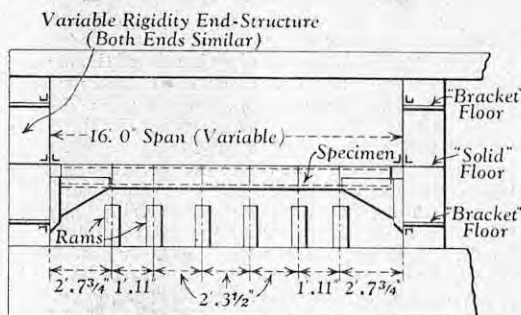
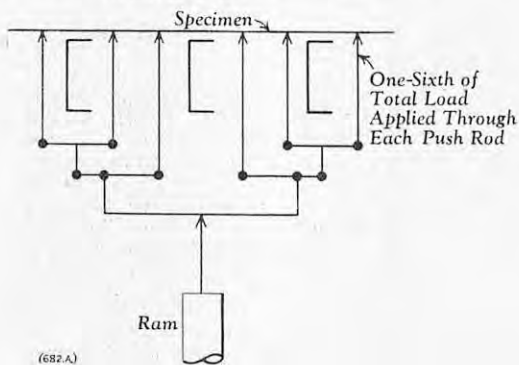


Fig. 3. METHOD OF DISTRIBUTING THE LOAD TRANSVERSELY.



may permit reductions in section modulus up to 15 per cent. and in inertia up to 25 per cent. Similarly, welded brackets show appreciable reductions in stress compared with their riveted counterparts, attributable to the greater rigidity of the welded bracket.

Many ship girders, such as those within the double bottom and on the underside of decks, suffer both lateral loads and end loads arising from the flexure of the hull. A new machine (Figs. 4, 5 and 6, herewith) has therefore been constructed for B.S.R.A., capable of applying lateral loads up to 300 tons, and end loads up to 600 tons. In this machine it will be possible to investigate strains and deflections in a stiffened area of plating some 24 ft. by 9 ft., representing a portion of tanker bottom plating, for example. Tests have also been made in the 1,500-ton compression machine of Dorman Long and Company, on sections of a double bottom, again with the basic aim of comparing the structural behaviour of riveted and welded construction. These specimens represented a section of a double bottom of a ship of about 400 ft. in length, and were 10 ft. by 7 ft. 6 in. by 3 ft. in depth. The object of the experiments was to observe the behaviour of a panel of plating some 0.6 in. thick in the section, when under compressive loading. The experiments are still proceeding, they confirm the enormous capacity of a welded structure to absorb energy.

Fundamental problems in the strength of ships are the stresses and deflections in flat plates when subjected to uniform lateral loading combined with

Fig. 4.

SECTIONAL ELEVATION AT Y-Y

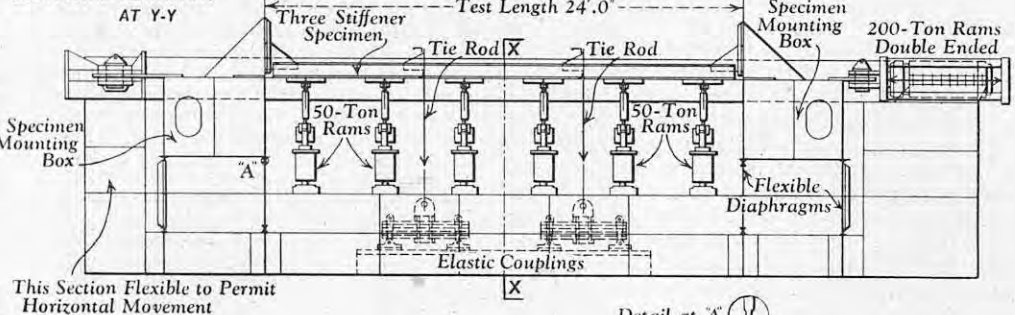


Fig. 5. PLAN

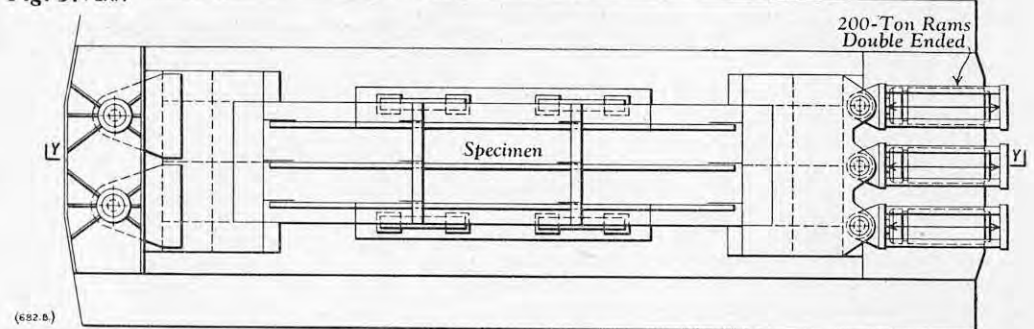
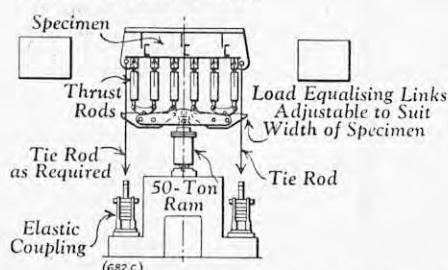


Fig. 6. SECTION AT X-X



tension or compression in the plane of the plate. Few experimental data are available on this subject, and, to fill this gap in knowledge, a series of tests is being made at Cambridge University in a specially designed and constructed testing machine. Panels of mild steel plate 2 ft. by 2 ft., 2 ft. by 4 ft., and 2 ft. by 6 ft. are subjected to uniformly distributed lateral loads combined with tension or compression in the plane of the plate while strains and deflections are measured.

A box girder can be regarded as a very elementary and simplified model of a ship's hull. Experiments have therefore been made on a large stiffened box girder 68 in. in width by 45 in. in depth. The plating was 0.1 in. thick, and the box was stiffened transversely by riveted angles 3/4 in. by 3/4 in., spaced 4 in. apart. This box girder was tested in pure bending. The heart-of-plate stress differs very considerably from the maximum fibre stress. It is intended to continue this work, and to find the effects of adding longitudinal stiffening material, thus increasing the resemblance to a ship's hull girder, and the effect on stress

distribution over the cross-section of adding additional decks and superstructure.

A relatively new technique, using models made of rubber sheet, has been used in preliminary theoretical investigations and experiments to determine the effect of expansion joints in large superstructures. This work has confirmed the expected existence of very large stress concentrations at the roots of expansion joints. More detailed investigations are proceeding. The Admiralty are carrying out studies of the stress concentrations in small scale models, constructed of Xylonite, of important parts of ships' structures such as deck openings, etc., using photo-elastic methods to establish the principal stress directions and small wire-resistance strain gauges, suitably oriented, to obtain actual stresses. Opportunity is then taken at launches of vessels to check the main features of the stress concentrations determined in greater detail by the model experiments.

(To be continued.)

THE ROYAL SOCIETY: WARREN RESEARCH FUND COMMITTEE.—The Warren Research Fund Committee of the Royal Society is initiating a programme of research on low-pressure gaseous discharge, and, for this purpose, has appointed several research workers for a period of three years. These are Mr. L. W. Kerr, who is to work at the University of Birmingham; Mr. C. G. Morgan, at University College, Swansea; and Dr. E. J. Smith, at University College, London. A grant has also been made to Mr. J. M. Somerville, of New England University College, Armidale, Australia, to enable him to work for one year at University College, Swansea.

CREEP-TEST RESEARCH STATION.

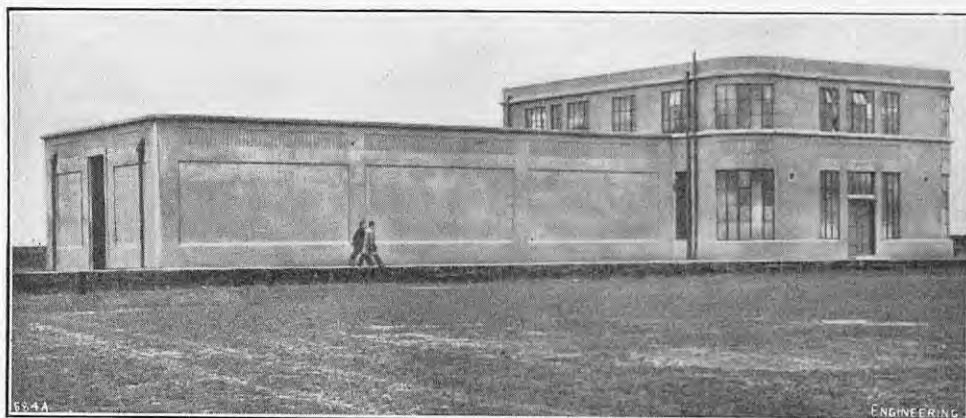


FIG. 1. GENERAL VIEW OF STATION.



FIG. 2. MAIN TESTING LABORATORY.

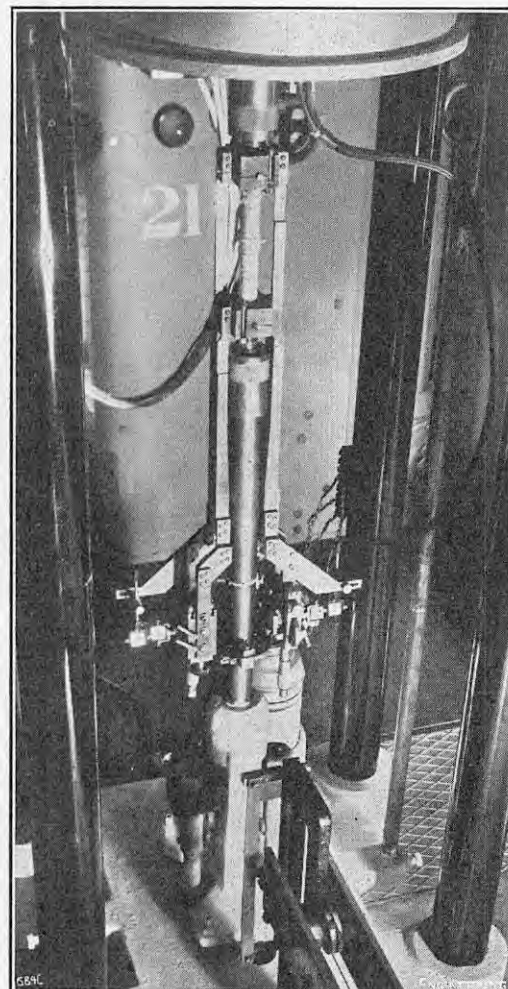


FIG. 3. ARRANGEMENT OF TEST SPECIMEN.

TRADE PUBLICATIONS.

Rotary Semaphore Keys.—Details of the rotary semaphore keys designed by them to give an illuminated indication of a particular switching operation are given in a leaflet received from Standard Telephones and Cables Ltd., New Southgate, London, N.11.

Flameproof Switchgear.—The flameproof switchgear constructed by them for currents up to 150 amperes at 3.3 kV and the flameproof drum controllers made for direct-current motors up to 70 h.p. and alternating-current motors up to 100 h.p. at voltages up to 600 volts are described in leaflets received from Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Adjustment of Ships' Compasses.—The British Nautical Instrument Trade Association, 105, West George-street, Glasgow, C.2, have issued a brochure containing information of use and interest to shipowners, mainly on the subject of compass adjusting. A list is included of the addresses in the United Kingdom, and some foreign, ports where the services of a certified compass adjuster can be obtained, and a schedule of charges is given. Other services, such as the rating and cleaning of chronometers and the examination and correction of charts, are also referred to.

Mechanical Testing Laboratories.—We have received from Blackburn and General Aircraft Ltd., Brough, East Yorkshire, a brochure describing their mechanical-testing facilities, which are available to other engineering firms. Materials-testing equipment includes 30-ton and 10-ton Avery machines and 12,000-lb. and 2,000-lb. Denison machines. For testing large structures, two testing frames are available, one of which is provided with four straining gantries, each of 30 tons capacity. The other has four straining gantries, each of 10 tons capacity, and has an automatically-balanced weighbeam. A cold chamber is provided, in which the operation of hydraulic and pneumatic components can be tested, on special rigs, at temperatures down to -60°C . A wide range of electrical and electronic apparatus is available for strain-gauging techniques, investigating vibrations, and for measuring accurately time intervals of less than one millisecond.

CREEP-TEST RESEARCH STATION.

DURING the past few decades, there has been a continuous trend towards higher operating temperatures in many engineering processes. For example, boilers and turbines in modern power stations are working with steam at higher degrees of superheat than ever before, in order to secure the higher thermal efficiencies thereby made possible, gas turbines are running with blades red hot, and new chemical processes involving reactions at high temperatures are being developed. In consequence, it is becoming ever more important for designers to have accurate information on the physical properties of the materials—particularly the metals—which they subject to these high temperatures. For many years, engineering design was able to proceed satisfactorily on the basis of a knowledge of the mechanical properties of materials at ordinary temperatures, derived from short-term laboratory tests, but such knowledge is wholly inadequate when components have to be designed to withstand high temperatures for long periods since, under such conditions, creep of the materials and their ultimate mechanical failure may occur under loads and stresses far below those required to produce fracture at ordinary temperatures or under a rapidly increasing load.

It happens, therefore, that the phenomenon of "creep" in metals, the existence of which has been known for some considerable time, has lately assumed considerable importance and is receiving ever-increasing attention. Even so, the fundamentals of the subject are far from being wholly understood. There is no basic theory by which the creep of a metal or alloy under specified conditions of temperature and stress can be predicted with certainty, neither is it possible to say how the ultimate strength of a metal subjected to a high temperature will depend on the rate at which stress is applied to the material. Such information must be obtained from experiments, often of long duration, conducted under carefully controlled conditions and involving precise measurements of extremely small quantities.

The Metals Division of Imperial Chemical Industries, Limited, is one of the largest of the eleven manufacturing divisions of that company. It employs nearly

18,000 persons and is the largest single producer of wrought non-ferrous metals in the British Empire. Although its 19 factories are spaced over a wide area of Great Britain, its plant is concentrated mainly in the English Midlands and its headquarters are at Kynoch Works, Witton, Birmingham. It is obviously highly desirable that a large organisation of this kind should be in a position to test the materials which it uses and manufactures, and to supply its own engineers and its customers with accurate information regarding them. In particular, accurate information on the creep of metals is vital to economy and safety in design and is essential to metallurgists engaged on developing new alloys.

Taking advantage of the working economies made possible by the size of their Metals Division and the volume and continuity of the demand within it for specialised information on the properties of metals, Imperial Chemical Industries, Limited, have erected at Witton a research station for the study of creep in metals. The building itself is illustrated in Fig. 1, on this page, and consists of a two-storey block with an adjoining wing. The upper floor of the block contains offices and various other rooms used for calibrating and servicing equipment, recording observations and storing records. The ground floor houses an air-conditioning plant which maintains a constant temperature of 68°F . and a relative humidity of 60 per cent. in the testing laboratory, the long windowless wing, already referred to, which extends to the left of the block in the illustration.

The interior arrangement of the testing laboratory is illustrated in Fig. 2, herewith. Considerable advantage has been derived from designing the building *ab initio* as a creep-testing laboratory. In this, the company has had the advice of other organisations which undertake similar work. Two types of testing machine, both manufactured by Messrs. Samuel Derison and Son, Limited, Hunslet Foundry, Leeds, are installed. The larger machines, of which there are 36, are of 5 tons capacity. These are grouped into four batteries of nine machines, standing on separate concrete rafts, in order to insulate the machines from the main foundation of the building and from extraneous vibrations. Twenty-four smaller machines, each of

STANDARD MIXED-TRAFFIC 4-6-2 LOCOMOTIVE.



FIG. 1. STANDARD CLASS 6 LOCOMOTIVE, BRITISH RAILWAYS.

15 cwt. capacity, are mounted on concrete plinths at one end of the laboratory and are visible in the background of the illustration. Hollow concrete benches extending along the centre of the room support accurately aligned metal rails which serve as runways for the telescopes used to measure the extension of the specimens mounted in the larger machines. The louvred panels in the sides of these benches, which are visible in Fig. 2, communicate with the air-circulating system. Other louvres for the same purpose can be seen at the angle between the roof and each side wall.

The smaller machines are based on a design evolved by Mr. D. A. Oliver and Mr. G. T. Harris, and are used for tests to breaking point. The main frame of each machine consists of four vertical columns screwed into a bed-plate and supporting a bracket on which is pivoted a lever with a mechanical advantage of 10. The specimen to be tested is held by shackles, the upper one of which is connected to the shorter arm of the lever, by means of a universal joint, and the lower to a straining device. A pan for holding weights hangs from a knife-edge at the extremity of the longer arm of the lever. When a specimen has been screwed into the shackles, the appropriate load is placed in the scale pan which, at this stage, is resting on a wooden stand. The load is then applied gradually by turning a crank-handle connected to the straining device. The electric furnace which surrounds the specimen has three zones each with its own heater winding, and the furnace temperature is controlled by means of a thermostat which employs differential thermal expansion between stainless steel and Invar to vary the resistance in the heater circuit. The temperature of the specimen is measured by separately-wired thermocouples attached to the top and bottom of the 1-in. gauge-length of the specimen, the leads being taken to potentiometers and to thermostatically-controlled cold junctions. For ease of temperature measurement, two 24-point selector switches, mounted on a control panel, are incorporated in the measuring circuit and connected to the 48 thermocouples of the 24 machines.

In each furnace, an additional couple is bound to the centre of the specimen and connected to one channel of a six-channel autographic temperature recorder. There are ten such recorders, manufactured by Messrs. George Kent, Limited, Luton, in the records room referred to above. Extremely high accuracy of control and measurement is not essential in the case of specimens tested to rupture. The mechanical thermostat maintains the temperature of each specimen constant to within ± 2 deg. C. and the extension of the specimen is recorded on a dial-gauge mounted on the frame of the machine. When the specimen breaks, the furnace current is cut off automatically and the consequent drop in temperature is quickly shown on the automatic temperature recorder, so that the duration of the test can be determined. The readings of the dial-gauges are noted periodically and families of curves relating stress, time and creep-strain are plotted.

The larger machines are used to determine the rate of creep of specimens under various loadings up to 5 tons and at various temperatures up to 1,000 deg. C., or more. The machines are based on a design evolved by the National Physical Laboratory, Teddington.

As in the other case, the specimen is held in shackles, but these are supported by crossed knife-edges situated as far away from the specimen as possible. Ancillary equipment on each machine includes highly sensitive extensometers of the Martens type which not only measure the extension of the specimen but provide a check that the loading is purely axial. These extensometers are manufactured by the Cambridge Instrument Company, Limited, London. Their arrangement on the test specimen is illustrated in Fig. 3, on page 107.

The two inner mirrors of the extensometer are connected through rhomb-shaped spindles to the moving and fixed limbs of the instrument and, as the specimen extends, are displaced in angle relative to the outer pair. By means of an optical system and light source, the extension is magnified 2,000 times, so that an extension of 0.5 micron (0.00002 in., approximately), equivalent to one division on the measuring scale, can be detected readily. The reading is observed by means of a telescope mounted on the rails on the benches in the centre of the room, as mentioned previously. To avoid interference with the beam of light, the source of which is adjacent to the telescope, the straining gear of each machine is mounted above the top plate, and the graduated steelyard which carries the movable load is placed just above the bed-plate, as can be seen from Fig. 2.

The furnaces can also be seen in Fig. 2, housed between the four vertical columns of the machines. For ease of adjustment of their position they are supported by balance weights acting over pulleys. During development work, it was established that for the temperature-gradient to be satisfactorily small, the length of the furnace should be at least four times that of the specimen. It was also found necessary to have three separately wired heating zones. The furnace temperature is controlled by means of a platinum resistance thermometer connected to an electronic regulator which operates a vacuum switch by means of a thyatron valve. The regulator, which is a product of Sunvic Controls, Limited, maintains the temperature of the specimen constant to within ± 0.5 deg. C.

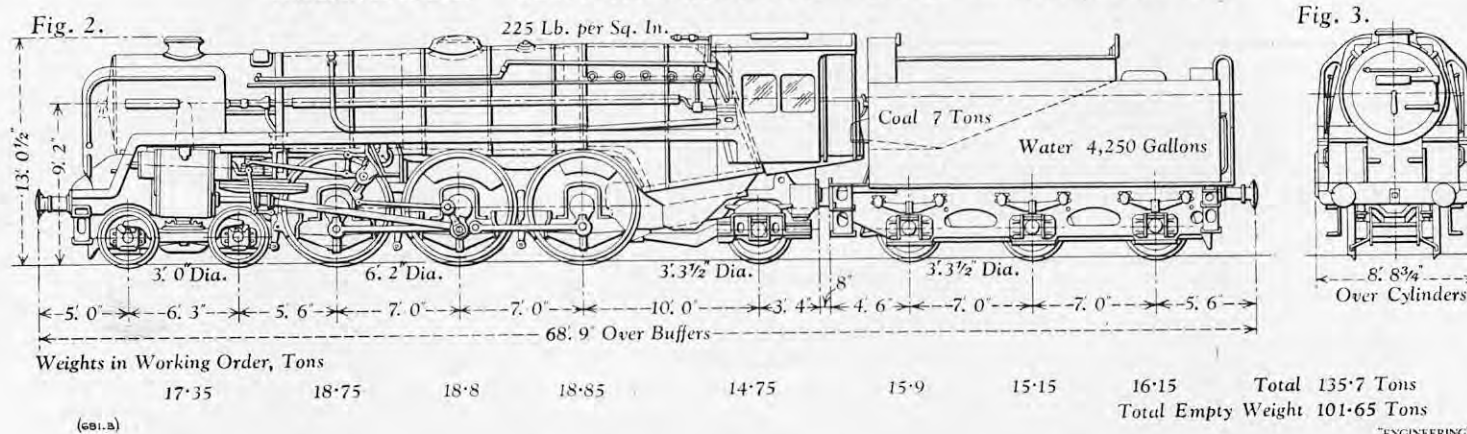
The measurement of the temperature is effected in the same manner as in the case of the small machines, but there are, in all, four thermocouples. One of these is strapped on at the top of the gauge length of the specimen, another at the bottom, and two in the middle. The length of the specimen is 5 in. Leads from three of the thermocouples are taken to a phenolic-resin junction-box which can be seen in Fig. 3, screwed to one of the rear vertical columns of the machine. The leads are then continued to a vernier potentiometer by which the temperatures may be measured correctly to within 0.08 deg. C. Three 18-point selector switches are mounted on a panel at an instrument-table so that the temperature at any one of 18 of the specimens can be determined. There are two such instrument tables, one on each side of the laboratory. Leads from the duplicate thermocouples in the middles of the specimens are taken to the autographic temperature recorders in the records room, which have already been mentioned. The conditions of test and the accuracy with which the conditions are maintained are all well within the limits laid down in the relevant publications of the British Standards Institute.

CLASS 6 STANDARD 4-6-2 LOCOMOTIVE; BRITISH RAILWAYS.

THE locomotive illustrated in Fig. 1, herewith, is the first of ten new standard engines which are being built at Crewe Works. It is a Class 6, 4-6-2 mixed-traffic locomotive, the fifth of the series of standard types for British Railways which have been designed and constructed under the direction of Mr. R. A. Riddles, C.B.E., M.I.Mech.E., member for mechanical and electrical engineering, Railway Executive. There are two outside cylinders, 19½ in. bore by 28 in. stroke, the coupled wheels are 6 ft. 2 in. in diameter, the boiler pressure is 225 lb. per square inch, and the tractive effort 27,520 lb. The adhesion factor is 4.59. The weights on the axles, in working order, together with the chief dimensions, are shown in Fig. 2, opposite. The weights, empty, are 80.45 tons for the engine and 21.2 tons for the tender. The proportions of the locomotive make it suitable for passenger and fast freight traffic of the types handled by the London Midland Region Class 6 engines and, at the upper limit of their capacity, by the regional Class 5 engines. The chassis is the same as that of the larger, Britannia, class, except for minor details, but the boiler has been made smaller in order to keep the maximum axle-load below 19 tons, thus ensuring a route availability at least as good as the several regional class 5, 4-6-0 engines. The minimum radius of curve that the locomotive will negotiate is 4½ chains (with a specified widening of the gauge of the track), and the braking proportion of the engine and tender is 50.6 per cent. Derby drawing office was primarily responsible for the design, though the other locomotive drawing offices of British Railways contributed sections of the design, as with the previous standard designs. The ten engines, numbered 72000 to 72009, are being built under the 1951 locomotive renewal programme. They are being named after Scottish clans and all are to be allotted to the Scottish Region.

The boiler shell is of high-tensile carbon-manganese steel, and the barrel consist. of two rings, the second tapered and forming a true truncated cone. The two rings are rolled from ½-in. and ⅝-in. plate, respectively, the outside diameters being 5 ft. 4 in. at the front and 6 ft. 1 in. at the firebox end. The smokebox tubeplate is of the drumhead type, ¾ in. thick, and there are 35 large flue tubes 5½ in. in diameter outside, 7 s.w.g. thick, and 108 small tubes 2½ in. diameter outside and 11 s.w.g. thick. The length between tubeplates is 17 ft. A Belpaire firebox with wide grate is fitted. The steel wrapper plate is ½ in. thick and the inner firebox is of copper and has a ⅝-in. wrapper plate. The front of the firebox is extended into the boiler barrel to form a combustion chamber having a 1-in. tubeplate. All firebox water-space stays are of Monel metal, with steel nuts inside the firebox. The roof, longitudinal and transverse stays are of steel, the former being riveted over outside the steel wrapper. The firebox is 6 ft. 9 in. long outside, the width tapering from 7 ft. at the front to 6 ft. 8 in. at the back, giving a grate area of 36 sq. ft. The free flue area is 5.73 sq. ft. and the heating surfaces are: tubes, 1,878 sq. ft.; firebox, 195 sq. ft.; and superheater, 628 sq. ft. The

STANDARD MIXED-TRAFFIC 4-6-2 LOCOMOTIVE.



dome contains a Melesco centrifugal steam drier. The regulator is of the Superheater Company's multi-valve type, incorporated in the superheater header in the smokebox. The boiler is fed with water through two separate clack valves on the front barrel, delivering on to two inclined trays which deflect the water round the inside of the barrel clear of the tubes. A steam manifold is fitted on the top of the firebox in front of the cab, and the boiler and firebox are lagged with a light-weight Fibreglass mattress. The boiler is fitted with a manually-operated blow-down valve made by the Everlasting Valve Company, Limited, 125, Balham High-road, London, S.W.12.

A rocking grate is provided, consisting of 10 rocking sections, five on each side of the centre-line, each section carrying 12 renewable firebar units. The two sides of the grate can be rocked separately from the footplate, the operating gear being arranged so that two different travels can be employed, i.e., full travel for dropping the fire when the engine is over an ash-pit, and a shorter travel for agitating the fire to eliminate ash and break up clinker while the engine is on the road. The ashpan has three "self-emptying" hoppers, one between and one each side of the main frames; these hoppers have bottom flap doors connected by a shaft with universal joints and operated by a lever at ground level. Front damper doors on each hopper are opened and closed by screw gear worked from a handwheel on the fireman's side of the cab, allowing a fine adjustment of the air opening. The smokebox is of the cylindrical type, resting on a fabricated saddle. The blast pipe has a plain circular cap with a 5 1/4-in. nozzle which incorporates the blower ring. The smokebox is of the "self-cleaning" type, having plates and a wire-mesh grid to prevent accumulation of ash in the smokebox when the engine is working. On the right-hand side a tri-tone chime whistle is mounted, operated from the cab by a flexible cable passing down the right-hand handrail on the boiler. The whistle was supplied by the Crosby Valve and Engineering Company, Limited, 251, Ealing-road, Wembley, Middlesex. A stuffing box on the left-hand side allows the regulator shaft to pass through the smokebox plate.

The main frames are 1 1/4-in. plates spaced 3 ft. 2 1/2 in. apart, the centre-lines coinciding with the centre of the axlebox-guide faces. The axlebox guides are welded to the frame plates and are fitted with manganese-steel liners. The frames are well braced by vertical and horizontal stretchers, as shown in Fig. 4, and by pin-jointed cross stays attached to the horn plates. The frame extension at the rear end consists of two 2-in. thick slabs riveted to the main plates behind the trailing coupled wheels and carrying a fabricated dragbox. A solid drawbar transmits the tractive effort to the tender, with side intermediate buffers on the tender bearing on rubbing plates on the engine dragbox. Two of the vertical stretchers support the front of the boiler barrel and the firebox front on adjustable brass wearing liners, and the back of the firebox is carried on brackets on the rear extension frames. The side footplating is carried by brackets fixed to the boiler. The engine and tender are carried on Timken taper-roller bearing axleboxes throughout, those for the bogie and coupled axles being of the non-split cannon type. The faces of the axleboxes in contact with the horn guides are provided with manganese-steel liners welded to the body of the axlebox, and are lubricated with soft grease. All springs for the engine and tender are laminated, with plates of carbon steel secured in the spring buckles by a vertical centre rivet. Underhung spring brackets, with rubber damping pads and hangers in tension, are provided for the coupled-axle springs, which have a span of 4 ft. when loaded. The hangers are solid, with cotters at the top and bottom ends. Adjustment is obtained by fitting cotters of suitable depths.

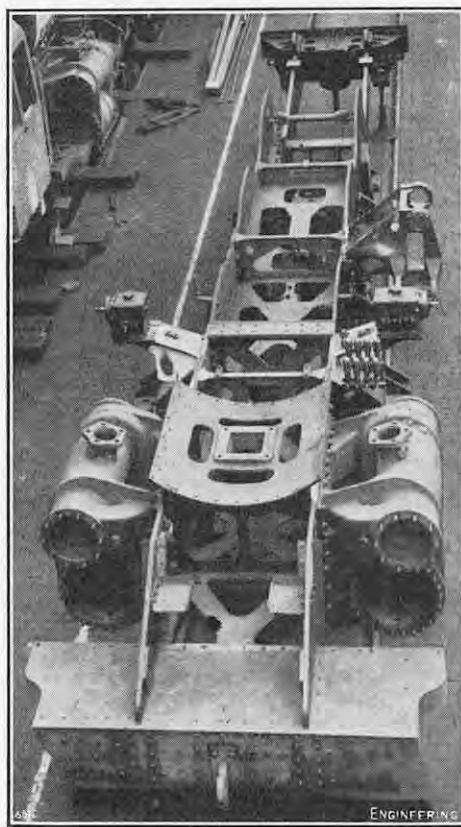


FIG. 4. CHASSIS IN ERECTING SHOP.

The two cylinders are steel castings with cast-iron liners, both in the barrel and valve chest. The 11-in. diameter valves have a steam lap of 1 1/8 in. and a lead of 1/4 in., and are actuated by valve gear of the conventional Walschaerts type, giving a travel in full gear of 7 3/4 in. and a full-gear cut-off of 78 per cent. The slidebars are of the three-bar type with an underhung crosshead. The piston head incorporates a bronze spring-loaded slipper which carries the head clear of the cylinder-barrel liner. Valve and cylinder lubrication is by atomised oil delivered by mechanical lubricators; the lubricators were supplied by Gulf Oil (Great Britain), Limited, 5, London Wall Buildings, London, E.C.2. Lubrication of the motion pins is by soft grease, nipples for the reversing shaft and expansion link being grouped together on the motion bracket. The eccentric-rod big-ends run in Skefko self-aligning ball bearings. Steam-operated cylinder cocks of large diameter are fitted for quick draining. Reversing is by a handwheel and screw, the latter being situated at the reversing-shaft lever and rotated by a tubular shaft from the cab. A drum-type cut-off indicator is provided and the operating wheel is placed parallel to the longitudinal centre-line of the engine. The coupled-wheel tyres are shrunk on and secured by two small lips, one each side of the wheel centre, there being no separate securing ring, studs or rivets. Built-up weights in the wheels balance the revolving weight and 40 per cent. of the reciprocating weight.

The bogie, which is interchangeable with that fitted to the Class 7 engines, has four wheels 3 ft. in diameter, and is carried on Timken roller-bearing axleboxes of the non-split cannon type. The engine weight is carried by side bolsters and by laminated springs fitted in compensating beams. Side-play control of the

bogie is by means of double coil springs. The pony truck, too, is identical with that on the Class 7 engines, and has wheels 3 ft 3 1/2 in. in diameter, fitted with Timken roller bearings running in outside axleboxes. The engine weight is taken at three points on the pony-truck frame, one being at the pivot centre of the pony truck, and the other two being bolsters sliding on pads on the truck frame and situated behind the centre-line of the pony-truck axle. Pony-truck side play is controlled by coil springs. The cab structure is carried by cantilever supports attached to the firebox backplate and by a diaphragm plate at the dragbox, this arrangement allowing freedom for the cab to move with the boiler as expansion takes place. All boiler fittings and pipes are kept free from the main frames to avoid differential expansion and ensure freedom from fracture due to this cause. For this reason, the Davies and Metcalfe exhaust-steam injector on the right-hand side and the live-steam injector on the left are carried on brackets attached to the ashpan and foundation ring. The steam and water controls for both injectors are operated from the fireman's side of the engine.

The tender is of the standard B.R. No. 1, 4,250-gallon type, holding 7 tons of coal. It is carried on six wheels 3 ft. 3 1/2 in. in diameter and is designed to give a good view to the rear when running tender first; the tank is welded and has a rectangular coal bunker narrower than the tank. Two external feed-water sieve boxes are provided to strain the water before it passes to the injectors; the sieve is easily withdrawn for cleaning or renewal. Water pick-up gear is provided. The wheels, axle and axlebox assembly for the tender is similar to that for the pony truck of the engine.

The engine and tender have steam brakes which can be worked independently or in conjunction with the vacuum brake by means of a separate Gresham and Craven driver's valve. A single brake block is applied to the six coupled wheels and all tender wheels. The brake rigging is grease-lubricated.

CONFÉRENCE INTERNATIONALE DES GRANDS RÉSEAUX ÉLECTRIQUES.—The fourteenth meeting of the Conférence Internationale des Grands Réseaux Electriques à Haute Tension will be held at the Fondation Berthelot, Rue Saint Dominique, Paris, from Wednesday, May 28, to Saturday, June 7, 1952. Details of the papers to be read and other particulars will shortly be issued by the British National Committee, Thorneycroft Manor, Dorking-road, Leatherhead, Surrey.

ALL-ELECTRIC SIGNALLING IN BRAZIL.—The section of the Estrada de Ferro Central do Brazil between the Roosevelt station, São Paulo, and Itaquera, which is being converted to electric traction, is being equipped by the Westinghouse Brake and Signal Co. Ltd., Kings Cross, London, N.1, with all-electric power frames and track circuits of the alternating-current reactance-feed type for signalling purposes. The main running signals will be of the searchlight type and the points will be operated electrically. Electrification has also necessitated the modernisation of the signalling by the same firm on the line between Mooca and Jundiaí.

ALMANACS AND CALENDARS.—Monthly tear-off wall calendars have been received from Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2; and the Westminster Chimney Sweeping Co., 10, Dacre-street, Broadway, London, S.W.1. A tear-off wall calendar showing two months on each page has reached us from Termomeccanica Italiana, La Spezia, Italy. This calendar is printed throughout in English. Russell and Chapple, Ltd., 23, Monmouth-street, Shaftesbury-avenue, London, W.C.2, have sent us a desk diary which contains one sheet for each week of 1952, and a calendar for three months is shown at the top of each sheet.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

IRON AND STEEL PRODUCTION.—Output of steel ingots and castings in Scotland during 1951 totalled 2,114,800 tons, a decline of almost 15 per cent. from the previous year's production of 2,426,200 tons. The output of pig iron expanded from 739,100 tons, in 1950, to 789,800 tons, last year. The increase of some 50,000 tons compared with only 36,800 tons for the whole of the United Kingdom. Pig production during December was at an annual rate of 852,400 tons, in contrast with 739,100 tons a year before. Steel output in December was equivalent to 2,145,200 tons a year against 2,398,400 tons in the corresponding month of 1950.

SHIPBUILDING STEEL SHORTAGE.—As well as suffering general shortage of steel, shipbuilders are faced with inadequate supplies of flats and plates. Since the adoption of welding on an extensive scale, fewer sections are now needed, but a larger output of flats, in particular, has become necessary. Under the new allocation scheme Clyde shipbuilders have had about 65 per cent. of their steel requirements authorised.

COAL EXPORTS.—Scottish coal exports, last year, totalled 807,641 tons, which compares with 950,430 tons in 1950, and 1,248,837 tons in 1949. The decline of 142,789 tons over 1950 did not, however, reflect the real drop in normal trade, as shipments included over 100,000 tons of silt, the fine residue accumulated from washery operations in former years, and unsaleable until now. Denmark, Belgium, Germany, and Italy are able to utilise this fuel, and each took substantial quantities.

INCREASE IN ELECTRICITY CHARGES.—A warning that an increase in the cost of domestic and commercial electricity is impending in South-East Scotland was given in Edinburgh on January 14, at a meeting of the South-East Scotland Electricity Consultative Council. The directors of the Glasgow Chamber of Commerce decided to protest to the British Electricity Authority, regarding the sudden and unexpected increase in the revised industrial electricity charges which became effective "quite unobtrusively" on December 15. They are to suggest that the increase should be spread over three years instead of 20 per cent. this year and 80 per cent. in 1953.

SEA TRANSPORT OF REFINERY TOWER.—Arrangements have been made for the transport by sea, from the Clyde to Swansea, of a refinery tower 70 ft. long, 12 ft. in diameter, and weighing 130 tons, to be erected at the Llandarcy plant of National Refineries Ltd. as part of a propane de-asphalting unit. The tower will be loaded at Glasgow into a tank-landing craft, fitted with a prepared timber foundation and securing stanchions. With favourable weather, the voyage, which is planned to begin about the end of this month, may be completed in four or five days. As the weight of the tower is beyond the capacity of the 50-ton floating crane at Swansea docks, it will be necessary to tow a 100-ton crane from Cardiff to unload it.

GLASGOW GLASS-TUBE FACTORY.—Mr. James Stuart, Secretary of State for Scotland, inaugurated a new plant at the Glasgow factory of Chance Brothers, Ltd., on January 16. This, it is claimed, will make Britain self-supporting in the manufacture of glass tubes for fluorescent lighting. The plant is described as the most up-to-date in Europe. It can produce 15,000,000 tubes a year. All the machinery has been constructed by British firms, and some of it has been designed by the owners' engineering department.

CLEVELAND AND THE NORTHERN COUNTIES.

IRON AND STEEL INDUSTRY.—Conditions in the iron and allied trades still confine business to extremely narrow limits and the general outlook continues to occasion much uneasiness, though in one or two branches some indication of a change for the better is not altogether absent. There is no saleable tonnage for supply this month, and allocations for February and March are much below requirements, but a little expansion in production is foreshadowed and imports promise to increase. Substantial parcels of American steel are expected, but delivery is unlikely to commence before the third quarter of the year. Acute scarcity of steel scrap continues.

TELEVISION ON THE NORTH-EAST COAST.—A deputation, comprising eight members of a committee formed last September under the chairmanship of Viscount Ridley to discuss and put forward the television interests

of North-East Coast local authorities, is planning to meet the Postmaster General. It is understood that one of the objects of the delegation is to persuade the Postmaster General to allow work to be resumed on a television transmitting station at Pontop Pike, Co. Durham.

CLOSING OF HAMSTEELS COLLIERY.—On January 12, the Hamsteels Colliery, near Lanchester, in the Durham Division of the National Coal Board, was closed down, owing to the exhaustion of its coal seams, after a useful life of 85 years. Of the 140 men employed at the colliery, 20 will stay until the pit has been dismantled. Of the others, upwards of 100 will go to the nearby Langley Park Colliery and the remainder to the adjoining Esh Colliery at Esh Winning.

LANCASHIRE AND SOUTH YORKSHIRE.

NEW FACTORIES IN SHEFFIELD.—More than a dozen factories or extensions of existing works are approaching completion in Sheffield on Corporation land alone. Most of them are in, or close to, the centre of the city. The trades concerned are cutlery, small tools, machine tools, fireplaces, saw making, clock making, bottling, weighing machines, metal research, and the manufacture of tungsten carbide.

HEAVY ORDER COMMITMENTS.—Sheffield cutlery manufacturers who have embarked upon a three-year programme to develop export trade, and have appointed their own agents abroad, are booked for seven months' ahead, and have had to decline to tender for cutlery for the Services. Acceptance would have meant delay to export deliveries which, it was felt, was undesirable. The home trade in cutlery has fallen off since before Christmas and some firms dependent upon home orders state that allocations of steel will be in excess of requirements.

EXPORTS AND CONCEALED UNEMPLOYMENT.—Hardy-pick, Ltd., have had to refuse an order from South Africa for 4,000 lb. worth of tools on account of lack of steel. The chairman and managing director, Mr. T. G. Jameson, states that the steel shortage is forcing his firm to use old rails, tyres and anything suitable they can obtain from which to forge components. The method is being used only as a last resort as it is wasteful and costly. Mr. Jameson adds that there is already concealed unemployment in Sheffield. If men cannot be found productive employment they are being given odd jobs about the works instead of being put on short time. The steel shortage, he asserts, is worse than during the war, and all the allocations in the world cannot produce steel if it is not there. Sheffield steelmakers have been advised that the first consignment of United States steel, for this country, has arrived at British ports.

STEELWORKS ABSENTEEISM.—A number of employees of the Park Gate Iron and Steel Co., Ltd., Rotherham, were suspended for periods of from one to three days because they absented themselves on New Year's Eve. The firm's 10-in. mill was out of commission on that night, and men had to be transferred from other departments to keep the open-hearth department at work.

THE LATE MR. W. H. TAYLOR.—We regret to record the death of Mr. Wilfred Henry Taylor, which occurred at Manchester on Tuesday, January 1, at the age of 77. Mr. Taylor joined the contracts staff of Messrs. Johnson & Phillips Ltd. in 1908 and subsequently became assistant contracts manager for the firm in the North-Western and Midlands area. In this capacity he was responsible for the erection of numerous sections of the grid and for many colliery electrification schemes. Although he officially retired in 1939 he was acting in an advisory capacity to the company until his death. Mr. Taylor was elected an associate of the Institution of Electrical Engineers in 1902 and transferred to the class of associate members in 1912.

THE MIDLANDS.

CONSUMPTION OF ELECTRICITY.—The effect of the raw materials shortage on Midland industry is reflected in the recent figures for electricity consumption. A statement issued by Alderman W. S. Lewis, chairman of the Midlands Electricity Board, in Birmingham, on January 14 shows that the consumption of electricity was 1.5 per cent. lower in December, 1951, than in the same month in 1950. This is the first time since the Board was established that a reduction in consumption has occurred. The December period included the long Christmas holiday, which accounted for some of the reduction, but the trend was evident earlier.

EMPLOYMENT IN THE MIDLANDS.—Figures given by Mr. J. W. Eldridge, deputy regional controller of the Ministry of Labour, on January 15, show that at least 6,627 persons in the region are working short time as a

result of the steel shortage. Mr. Eldridge stated that the figure had been arrived at by personal contact between managers of employment exchanges and employers, and should be regarded as a minimum. The major part of the total is shared equally between Birmingham and Coventry, only about 500 being affected in the rest of the region. The number of wholly unemployed in the area is now 10,077, but there is still a large demand for labour, over 46,000 vacancies being on the Ministry's books. Some progress has been made in transferring labour from less essential industries to those engaged on defence work. A number of carpet weavers from Kidderminster, who have been on short time, have been found employment in light engineering in the Bromsgrove and Redditch districts. Motor transport is being provided by the new employers to take the men to and from work.

INDUSTRIAL SAFETY EXHIBITION.—The industrial safety exhibition held last year at Bingley Hall, Birmingham, was so successful that the organisers are to hold another exhibition in the same building from May 4 to 16. The previous exhibition was local in scope, but it is hoped to attract exhibitors from all parts of the country to the next one. The organisers are the Birmingham and District Industrial Safety Group, whose secretary is Mr. G. M. Hopps, of Bakelite, Ltd., Redfern-road, Birmingham, 11.

ACCOMMODATION FOR VISITORS TO THE BRITISH INDUSTRIES FAIR.—In the past, hotel accommodation in Birmingham has sometimes proved inadequate for the large number of visitors to the Castle Bromwich section of the British Industries Fair. The Birmingham Chamber of Commerce, 95, New-street, Birmingham, 2, now have on their accommodation list over 2,000 private houses as well as hotels, which are prepared to provide accommodation during the period of the Fair.

TRANSPORT OF MOTOR VEHICLES FOR EXHIBITION.—The motor vehicles sent by the Austin Motor Co. Ltd., of Birmingham, for exhibition at the Brussels Motor Show, were transported by train ferry. A special train of 13 wagons was loaded at the Austin works and despatched via the Harwich-Zeebrugge route. This is the first time that the ferry service has been used for transporting vehicles to a foreign motor show. The Austin Co. propose to use the same means of transport for sending their exhibits to forthcoming motor shows in Geneva and Amsterdam.

SOUTH-WEST ENGLAND AND SOUTH WALES.

RECOVERY OF FINE COAL.—The South Western Division of the National Coal Board are making considerable progress with the recovery of fine coal, which previously entered the rivers. When measures being taken by the Coal Board were explained at a recent meeting with representatives of the Cardiff Port Development Association, it was stated that more than 60,000 tons of fuel were being recovered per annum.

EXPORTS AND IMPORTS.—The South Wales ports, between them, last year, handled a total of 20,460,191 tons of imports and exports, compared with 18,651,294 tons in 1950. Imports rose from 7,218,183 tons to 9,405,085 tons, but exports fell from 11,433,111 tons to 11,055,106 tons. The fall is due to reduced coal and coke shipments, which, last year, amounted to 6,708,606 tons against 7,943,840 tons a year before. Swansea handled no less than 47 per cent. of the total trade. Two steel cylinders, each weighing 69 tons, and two, each weighing 24 tons, were included in the cargo recently brought into Cardiff docks on the steamer Birmingham City. They were purchased in the United States for installation in the Ely Paper Mills, Cardiff.

EMPLOYMENT IN FACTORIES.—Capt. H. K. Oram, Controller for Wales, Board of Trade, speaking at the annual dinner of the South Wales Institute of Engineers at Cardiff on January 17, said that it was not easy quickly to switch factories and industries to defence contracts without some unemployment, but the maximum possible number of workpeople must be kept employed. This was particularly so in the interests of South Wales where the effect was magnified by the fact that many industries were in isolated districts, and the prospect of alternative employment was not so good as in industrial centres such as Birmingham and London. About 80 per cent. of the new industries brought to Wales were in no danger in this respect. Of the remaining 20 per cent., about half were engaged on work that could be reasonably expected to continue.

RECORD AT BRITON FERRY ROLLING MILL.—The Albion Steelworks, Briton Ferry, created a record in their rolling mill plant in the week ended January 12, in spite of the difficulties caused by shortage of scrap. Output reached 4,046 tons, using only five of the seven furnaces.

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 28, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "Should Further Television Development Be Concentrated on Colour to the Exclusion of Black and White?" to be opened by Mr. L. C. Jesty. **North-Eastern Centre:** Monday, January 28, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "A Brief Review of the Engineering Problems Associated with the Integration of the Undertakings in the North Eastern Electricity Board's Area of Supply," by Mr. T. M. Ayres. **North Midland Centre:** Tuesday, January 29, 6 p.m., Lighting Service Bureau, 24, Aire-street, Leeds. Discussion on "Is the Scope of Electrical Engineering Courses Too Narrow?" opened by Mr. R. A. H. Sutcliffe. **East Midland Centre:** Tuesday, January 29, 6.30 p.m., Loughborough College, Loughborough. "Electrical Characteristics of the Ljungström Turbo-Alternator Unit," by Mr. H. T. Price. **South Midland Centre:** Tuesday, January 29, 7.15 p.m., Winter Gardens Restaurant, Malvern. "A New Theory of the Magnetic Amplifier," by Mr. A. G. Milnes. **Supply Section:** Wednesday, January 30, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "Economic Plant Sizes and Boiler Set Groupings on the British Grid," by Mr. B. Donkin and Mr. P. H. Margen.

INSTITUTION OF WORKS MANAGERS.—Manchester Branch: Monday, January 28, 6.30 p.m., Grand Hotel, Manchester. "Re-Equipment and Profits," by Mr. D. G. Petrie. **London Branch:** Thursday, January 31, 6.45 p.m., Waldorf Hotel, Aldwych, W.C.2. "Management and the Trade Unions," by Mr. T. Birkett.

ILLUMINATING ENGINEERING SOCIETY.—Leeds Centre: Monday, January 28, 7 p.m., Lighting Service Bureau, 24, Aire-street, Leeds. Joint Meeting with the ELECTRICAL ASSOCIATION FOR WOMEN. "Television in Yorkshire," by Mr. J. T. Thornton.

INSTITUTION OF PRODUCTION ENGINEERS.—Southern Section: Monday, January 28, 7 p.m., Municipal College, Portsmouth. "Some Interesting Set-Ups on Modern Machine Tools," by Mr. R. C. Fenton. **Luton Section:** Tuesday, January 29, 7.15 p.m., Town Hall, Luton. "The Effective Use of Metals," by Dr. E. G. West. **Shrewsbury Sub-Section:** Wednesday, January 30, 7.30 p.m., Technical College, Shrewsbury. "Activities of the Production Engineering Research Association," by Dr. D. F. Galloway. **Cornwall Section:** Thursday, January 31, 7.15 p.m., Cornwall Technical College, Trevenon Park, Pool. "Work Study," by Mr. R. M. Currie. **West Wales Section:** Friday, February 1, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Methods and Relations," by Professor J. R. Immer.

JUNIOR INSTITUTION OF ENGINEERS.—Sheffield Section: Monday, January 28, 7.30 p.m., Co-operative Educational Centre, 201, Napier-street, Sheffield, 11. "Modern Power Station Construction," by Mr. S. S. Ellam. **Institution:** Friday, February 1, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Film Evening.

INCORPORATED PLANT ENGINEERS.—West and East Yorkshire Branch: Monday, January 28, 7.30 p.m., University, Leeds. "Plant Problems in Property Maintenance," by Mr. J. Stephenson.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Bournemouth Branch: Monday, January 28, 8.15 p.m., Grand Hotel, Firvale-road, Bournemouth. "Sports Lighting," by Mr. D. E. Beard. **Luton Branch:** Thursday, January 31, 8 p.m., George Hotel, Luton. "A Camera and the Engineer," by Mr. G. E. Whalley.

ROYAL INSTITUTION.—Tuesday, January 29, 5.15 p.m., 21, Albemarle-street, W.1. "Physical Methods in Meteorology,"—I. "Exploring the Atmosphere," by Mr. P. A. Sheppard.

INSTITUTION OF CIVIL ENGINEERS.—Railway Engineering Division: Tuesday, January 29, 5.30 p.m., Great George-street, Westminster, S.W.1. Discussions on "Continental Railway Civil Engineering Practice": (i) "Observations on a Visit to French Railways in 1949," by Mr. R. G. Thurtell. (ii) "Observations on a Visit to the Netherlands Railways in 1950," by Mr. J. G. F. Inglis.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 29, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Vibrations in Marine Engineering," by Mr. A. E. Fothergill.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, January 29, 7 p.m., Royal Society of Tropical Medicine and Hygiene, Manson House, Portland-place, W.1. "Some Mechanical Considerations in the Design of Electrical Servo Systems," by Professor A. Tustin.

INSTITUTION OF NAVAL ARCHITECTS AND INSTITUTE OF MARINE ENGINEERS.—Southern Junior Branch: Tuesday, January 29, 7.30 p.m., Municipal College,

Portsmouth. "Propeller Calculations," by Dr. John F. Leathard.

ROYAL SOCIETY OF ARTS.—Wednesday, January 30, 2.30 p.m., Wednesday, January 30, 2.30 p.m., John Adam-street, Adelphi, W.C.2. "Security Offered by Locks and Safes," by the Hon. George C. H. Chubb.

INSTITUTION OF MECHANICAL ENGINEERS.—Western Branch: Wednesday, January 30, 3 p.m., Electricity Offices, The Parade, Taunton. Joint Meeting with the *South-Western Sub-Centre* of the INSTITUTION OF ELECTRICAL ENGINEERS. "The Development of the Electrical System of the Bristol Brabazon," by Mr. M. J. J. Cronin. **Forkshire Branch:** Wednesday, January 30, 7 p.m., Mappin Hall, The University, Sheffield. Repetition of the Thomas Hawksley Lecture on "Some Fuel and Power Projects," by Dr. H. Roxbee Cox. **Southern Branch:** Wednesday, January 30, 7.15 p.m., Royal Aircraft Establishment Technical College, Farnborough. "Control of Quality of Engineering Parts Produced in Medium and Large Quantities," by Mr. J. Loxham. **Institution:** Friday, February 1, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Hydraulics Group*. "Powered Flying Controls: Some Design Considerations," by Mr. F. J. Bradbury. **AUTOMOBILE DIVISION.—Western Centre:** Thursday, January 31, 6.45 p.m., Royal Hotel, Bristol. "Independent Rear Suspension," by Mr. Donald Bastow. **Coventry Centre:** Tuesday, February 5, 7.15 p.m., Craven Arms Hotel, Coventry. Informal Discussion Meeting.

INSTITUTION OF STRUCTURAL ENGINEERS.—Lancashire and Cheshire Branch: Wednesday, January 30, 6.30 p.m., College of Technology, Sackville-street, Manchester. Three short lectures, by Mr. W. H. Rosier, Mr. A. S. Sinclair and Mr. C. Thirsk.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, January 30, 6.30 p.m., 9, The Temple, 24, Dale-street, Liverpool. "Dynamometers and Engine Test Plant," by Mr. K. G. Reeves.

ROYAL STATISTICAL SOCIETY.—Industrial Applications Section, Birmingham Group: Wednesday, January 30, 6.45 p.m., Chamber of Commerce, 95, New-street, Birmingham. "Problems of Quality Control in a Rubber Factory," by Mr. M. G. Peakman. **Sheffield Group:** Thursday, January 31, 7 p.m., Grand Hotel, Sheffield. "Some Applications of Sequential Sampling to Steel Works Problems," by Mr. G. F. Komlosy.

INSTITUTE OF BRITISH FOUNDRYMEN.—London Branch: Wednesday, January 30, 7 p.m., Waldorf Hotel, Aldwych, W.C.2. (i) Short address on "The Implementation of the Garrett Report," by Mr. Colin Gresty. (ii) "The Observation and Control of Dust in Foundry Dressing Operations" (with film), by Mr. W. B. Lawrie.

INSTITUTION OF ENGINEERING INSPECTION.—Thursday, January 31, 6 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "The Use of Photoelasticity in Engineering Design," by Mr. H. T. Jessop.

ROYAL AERONAUTICAL SOCIETY.—Section Meeting: Thursday, January 31, 7 p.m., 4, Hamilton-place, W.1. "The Problem of Short Haul Air Transport," by Mr. P. W. Brooks.

INSTITUTE OF ECONOMIC ENGINEERING.—Liverpool Branch: Thursday, January 31, 7.30 p.m., Radiant House, Bold-street, Liverpool. Open Discussion Meeting. **Glasgow Branch:** Saturday, February 2, 10.30 a.m., Christian Institute, 70, Bothwell-street, Glasgow. "American Business Education," by Dr. Eric Thompson.

INSTITUTE OF FUEL.—South Wales Section: Friday, February 1, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion Meeting.

BIRMINGHAM ASSOCIATION OF MECHANICAL ENGINEERS.—Friday, February 1, 6.45 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Dynamic Balancing and Testing," by Mr. A. Binns.

INSTITUTION OF SANITARY ENGINEERS.—Tuesday, February 5, 6 p.m., Caxton Hall, Caxton-street, Westminster, S.W.1. "Sanitation in the British West Indies," by Mr. C. L. Langshaw.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, February 6, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Informal Discussion on "Passenger Comfort on Modern Coaching Stock."

BRITISH INSTITUTION OF RADIO ENGINEERS.—Scottish Section: Thursday, February 7, 7 p.m., Royal Technical College, Glasgow. "Some Special Oscillograph Techniques," by Professor F. M. Bruce.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 8, 6.15 p.m., Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Fuel-Injection Systems for Large Marine Engines," by Mr. P. Jackson. **Student Section: Saturday, February 9, 2.30 p.m., Bolbec Hall, Newcastle-upon-Tyne. Address by Mr. P. L. Jones.**

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, February 8, 6.45 p.m., College of Technology, Manchester. Annual Lecture, by Professor F. C. Williams.

PERSONAL.

LORD RIVERDALE has relinquished his seat on the board of the Telegraph Construction and Maintenance Co., Ltd. His successor is DR. EDMOND W. SMITH, B.Sc., M.I.E.E.

MR. C. M. COCK, M.I.E.E., M.I.Mech.E., has been nominated by the Council of the Institution of Locomotive Engineers, 28, Victoria-street, London, S.W.1, to succeed Mr. J. S. TRITTON, M.I.C.E., M.I.Mech.E., as President of the Institution when the latter retires on May 31, 1952.

MR. F. G. WOOLLARD, of the Birmingham Aluminium Casting (1903) Co. Ltd., has been elected chairman of the Zinc Alloy Die Casters Association Council, Lincoln House, Turl-street, Oxford, for 1952-53. He will be assisted by Mr. J. W. CARTLIDGE, who, as retiring chairman, assumes the office of deputy chairman.

MR. JAMES A. EDDISON, M.A.(Cantab.), A.M.I.C.E., A.M.I.Struct.E., has been taken into partnership in the firm of Blyth and Blyth, consulting structural engineers, 135, George-street, Edinburgh, 2.

MAJOR-GENERAL G. N. TUCK, late R.E., has been appointed Engineer-in-Chief, War Office.

MR. J. A. MACLEAN, B.Sc.(Glas.), A.M.I.E.E., has been appointed representative of the Metropolitan-Vickers Electrical Export Co., Ltd., in Canada and Mr. W. BAILEY, D.S.C., G.I.E.E., manager for this firm in Portugal.

MR. B. L. BELL, B.Sc., A.M.I.C.E., assistant district engineer, London Midland Region, British Railways, Barrow-in-Furness, has been appointed assistant district engineer, North Eastern Region, Newcastle-upon-Tyne.

MR. L. E. SAKER, who has been for more than 40 years with Lancashire Dynamo and Crypto (Mfg.) Ltd., has been appointed chief engineer of the Willesden Works of that company.

MR. M. H. ROLLASON has been elected deputy chairman of Wright's Ropes Ltd.

MR. D. E. WOODBINE PARISH has been elected President of the London Master Builders' Association.

MR. I. A. DANNREUTHER, M.A.(Oxon.) has been appointed principal assistant to Mr. E. G. CLARKE, executive director of Acheson Colloids Ltd., 18, Pall Mall, London, S.W.1.

MR. J. W. R. WHITE, deputy district manager of the Dunlop Rubber Co. (Scotland) Ltd., since 1947, has been made district manager in Edinburgh in succession to Mr. E. J. LAWSON CLARK, who, as stated on page 79, *ante*, has been appointed regional manager in Northern Ireland.

MR. R. S. EADIE, M.Sc., formerly chief engineer, Eastern Division, has been appointed vice-president and manager, Eastern Division, Dominion Bridge Co., Ltd., Montreal, Canada. **MR. A. S. GENTLES, manager of the firm's Pacific Division,** and **MR. G. P. WILBUR, manager of the Ontario Division,** have been appointed, in addition, vice-presidents of the company. **MR. D. B. ARMSTRONG, formerly assistant chief engineer,** has been made chief engineer, Eastern Division. **MR. R. M. ROBERTSON, B.Sc., formerly designing engineer,** succeeds Mr. Armstrong as assistant chief engineer, and **MR. P. G. A. BRAULT, formerly assistant to the designing engineer,** has now become designing engineer.

MR. G. W. JOHNSON, B.Sc., A.M.I.E.E., A.M.I.Mech.E., is the new full-time manager of the Liverpool district office of the British Thomson-Houston Co., Ltd., Rugby. **MR. A. B. RACE** continues as the firm's Manchester district office.

MR. J. G. GORDON and Mr. R. G. HILL have been appointed joint assistant secretaries of the Liverpool Steamship Owners' Association, 10, Water-street, Liverpool, 2. Mr. Gordon will act in the Association's London office.

E.C.D. LIMITED are to manufacture and sell under an exclusive licence in Great Britain, and on a non-exclusive basis in certain other territories, the tonnage ozone equipment of WELSBACH INTERNATIONAL, INC., of Philadelphia, U.S.A.

SMALL AND PARKES LTD., Hendham Vale Works, Manchester, 9, announce that the new address of their Southampton office is 5-9, Payne's-road, Freemantle, Southampton. (Telephone: 71276.)

THE STANDARD MOTOR CO. LTD. have bought the factory at Allesley, Coventry, at present occupied by PEERLESS and ERICSSON LTD., who are concentrating production at their premises at King's Norton, Birmingham. The Allesley factory will house the Standard Motor Co.'s service and repair department until a new building, now being erected at Liverpool, is ready.

BRITISH INSULATED CABLES LTD. and the LOEWY ENGINEERING CO. LTD. have formed a new company, **ALSHEATH LTD., Norfolk House, Norfolk-street, London, W.C.2,** to utilise their knowledge and experience in the field of aluminium sheathed cables.

The address of the Manchester area sales office of the **NORTHERN ALUMINIUM CO. LTD.** is now: 75, Piccadilly, Manchester, 1. (Telephone: Central 5479.)

TEST HOUSE FOR TIMBER STRUCTURES.

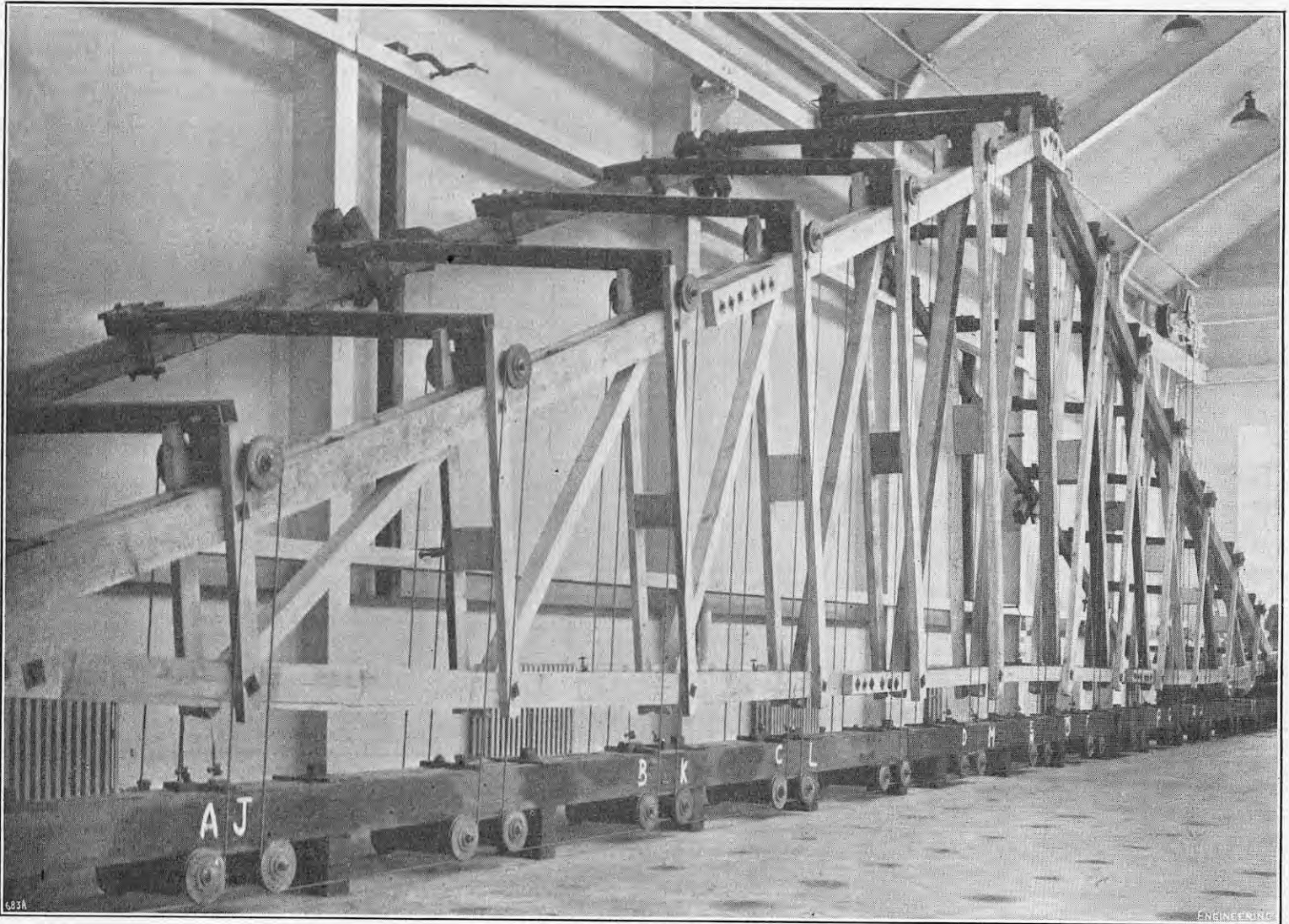
(For Description, see Page 127.)

FIG. 1. TRUSS AFTER COLLAPSE UNDER LOAD.

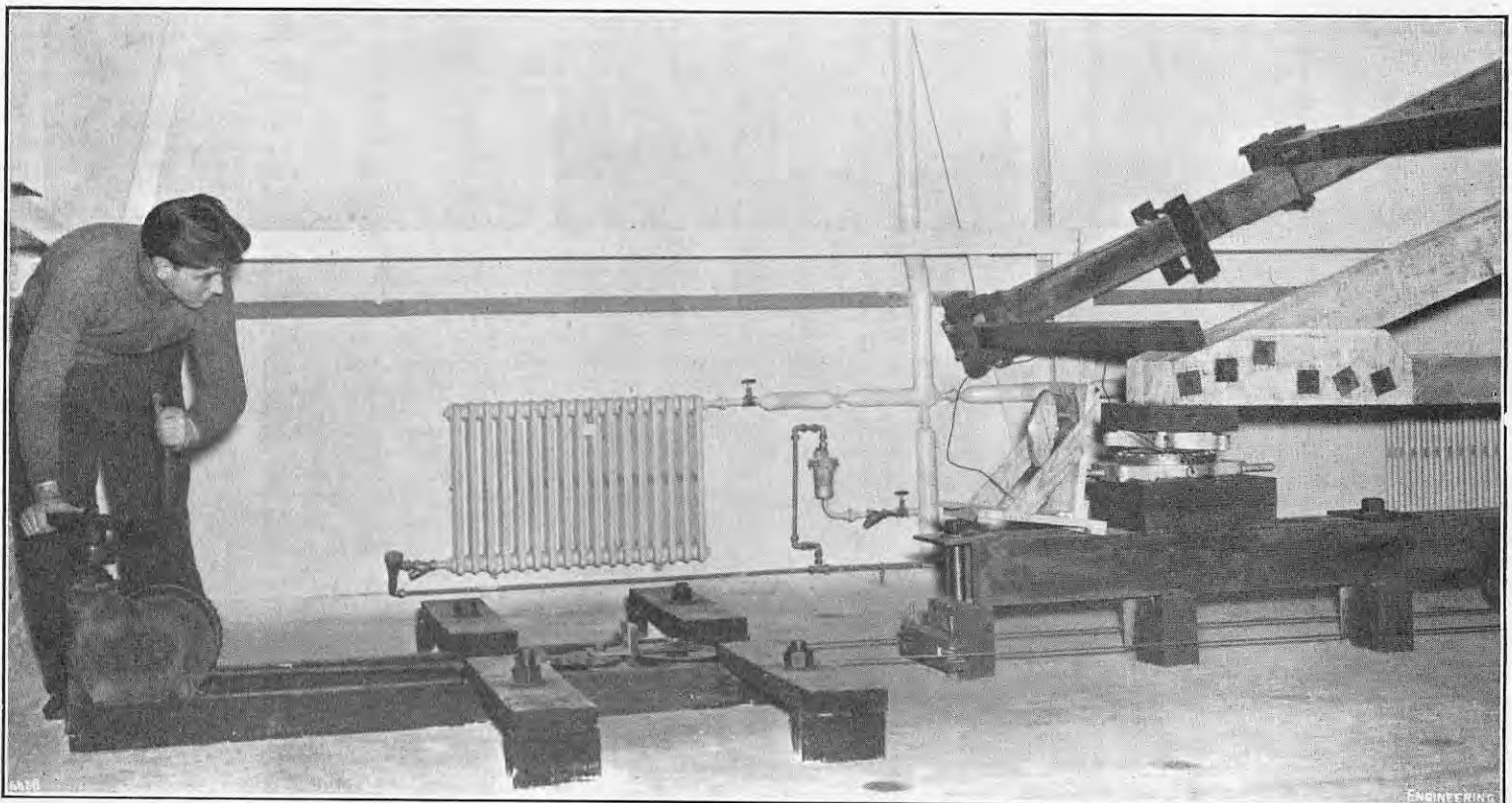


FIG. 2. WINCH FOR LOADING TRUSS.

ENGINEERING

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

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

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

SUBSCRIPTIONS.

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

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

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

ADVERTISEMENT RATES.

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

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

INDEX TO VOL. 171.

The Index to Vol. 171 of ENGINEERING (January-June, 1951) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, JANUARY 25, 1952.

VOL. 173.

No. 4487.

INDUSTRY AND THE STERLING CRISIS.

THERE are evident indications that the conference of Commonwealth Finance Ministers, which was concluded in London on January 21, has resulted in agreement on a number of vital points; not least among them being recognition of the fact that the crisis which threatens in the life of the British nation—and which must affect, in greater or less degree, every nation that is associated with or does business with Britain—is one of a magnitude probably unknown in living memory. Mr. R. A. Butler, the Chancellor of the Exchequer, has described the conference as having "given a new lease of life to the sterling area"; an optimism that would have seemed more emphatic if the Chancellor had not appeared to qualify it, within 24 hours, by renewed warnings of the gravity of the situation. To record that fact is not an implied criticism of his earlier statement, for it is not hard to realise how difficult is the position of a Minister who is faced with the complex problem of developing in the public a due seriousness of mind, without, however, causing despondency and despair; and, concurrently, arousing that spirit of high endeavour which is usually associated with a healthy optimism, without allowing that optimism to induce complacency. When, at the same time, industry and the public at large are already obsessed—perhaps, over-obsessed—with the thought of the Budget that the Chancellor must have in active preparation, there is all the greater need that he should choose his words with particular care.

The principal steps that it is proposed to take, according to the official statement, comprise action to check inflation, more especially by increasing exports and the nation's earning power; long-term borrowing "from outside the sterling area," to develop its resources; and a serious endeavour to restore and maintain the convertibility of sterling. It would seem that the Ministers who attended the Conference entertain no doubt that the Commonwealth countries can, if they will, reach a speedy solution of their present difficulties; for, it is stated,

they are to put before their respective Governments "definite proposals calculated to ensure that the sterling area as a whole will be in balance with the rest of the world in respect of the second half of 1952." So far as Britain is concerned, these proposals will involve some reduction of imports, though it is emphasised that the conference was not disposed to rely on that sterile and depressing policy as being more than a temporary palliative while more fruitful proposals are being explored. Presumably, they did not need to be convinced that exports without imports, as a long-term *modus operandi*, is as impracticable as Britain is now finding the maintenance of imports without equivalent exports.

Admirable as these expressed intentions are, however, they are going to be uncommonly difficult to implement unless there is a wholesale change of heart in the working population of this country, and an open declaration of that change, not only by His Majesty's Opposition in Parliament, but by the accredited spokesmen of all the organised sections of the community. We have said before, and still firmly believe it to be true, that the greater part of the national difficulties could be overcome in a matter of months if there were evinced a general resolution to do more work without demanding extra money for doing it; or even a united and determined resolve to do, without argument or evasion, the work that is being paid for, but not done, at the present time. If, by way of a start, the Government would take some really drastic—but patently sensible—action to cut down their swollen Departments, and abolish a few of them entirely, the public would probably respond to the needs of the moment with an appreciably greater alacrity.

One of the cardinal points of the Conference programme, as indicated above, is the encouragement of investment "from outside the sterling area"; an expression which, as the commentators in the national Press have been quick to remark, can only mean "from the United States." It is pertinent to inquire, however, what inducement there is to any potential investor in that commercially realistic nation to tie up his capital in a country which has already absorbed so much of it, and in which it has become the fashion to decry "profit" as something anti-social, if not positively unclean. The idea is, apparently, that the desired influx of new capital shall be used to develop productive resources; but that was the ostensible purpose of the American loans already received, the interest on which is now a first charge on the British revenue. That American money came from savings—the only source of new capital that exists in any country; and American taxation is becoming steadily heavier, like the taxation in most other countries. On the face of it, a much better policy would be to see to it that the British citizen is provided with the means and the encouragement to do his own saving so that he may be able to finance his own developments of resources; but if he is to save, he must be allowed to make and retain a more liberal profit from his labours than is possible in present circumstances.

There is a great need for some clear thinking on this question of profit, and in this connection the national newspapers of this country could perform a valuable service by exercising a tighter control over the way in which the earnings of a few outstanding industrial companies are publicised in their columns. Many companies, when presenting their annual financial statements, now make it a practice to explain whence their income is derived and how it is spent; but, unfortunately, these explanations do not always receive the same publicity as the figures of their gross "profits"—which, as Sir George Nelson told the shareholders of the English Electric Company a couple of years ago, ought rightly to be termed "balance on trading account." How very modest are the actual profits accruing to the shareholders in the average industrial

concern is well brought out in *The Earnings of Industry*, a copy of which we have received recently for review,* and in which the financial statements of a large number of typical companies are analysed, in different branches of industry.

In the section dealing with "Iron, Steel and Engineering," detailed analyses are given of the accounts of seven large companies or groups of companies, and the following sections continue the review with similar particulars of 25 or 30 more. Some of the businesses have been nationalised, and in those cases the figures given are for pre-nationalisation years. For example, in 1949-50, the United Steel Companies group had a gross income of 56,118,187*l.* Of this total, more than 34*l.* millions was expended in the purchase of materials, fuel and services; wages, salaries and State insurance took nearly 13*l.* millions; depreciation, and other money retained in the business for necessary operating purposes, accounted for nearly 2*l.* millions; and only 574,686*l.* went to the stockholders as dividends. In some other cases cited, the relative proportions of receipts and expenditure are given per pound sterling of turnover. For instance, the Brightside Foundry and Engineering Company stated that, in 1950, out of each 20*s.* received, they spent 12*s.* 11½*d.* on materials, 5*s.* 1½*d.* on wages, salaries and insurance, 11*d.* in taxes, and only 3½*d.*, or 1·6 per cent., in dividends. Colvilles, Limited, in 1948 and 1949, respectively, spent 10*s.* 11*d.* and 12*s.* 7*d.* on materials and services, 4*s.* 7*d.* and 4*s.* 1*d.* on wages and insurance, 1*s.* 3*d.* on taxation, and 2*d.* in dividends. John Summers and Sons, out of a turnover in 1950 of rather more than 24*l.* millions, spent over 9*l.* millions on materials, 5½*l.* millions on wages and insurance, over 1½*l.* millions in taxation, and 377,188*l.* in dividends.

The proportions in the case of manufacturing firms engaged in the engineering and allied industries are broadly similar. The Lancashire Dynamo and Crypto Company, in 1950, spent 47·8 per cent. of their gross revenue on materials, 33·2 per cent. on wages, salaries and welfare services, 4·6 per cent. on taxes, and distributed 1·7 per cent. to the stockholders. Corresponding figures for the Crittall Manufacturing Company, in 1950, per 20*s.* of revenue, were 10*s.* 0½*d.*, 7*s.* 2½*d.*, 1*s.* 6½*d.* and 4*d.* The engineering firm of Richardsons Westgarth, and Company, for their 1949-50 financial year, reported 10*s.* 8·3*d.*, 6*s.* 11·4*d.*, 1*s.* 0·4*d.* and 3·1*d.* under the same heads; and General Refractories, Limited, in 1947, gave their corresponding proportions as 9*s.*, 5*s.* 3½*d.*, 10½*d.* and 2½*d.* It may be noted that, in this case, the item of 5*s.* 3½*d.* included "wages, salaries, national insurance and holidays with pay." The cost of the holidays with pay was not given separately, but the United Steel Companies, in their 1949-50 statement quoted above, recorded that this item cost 363,855*l.* (0·65 per cent.) out of their gross revenue of 56*l.* millions.

Broadly speaking, shareholders in the engineering and allied industries are by no means generously rewarded, especially when it is borne in mind that, during the greater part of the inter-war period, many firms paid no dividend for years in succession. In this, of course, they are no worse off than shareholders in many trading companies. There is quoted in *The Earnings of Industry* a review, taken in 1950, of the whole of the 17,000 public companies in Great Britain, from which it appears that, in that year, wages and salaries totalled 5,055*l.* millions, but dividends only 320*l.* millions—less than 7 per cent. before taxation. Such a level of remuneration is hardly likely to attract fresh capital "from outside the sterling area," especially into industries, such as engineering, in which depreciation is already inadequate and productivity depends upon the provision of modern plant and ample power.

EDUCATION OF ENGINEERS IN THE UNITED STATES.

AMID the welter of arguments on engineering education it is worth pointing out that an authoritative American organisation is emphatically in favour of resisting the tendency towards specialisation, even in post-graduate work, and of strengthening the instruction given in basic knowledge. Evidence of this is to be found in the 19th annual report* of the Engineers' Council for Professional Development. The eight societies represented on the Council are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Engineering Institute of Canada, the American Society for Engineering Education, the American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners. The weight of authority behind the E.C.P.D., however, has clearly not had a retarding influence, since the report shows that, in technical education as in general education, there are many people in the United States whose approach is anything but complacent. The work of two of the committees—the ethics of engineers and campaigning for greater public recognition of engineers—will not make a strong appeal to engineers in this country, where, more often than not, men with the highest principles have the least to say about ethics and engineers with the greatest reputations have the least to say about themselves; but this is a basic difference in the conventions natural to the two communities and should not diminish the respect of each for the other.

The E.C.P.D. Committee on Adequacy and Standards of Engineering Education, in their report, go back to first principles in a critical appraisal of the work of engineering schools and colleges. They found that engineering education had no generally accepted professional objective; the objectives, such as they were, ranged from highly professional programmes, supported by strong science backgrounds, to vocational work in which only a moderate amount of science was included. There was general agreement on the form of the curriculum; the major differences lay in the depth of instruction in each subject and in the professional outlook at which each institution aimed.

In the Nineteenth Century, applied engineering predominated in engineering syllabuses, but gradually basic science courses were evolved. From 1885 until the first World War, mathematics, terminating with the calculus, was stabilised in the older curricula. Since then, only a few schools have carried the subject farther in civil, mechanical, chemical and mining engineering, though many have required additional mathematics in electrical engineering. The time devoted to physics has remained practically constant for 70 years, and the classical approach has generally been followed, but the committee suggest that the approach should now be based on modern knowledge of atomic and molecular structure. In mechanics, as in physics, the "depth" of instruction varies between different schools; in mechanical engineering, for example, vibrations and their effects are treated in only a few schools, and, in civil engineering, dynamics is regarded as being unnecessary in spite of the fact that fatigue is becoming more important in structural design. Hydraulics, used to be taught from the empirical standpoint, but between the two wars there was pressure from the aeronautical field for instruction in fluid mechanics. The committee found that some schools dealt sincerely with this requirement, but

many others simply changed the name of the course from hydraulics to fluid mechanics.

The difficulty of preparing a curriculum arises from the fact that the science and practice of engineering 20 or more years hence, when the work of to-day's students will reach maturity, must be envisaged now, however hazily. The committee therefore conclude that emphasis must be placed on "those elements of the curriculum that will give the most continuous and lasting support to the graduate's professional life." Too much time must not be spent on instruction relating to the present state of the art of engineering, since it will change with time; rather must time be spent on the basic sciences, and of these "the greatest potential for future development in science and technology is to be found in mathematics." An engineer with a good knowledge of mathematics can read with understanding and profit in physics and chemistry, he can extend his reading in the applied sciences, and he can assimilate new applications of science to engineering.

The committee were also concerned with the way in which the applied engineering courses are related to courses in basic and applied science. They discerned two distinct approaches: one used the engineering situations provided in the applied courses to illustrate the manner of employing the sciences in engineering work, while the other made the applied courses the goal of the curriculum, with the minimum of application of the sciences. The first method gave the student a power of analysis and resolution in engineering situations that permitted a wide range of application, whereas the second led to skills which were intended to equip the student for specific jobs immediately after graduation. The distinction was as between professional preparation and vocational training, and the report leaves no doubt as to which the committee preferred. They envisage, as the ideal of engineering education, "the development and expansion of the imaginative process of creative thought," and complain that "engineering educational processes are most commonly of the problem type, requiring but a single answer, with no latitude for judgment and no imaginativeness beyond the visualisation of the circumstances of the problem." Architectural education, they say, is far superior in this respect. It may be argued, of course, that it takes all sorts of engineers to make the engineering industry, but not every one needs to be a good mathematician or to have a capacity for creative thought in engineering design and development; but the technical advancement of engineering depends on such people. The responsibility for solving these problems rests with the engineering schools.

When more and more has to be packed into the four or five years of undergraduate study, attention is naturally turned to the possibility of extending post-graduate work. Though the committees recognise that most professional work in engineering will continue to be done by baccalaureates, they suggest that candidates for post-graduate work should be persons with inquiring minds, generally engaged on some form of creative work. The major purpose of their work is "to develop a more profound comprehension of basic knowledge than can be acquired in undergraduate study and to inculcate in the student initiative and self-reliance, originality and judgment in dealing with new problems." The course should be designed for each student, and should consist of a strengthening of his basic knowledge, followed by instruction on methods of applying the basic knowledge. It should be concerned only incidentally with application to engineering operations as such. There is no doubt that these views of undergraduate and post-graduate study are soundly based. Though they appear to be generally accepted in the United States, they have still to be put into practice in many American engineering schools.

* *The Earnings of Industry: The Truth about Prices and Profits.* 1951-52 edition. Aims of Industry, Ltd., 12, Cartaret-street, London, S.W.1. [Price 4*s.*]

* *Nineteenth Annual Report, 1950-51, Engineers' Council for Professional Development, Engineering Societies Building, 25-33, West 39th Street, New York 18, N.Y., U.S.A.*

NOTES.

THE THOMAS LOWE GRAY LECTURE.

THE Thomas Lowe Gray Lecture, annually delivered to the Institution of Mechanical Engineers, was established in 1924 as the result of a bequest by Thomas Lowe Gray, who died in the previous year after 44 years' membership of the Institution, to commemorate his father, Thomas Gray, an official of the Marine Department of the Board of Trade and the author of the well-known rhymed "Rule of the Road at Sea." By the decision of some former Council of the Institution, which no subsequent Council has seen occasion to rescind, the Lecture was named after the donor of the fund and not, as he had desired, after his father; but the original intention that it should deal with some topic of seafaring interest has been scrupulously observed, and the 24th Lecture of the series, delivered on Friday, January 18, by Dr. S. Livingston Smith, C.B.E., Director of Research of the British Shipbuilding Research Association, certainly observed that fundamental requirement. Under the title of "Ship Research," Dr. Livingston Smith presented to the Institution a review of the work of the Association which, severely condensed as it had to be, was notably successful in placing before the members an outline of the Association's purpose and activities. It is probably true to say that, to most of his hearers, it was a revelation of the extent of the field covered and the amount of work that has been accomplished by the B.S.R.A. in its comparatively short existence. Dr. Smith divided his Lecture into four main sections, dealing respectively with ship structures, hydrodynamics, ship performance, and ship machinery, and in all of them he had notable progress to report. Much of the work of the Association, of course, has consisted in co-ordinating activities that were already well developed, especially at the National Physical Laboratory and in the experiment tanks owned by the Admiralty and by various progressive shipbuilding firms; but a great deal of original research has been initiated by the Association and by Dr. Livingston Smith himself, more particularly the application of jet engines to propel the former paddle steamer *Lucy Ashton* for the purpose of establishing the laws governing the hull resistance of ships on a more firm basis than was possible when William Froude carried out his classic towing trials with the wood-sheathed H.M.S. *Greyhound*. Almost equally striking has been the development of research on the subject of the structural strength of ships, for so many years entirely empirical, but now approaching the status of an exact science, and on the design of propellers. Machinery development, as Dr. Smith showed, still offers a fruitful field for exploration, the boundaries of which have been considerably extended by the introduction of the gas turbine. The Lecture may not have been intended as a justification of the establishment of the British Shipbuilding Research Association, but if there were any among Dr. Livingston Smith's audience who entertained any doubt on that score, it is reasonably certain that they left the Institution building with no doubt about the value of the work that the Association is doing.

FEDERATION OF BRITISH INDUSTRIES
IN SCOTLAND.

Speaking at the annual general meeting of the Scottish members of the Federation of British Industries, held in Glasgow on January 11, Sir Archibald Forbes, President of the Federation, said that the year which had just begun promised to be an exceptionally testing one for this country and for industry. It was in 1952 that the real impact of the defence programme would begin to be felt, and because of the critical overseas trade balance there would be a greater necessity than ever to expand the volume of exports. The adoption of the necessary measures to curb inflation by limiting the claims upon the national income required courage and determination, because a lowering of standards—however inevitably and however temporarily—was bound to be unpopular. The Government had indicated their intention of reducing expenditure on public account. As the

high level of Government spending had been one of the greatest factors in promoting inflation, it was essential that the cut be a major one and so set an example in restraint. The immediate situation unfortunately required some rationing or allocation of certain materials and some change in the character and destination of output. This, coupled with the shortage of foreign exchange, might establish a case for the retention of some controls and even suggest their extension into other fields; but it was to be hoped that such measures would be kept to the irreducible minimum. While there must be recognition of the plain fact that there was not enough steel to meet the demand, it was possible that the initial allocations might have been based upon information which was not fully up to date and they might not have given full weight to the relative importance of certain products or markets. An effort was therefore being made, through the various trade associations and principal consumers, to obtain authoritative information as to the effect of the allocations and so to consider whether representations for adjustment could be made in particular instances. The use of taxation as a means of draining away the inflationary gap had reached a point where there was a real danger of bringing into operation the law of diminishing returns. If industrial capital were allowed to run down, productive efficiency and finally the volume of output would fall, and recurring crises in the balance of overseas trade would continue to arise. The general question of what constituted profit might be open to much academic argument, but it was clear that the conventional method adopted in presenting most published accounts was apt to cause misunderstanding and misrepresentation.

THE WORLD'S SHIPBUILDING.

The fact that the shipyards of Great Britain and Northern Ireland continue to be very fully occupied is well shown in the Lloyd's Register shipbuilding returns for the last quarter of 1951, issued this week. The returns indicate that the merchant steamers and motorships of 100 tons gross and upwards, under construction in this country on December 31, totalled 360 vessels, aggregating 2,209,012 tons, a slight decline, amounting to 62,628 tons, as compared with the figure for September 30, 1951. The total of 360 vessels comprises 120 steamers, making together 930,757 tons, and 240 motorships, aggregating 1,278,255 tons. The returns also show that 69 vessels, comprising 361,259 tons, were commenced in this country during the quarter; that 73 ships, totalling 433,364 tons, were launched and that 76 vessels, making together 434,415 tons, were completed. Oil-tank ships, of 1,000 tons and upwards, being built in the shipyards of the United Kingdom numbered 105 of a total tonnage of 1,239,497, or 56.1 per cent. of all the shipping under construction, as compared with 55.3 per cent. in the previous quarter. The steamers and motorships under construction abroad on December 31, 1951, totalled 852 vessels, aggregating 3,285,053 tons, an increase of 92,191 tons as compared with the figure for September 30, 1951. As has been the case for some time past, figures are not available for China, Poland and Russia. The leading shipbuilding country overseas is the United States, whose total of tonnage building on December 31, 1951, was 562,514. Second came France, with 472,638 tons; third was Germany, with 429,545 tons; fourth, Holland, with 321,199 tons; fifth, Sweden, with 312,388 tons; sixth, Japan, with 294,775 tons; and seventh, Italy, with 275,516 tons. All other maritime countries' totals were well below 200,000 tons. During the December quarter, 209 vessels, aggregating 711,924 tons, were commenced abroad; another 209 ships, making together 743,815 tons, were launched, and 186 ships comprising 618,417 tons were completed. Oil-tank ships of 1,000 tons and upwards under construction in foreign shipyards totalled 101 vessels, aggregating 1,095,901 tons, which is 107,666 tons above the figure for September 30. Of the 101 oil tankers, 23 (totalling 245,340 tons) are being built in Sweden; 16 (156,140 tons) in Germany; 9 (149,100 tons) in the United States, 11 (118,614 tons) in Holland, six (95,728 tons) in France, and seven (76,300 tons) in Italy. Oil tankers represent 33.4 per cent. of the total tonnage being built abroad.

OBITUARY.

MR. R. P. WAILES.

WE regret to learn of the death, on January 14, of Mr. Reginald Percy Wailes, for more than 40 years head of the general engineering firm of George Wailes and Company, Limited, 382, Euston-road, London, N.W.1. Mr. Wailes was 80 years of age, having been born at Watford on September 9, 1871. He was educated at private schools and at Repton, and in 1889 entered his father's firm (then at 258, Euston-road) as an apprentice. His father, whose views on the training of young engineers might be termed rigorous, saw to it that his son obtained a thorough experience of the fitting and machine shops, pattern shop, foundry and drawing office, and employed him as foreman, assistant works manager and works manager before admitting him into partnership in 1898. Eight years later, when George Wailes decided to retire, he would show no favouritism towards his son, but put the business and plant up for sale and obliged him to buy, in the open market, what he could of it. R. P. Wailes then started on his own account in rented premises, using the old name of the firm and taking with him a select few of his father's former employees. Eventually, he was able to build the present works at 382, Euston-road, where he continued to specialise in the construction of special machines and prototypes. During the 1914-18 war, he served in the City of London National Guard. On the conclusion of the war, when the outlook for small general-engineering works appeared somewhat uncertain, he widened the scope of his business to include the supply of engineers' tools and stores; but, in fact, he succeeded, in spite of the depression between the wars, in maintaining his position as a maker of special plant, and a wide reputation for precision engineering work. Increasing age and, in particular, failing sight, forced him to relinquish active management some years ago. Mr. Wailes was a member of the Institution of Mechanical Engineers, to which he was admitted in 1907.

MR. W. H. WILLIAMS.

RAILWAYS are so much an integral part of modern civilisation that their relatively recent introduction is not always appreciated until it is brought to mind by such events as the death, on January 20, at his home in Watford, of Mr. Walter Hugh Williams, formerly of the London and North Western Railway. He joined that railway in 1878 and so had been associated with rail transport for considerably more than half of its total life. Even when he retired, in 1925, his working life as a railway official spanned nearly half of the period since the inauguration of public passenger transport by rail, on the Stockton and Darlington Railway exactly 100 years earlier.

Mr. Williams, who was born on June 18, 1863, received his technical education in the Science and Art Department at South Kensington, and, from 1880 to 1883, at Owen's College, Manchester, where, in 1882, he was awarded an Ashbury Exhibition in engineering. He entered the engineering department of the London and North Western Railway at Crewe, on the staff of Mr. Harry Footner ("the father of modern permanent way," as he has been described), in January, 1878, serving there for ten years as engineering draughtsman and surveyor. He was then appointed as resident engineer for the London and North Western Railway and the L.N.W. and Great Western joint railways on their respective diversion lines at Warrington, in connection with the Manchester Ship Canal works. He was transferred from this work, in 1890, to the southern division of the London and North Western Railway, as divisional engineer, under Sir Richard Moon, with his headquarters at Watford. He was the last official to be appointed by Sir Richard Moon—and, incidentally, the youngest. After 30 years at Watford, he was posted again to Crewe, as maintenance engineer and, in January, 1922, was appointed divisional engineer, retaining this position until his retirement in 1925. He was a member of the Institution of Civil Engineers for over 60 years, having been admitted as an associate member in December, 1890.

LOADMETER FOR INDUSTRIAL MILLS.

Fig. 1. GENERAL ARRANGEMENT OF LOAD METER.

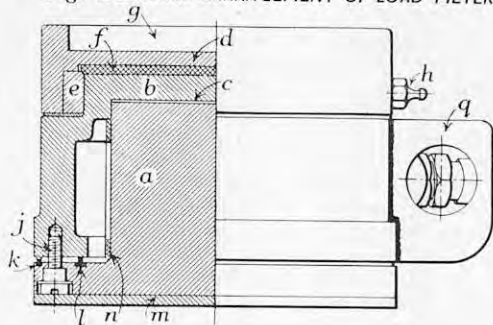
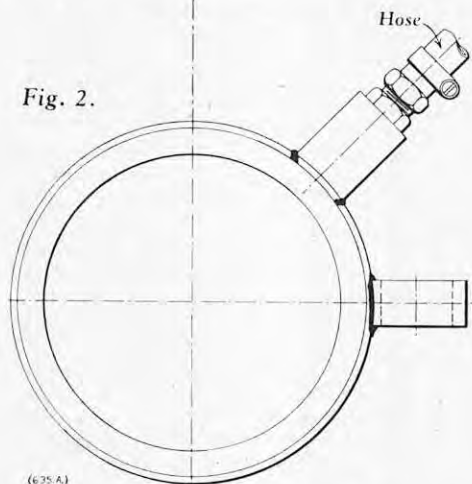


Fig. 2.



LOADMETER FOR INDUSTRIAL MILLS.

By R. B. SIMS, J. A. PLACE and A. D. MORLEY.

A GREAT deal of information on the performance of a rolling mill may be obtained by measuring the load on the work rolls; for example, the loads at which the rolls spall or break may be obtained, and, where the damage is frequent, the pass schedules may be adjusted systematically with the minimum loss of output. The efficiency of the mill as a production tool may be judged by comparing the loads in the successive passes with the designed maximum load. When all passes are loaded to the operating limit, not only will the greatest output be achieved, but the roll distortion will be constant for a given width of material. The camber may then be adjusted by experiment to give a good shape to the rolled product. Again, a change in the ratio of the loads on each screw during rolling may be due to the strip becoming displaced laterally in the roll gap or changing in cross-section along its length. In either event, there will be a loss of straightness or flatness in the product, which can be corrected from an indication of load. Perhaps the most useful function of the loadmeter is to indicate changes in gauge, and in this capacity it forms an essential component in certain methods of automatic gauge control.

Many attempts have been made in the past to produce a loadmeter using load detectors such as extensometers on the mill housings,* the pressure developed in hydraulic cylinders, the piezo-electric effect† and electromagnetic methods. Douglas and Ford‡ have discussed the difficulties in attempting to install these loadmeters in industrial mills. The design described below was developed by the British Iron and Steel Research Association to meet the requirement for a loadmeter which would not increase the mill spring materially, which would give an accurate measure of the load independent of temperature changes, and which would be of suffi-

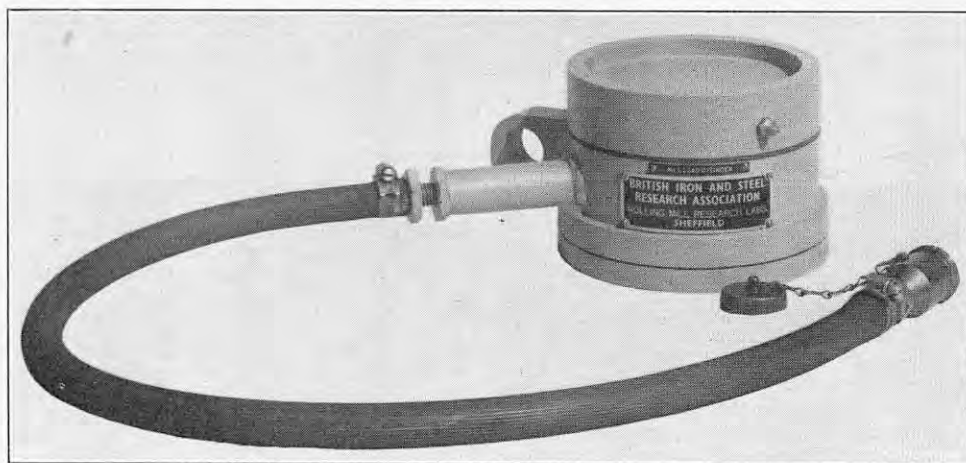


FIG. 3. LOADMETER COMPLETE.

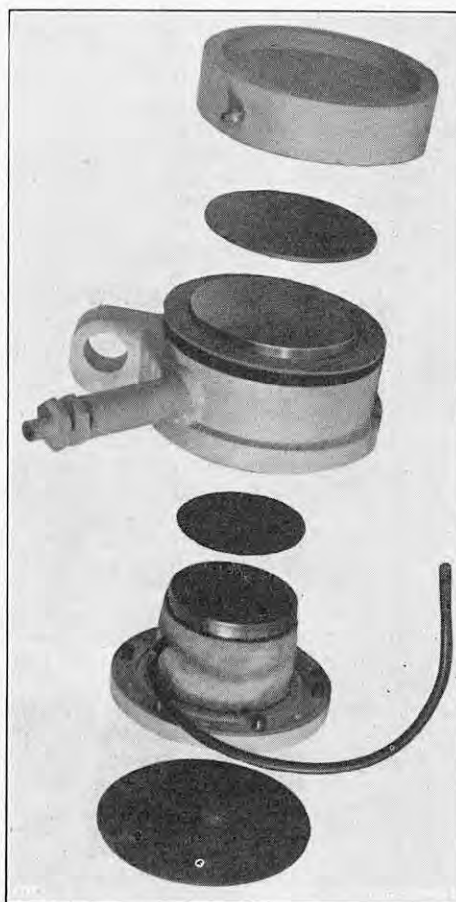


FIG. 4. PARTS OF LOADMETER.

ciently robust design to withstand, over long periods, the arduous conditions met in production mills. It is essentially a solid cylinder of steel, placed between the loading screw and the top roll bearing. A measure of the load applied to it is obtained from the output of an unbalanced temperature-compensated Wheatstone network of electric resistance strain gauges, bonded to the surface of the cylinder.*

Two loadmeters, each of 50 tons capacity, using this form of strain-sensitive network, have been in use for over three years on the British Iron and Steel Research Association's 10 in. by 10 in. two-high experimental mill at Sheffield University, and have been described by Rankine, Bailey and Stanton.† In the design of a geometrically-similar instrument for, say, 600 tons maximum load, the yield strength of the cylinder governs the choice of scale factor, and it was found that, if

Fig. 5. ARRANGEMENT OF STRAIN GAUGES.

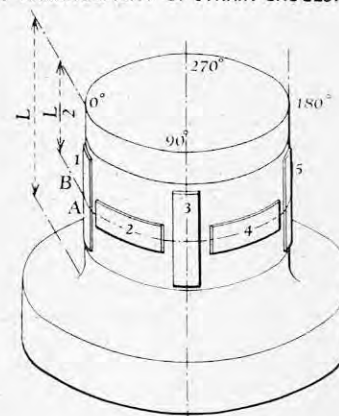


Fig. 6.

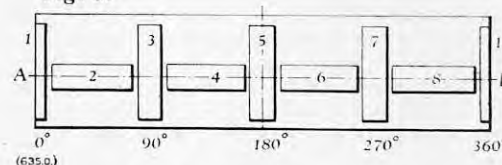
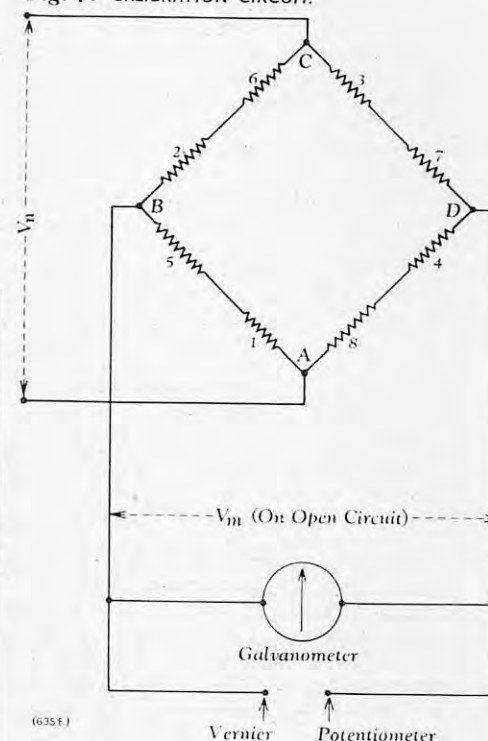


Fig. 7. CALIBRATION CIRCUIT.



* M. D. Stone. *Am. Iron and Steel Engineer*, vol. 13, page 21 (1936).

† E. Siebel and W. Lueg. *Mitt. K. W. Inst. Eisenforschung*, vol. 15, page 1 (1933).

‡ A. L. M. Douglas and H. Ford. *Iron and Steel Inst. Special Report No. 34*, sec. IV, page 97.

* British Patent No. 626206. E. Orowan, E. A. W. Hoff, J. Los and the British Iron and Steel Research Association.

† J. Rankine, W. H. Bailey and F. P. Stanton. *Jl. Iron and Steel Inst.*, vol. 160, page 381 (1948).

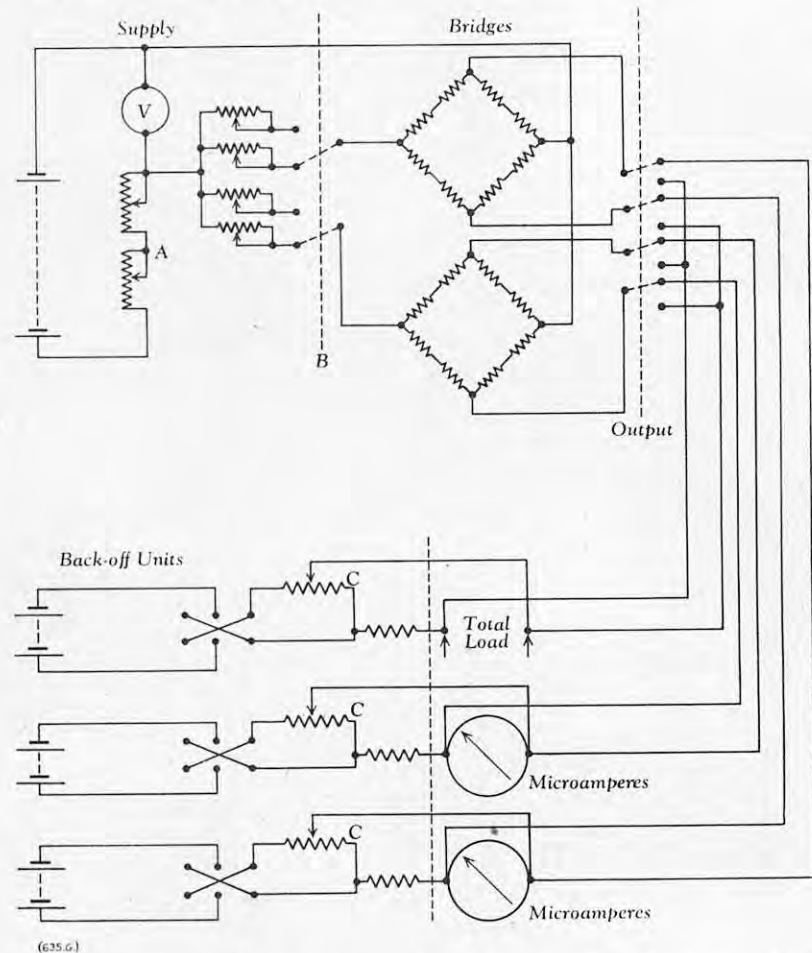
commercially available materials were used, the 50-ton loadmeters, scaled up, would be too tall to be fitted to the majority of mills. Moreover, the strain gauges were insufficiently protected from

LOADMETER FOR INDUSTRIAL MILLS.



FIG. 8. DIRECT-CURRENT MEASURING SET.

Fig. 9. D.C. INDICATOR CIRCUIT.



water and water vapour to operate in a hot-rolling mill.

Experimental work on the new design has shown that the accuracy of the load measurement is dependent on the ratio of the overall height of the instrument to the diameter of the strain-sensitive cylinder. A decrease in this ratio increases the errors due to inhomogeneous compression, and the present instrument, using eight strain gauges, represents a compromise between the permissible level of error and the limitation in height set by current mill design. Loadmeters of 20, 50, 300, 600 and 1,200 tons capacity have been built and have been used successfully in hot and cold rolling mills. They have been calibrated under symmetrical and eccentric conditions of loading, and the results show the design to be reliable and accurate. Although an instrument for the measurement of roll force is discussed here, the basic circuit and the principles of the mechanical design may be adapted to a variety of load-measuring devices. It has been re-designed for use in tension, for instance, as a load indicator for a crane.

The general arrangement of a loadmeter of 300 tons capacity is shown in Figs. 1 and 2, opposite, and the completed instrument is illustrated in Figs. 3 and 4. Instruments with differing load capacities may be scaled from it, the scale factor being chosen so that the maximum load produces an elastic strain of 0.18 per cent. in the cylinder. This gives a margin of safety for both the gauges and the steel. In Figs. 1 and 2, the solid cylinder, *a*, is integral with the base of the instrument and is forged from EN 17 steel, subsequently heat-treated to the R condition of B.S. No. 970:1947. The yield stress is then not less than 34 tons per square inch. EN 25, heat-treated to the U condition, is also suitable and gives a greater factor of safety to the design. The forging is then machined all over. The protecting cover *b* is machined from heat-treated EN 17 steel, and is a sliding fit on the cylinder. Between the cover and the cylinder top is a thin Ferodo disc, *c*. On earlier models, without this pad, the cover tended to slip on the cylinder during loading, giving a random error in the calibration. On the

top of the cover is a bearing, *d*, to carry both the radial and thrust loads from the mill screw, and this is also machined from heat-treated EN 17 steel. The end of the mill screw fits into the recess, *g*. The phosphor-bronze insert, *e*, is machined to a close running fit with the cover, and carries the radial loads. The thrust load is taken on a pad, *f*, of laminated fabric bonded with a thermosetting resin, which has an ultimate yield strength in compression of 20 tons per sq. in. Clearances are necessary at the junction of the two bearing materials to prevent binding between the moving surfaces; otherwise, if the thrust pad is gripped at the periphery when loading through a small-diameter screw, it may fail in shear. It is essential that the top of the loadmeter cover and the underside of the bearing, *d*, the two surfaces in contact with the laminated plastic sheet, should be ground flat and plated with hard chrome. A good quality non-alkaline oil, which does not attack the laminated pad, should be injected into the thrust bearing through the nipple *h*.

Four socket screws, *j*, round the base, hold the cover to the cylinder, and two jack screws lift the cap to give access to the cylinder and gauges. They do not restrain the movement of the cap when load is applied. A rubber seal, *k*, protects the screws, and, with the inner seal, *l*, provides the first protection for the gauges. The outer rim of the base is tapered at an angle of 3 deg. to avoid stressing the thin section carrying the seals and fixtures. A copper pad, *m*, 0.1 in. thick, may be used on the base of the cylinder to ensure contact with the top of the chock over the entire base of the loadmeter.

The loadmeters designed for research are prevented from rotating under load with the mill screw by a universal coupling attached to the lug *g*, and to the mill frame. This design is used so that the instruments may be fitted to any mill with the minimum of difficulty; but in practice the stresses in the coupling are high, and it is recommended that, where the loadmeters are to be installed permanently, a seating which prevents rotation should be made for them in the top of the chock. The

exposed metal parts of the loadmeter should be thoroughly proofed against corrosion, either by a metallic sprayed finish, by phosphating, or by a properly bonded paint. The cabling should be carried in non-rusting armoured hose.

The electric resistance strain gauges* used on the loadmeters consist of approximately 25 in. of Nichrome wire, 0.001 in. in diameter, which is wound into a flat grid, 25 mm. long and 7 mm. wide, and bonded between two pieces of paper. They are cemented to the steel cylinder, alternately parallel and normal to the axis, with the gauge wires spaced symmetrically on a section midway along the axis of the cylinder. The arrangement is shown in Figs. 5 and 6, herewith, where the curved surface of the cylinder has been developed and presented in the plane of the paper and the gauges numbered consecutively. When the cylinder is loaded, the resistance of the strain gauges will alter in proportion to the strain in the steel, so that the gauges parallel to the axis of the cylinder (numbered 1, 3, 5 and 7 in Figs. 5 and 6) will undergo compressive strain and will decrease in resistance, while the gauges normal to the axis (numbered 2, 4, 6 and 8) will increase in resistance due to the hoop tensile strains developed as the cylinder dilates. Gauges on each end of a diameter of the section AB are either both vertical or horizontal, and are connected in series to form the arms of a Wheatstone bridge as shown in Fig. 7, on page 116.

The adhesives used to bond the strain gauges to the cylinder depend on the use for which the loadmeter is intended. Durofix is suitable only for instruments in which the temperature will not be raised above 20 deg. C., but has the advantage of ease of application. Thermosetting resins may be used at working temperatures up to 70 deg. C., but many of them need curing at temperatures above 180 deg. C., the charring temperature of the gauges.

* For a detailed description of this type of gauge, see *Electric Resistance Strain Gauges*, by W. B. Dobie and P. C. G. Isaacs, page 27 (1948): English Universities Press, Warwick-square, London, E.C.4.

LOADMETER FOR INDUSTRIAL MILLS.

Fig. 10.

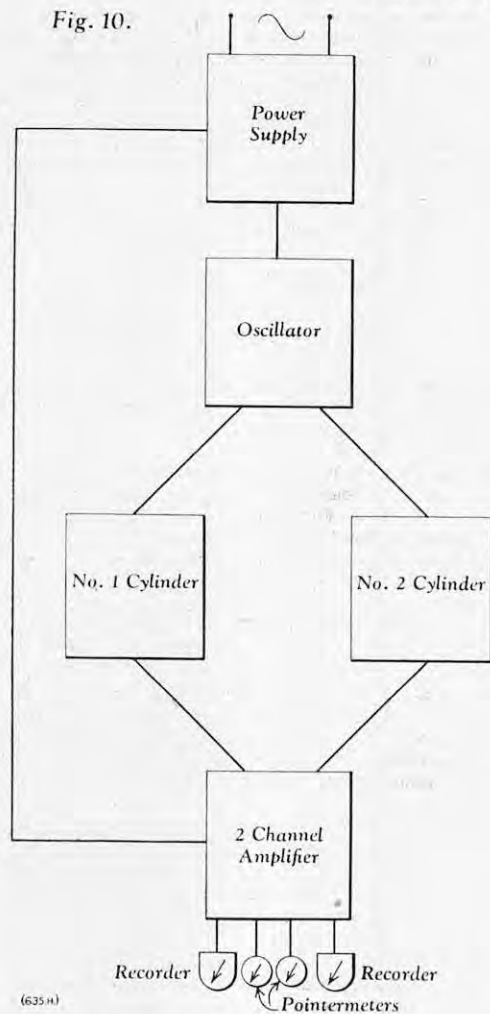
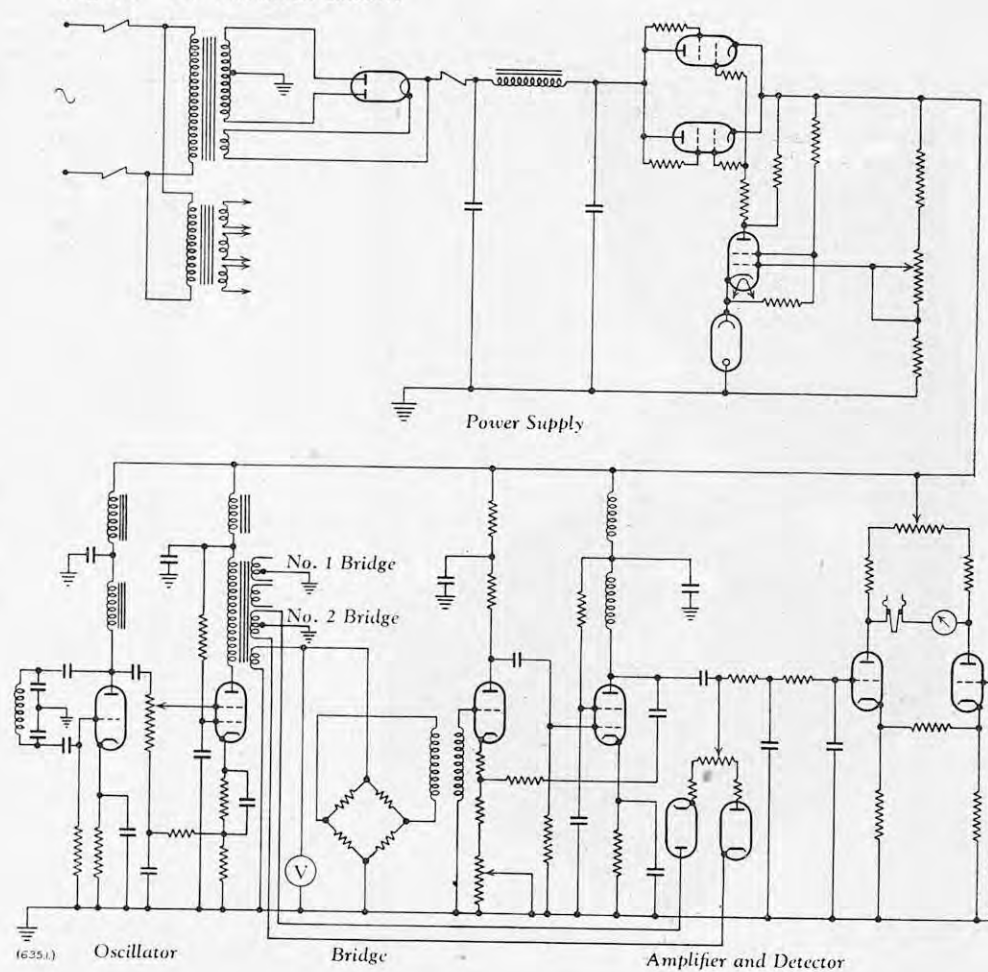


Fig. 11. A.C. INDICATOR CIRCUIT.



Araldite 15, a thermosetting resin, has been used whenever possible, since it cures at 170 deg. C., has relatively a high fatigue strength in shear, and will provide adequate electrical resistance between the strain gauge and the cylinder. It does not possess a long shelf life, however, and a sample which has been stored at room temperature for a few weeks may lose its adhesive properties. It is advisable to obtain the strain gauges from the manufacturers without an adhesive layer; and, to prevent absorption of moisture by the gauges, they should be stored at about 20 deg. C. in a desiccator until required. If the gauges are damp when they are fixed, they can almost invariably be peeled off after curing, particularly if the adhesive is a thermosetting resin. A slight pressure is necessary on the gauges during the curing, especially with resin adhesives. The following method is suggested as suitable. After degreasing the surfaces with carbon tetrachloride, the gauges are attached with the liquid resin, which is allowed to become tacky enough to hold the gauges in position. A piece of paper and a cork pad are placed over each gauge, and the assembly is wrapped round with a linen strip which is stitched in position. The linen is then covered with aeroplane "dope," which contracts on drying and causes the linen to exert a pressure on the gauges. The gauges may then be baked without danger of them slipping.

The electrical resistance between the gauges and the metal cylinder is provided by the adhesive and should not fall below 100 megohms for the whole network. R. F. Bowler has established that the insulation resistance of Durofix and of thermosetting resins such as Bakelite and Araldite, when used as adhesives for strain gauges, varies in a complex manner. At temperatures below 20 deg. C. immediately after curing, the resistance is very high (above 800 megohms), but it falls to a few megohms as the temperature is increased to 95 deg. C. The variation of resistance with temperature differs with each adhesive, depending on whether the temperature is rising or falling, i.e., there is considerable hysteresis. Moreover, after a few such cyclic changes, the

insulation resistance at any temperature seems to suffer a permanent decrease. The temperature insulation resistance characteristics of Araldite are markedly superior to those of Durofix, and, for that reason, it has been chosen for the industrial application of loadmeters.

The effect of a change in insulation resistance of the Wheatstone network of electrical resistance strain gauges is not clear. Theoretically, the leakage between gauges should not alter the calibration materially until the total insulation resistance for the bridge is below about 10 megohms. At resistances below 100 megohms, however, it becomes increasingly difficult to balance the network, and it is suggested that the small leakage currents cause

corrosion which quickly damages the gauges and progressively decreases the insulation resistance. To protect the gauges from water and water vapour, a wide strip of rubber (indicated at *n* in Fig. 1) is wrapped round the cylinder over the gauges, and is bonded to the metal. The rubber-covered lead wires to the gauges are bonded into this seal. The sealed gauge compartment is filled with DiJell, and the space between the cylinder and cover is filled with DiJell after the loadmeter is assembled. It must be emphasised that the effectiveness with which the gauges are protected determines the life of the loadmeter in the mill.

With the electrical resistance strain gauges connected in the network shown in Fig. 6, either a



FIG. 12. ALTERNATING-CURRENT MEASURING SET.

null or an out-of-balance method may be used to measure the load. The out-of-balance method has been chosen for the present design, since it has advantages in circuit simplicity, speed of measurement and in lower cost. Three current-measuring circuits are available, namely, a four-channel amplifier and power supply described by Douglas and Briggs,* a self-contained direct-current set intended for industrial research and designed for use with a range of loadmeters, and an alternating-current set, which was designed and constructed by Mr. P. R. A. Briggs, of B.I.S.R.A., for use with a pair of loadmeters permanently installed in a mill. A potentiometer circuit may be used.

The completed direct-current set is shown in Fig. 8, on page 117, and the circuit is given in Fig. 9. The two loadmeter networks are supplied independently at 100 to 200 volts from high-capacity batteries in the case, and the loads are indicated on 1st-grade microammeters (B.S. No. 89). The total load in the mill may be obtained on a single meter by combining the two circuits, as described below.

The indication of load from each loadmeter in terms of microamps may be varied by adjusting the bridge voltage from the batteries. To make the load-indicating set serve several loadmeters, each loadmeter and each circuit in the set is numbered, so that the loadmeters may always be connected to the same circuit. During the calibration the voltage from the batteries to each loadmeter is adjusted to give full-scale deflection on the microammeter at maximum load. In use, the main battery resistor A (Fig. 9), is adjusted to give a standard voltage (150 volts in the existing equipment) and the switches, B, put into the separate circuits supplementary fixed series resistors to adjust the bridge volts according to the loadmeters in use. Before measuring load, the loadmeters are balanced from the variable back-off unit, C, so that the microammeters are set at zero.

The circuit of the alternating-current set is illustrated by a block diagram, Fig. 10, on page 118, and the detailed circuit is given in Fig. 11. A completed set is shown in Fig. 12. The unit is designed to operate from a single-phase alternating-current mains supply. The gauge networks are supplied with alternating current at 500 cycles per second from an oscillator fed by a simple stabilised power pack. The out-of-balance current from each loadmeter is taken to separate amplifiers, the amplification factor of which is adjusted during calibration to give full-scale deflection on the load-indicating meters at maximum load. The zero of each load-indicating circuit may be set by a single control while the loadmeters are in service. The loads are indicated separately on 0 to 10 milliamp pointer-meters, or total load is available on a third milliammeter. These milliammeters are more robust than the microammeters used with the direct-current set, and are available with $6\frac{1}{2}$ -in. scales for installation near the mill. This set will operate a continuous pen recorder.

A more accurate indication of load may be obtained by connecting the output of the loadmeter to a recording potentiometer. A stabilised direct-current supply, working from the alternating-current mains, is needed, but no amplification of the signal is required to present it on a 10 in. to 14 in. scale, other than that incorporated in the recorder. If large rapidly fluctuating loads are expected, however, the response of this form of equipment will probably be too slow to record peak values.

(To be continued.)

TRANSPORT CONSULTATIVE COMMITTEE.—The first term of office of the Central Transport Consultative Committee for Great Britain having expired on December 31, 1951, the Minister of Transport, the Hon. J. S. MacLay, has appointed members to serve until December 31, 1954. The chairman, as before, is Major Egbert Cadbury. The only new members are Mr. A. I. Anderson, to represent shipping, and Mr. C. E. Jordan, who joins Mr. A. G. Marsden and Mr. R. H. E. Thomas in representing industry and commerce. The committee's secretary is Mr. G. Cole Deacon and the address is 22, Palace Chambers, London, S.W.1.

* A. L. M. Douglas and P. R. A. Briggs. *Instrument Practice*, December, 1948.

GAS-TURBINE ALTERNATOR PROPELLING MACHINERY IN TANKER "AURIS."

In the course of a demonstration trip on Southampton Water, on Tuesday this week, the potentialities of the gas turbine as a prime mover for ships were shown in a convincing manner to a large company aboard the tanker Auris, guests for the occasion of the Anglo-Saxon Petroleum Company, Limited, owners of the vessel. It will be recalled that the Auris is a ship of 12,250 tons deadweight, which was built by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, at Hebburn-on-Tyne, and commissioned in 1948. Her designer was Mr. John Lamb, O.B.E., head of the Shell Marine Research and Development Department, who envisaged her as an experimental ship in which new developments of many kinds might be tried out at sea. Among the proposals, the use of a gas turbine as a propulsion unit figured prominently, but although such turbines had worked satisfactorily on land, their reliability for ocean-going vessels had to be proved.

To begin with, therefore, the Auris was fitted with four Diesel engines driving 16-pole alternators in parallel. The alternators were synchronised and supplied current to a single motor driving the propeller shaft. The engine room, however, was designed so that, at a later stage, one of the Diesel sets could be removed conveniently and replaced by a 1,200-h.p. gas-turbine alternator unit, an order for which had been placed with the British Thomson-Houston Company, Limited, Rugby. After over three years of normal service on her Diesel engines, the Auris returned to Hebburn-on-Tyne in August, 1951, for the installation of the gas-turbine unit, which, in the meantime, had been completed at Rugby and had undergone successful trials there. Details of these trials and of the gas turbine were published in *ENGINEERING* in February, 1951 (vol. 171, page 209).

To accomplish the work at Hebburn, the 150-ton Titan, the largest floating crane on the Tyne, was employed. The operation called for careful handling, owing to the restricted space in the engine room, but it was completed successfully and without untoward incident. The inner starboard Diesel set was removed and the gas turbine lowered into position in three parts; first, the low-pressure turbine and alternator section, weighing 22 tons, then the high-pressure turbine and compressor section, weighing 14½ tons, and finally the heat exchanger, which weighs 16 tons. On completion of the installation, the vessel underwent 48 hours of trials off the Northumbrian coast, which were completely successful. It is reported that, for six hours continuously during this period, the three remaining Diesel engines were shut down completely and the tanker, which was fully laden, was propelled solely by the gas-turbine alternator at an average speed which exceeded 7 knots, despite strong winds and a moderate sea which caused some rolling of the vessel. The absence of engine vibration during this period was a marked feature of the trial.

Immediately afterwards, and without requiring any adjustments to her engines, the Auris left the Tyne for Port Arthur, Texas, U.S.A., where she arrived on November 19, 1951, after a voyage of 4,905 miles accomplished at an average speed of 9.21 knots. The gas turbine ran continuously during the 22-day voyage in conjunction with the three Diesel sets and required no adjustments. The rotor speed did not require to be reduced at any time, although six days of continuously heavy weather were experienced when the vessel's speed had occasionally to be reduced to 7 knots. After loading a full cargo of benzene at Port Arthur, the Auris proceeded to Caracao. When, after completion of her voyage, she berthed at Avonmouth on December 22 last, she had covered a distance of 10,929 nautical miles since leaving the Tyne, and during the 44 days which she had spent at sea, the gas-turbine unit had given no trouble.

Since her return, the tanker has made other shorter trips which have brought her nautical mileage up to 13,211, and the hours running of the gas-turbine unit to 1,391. During the run to Caracao and back, Diesel fuel oil was burned in the turbine combustion-chamber, but, in her recent shorter trips, boiler fuel of 1,500 seconds viscosity, on the Redwood scale, has been used. The fuel consumption has averaged 0.75 lb. per brake horse-power per hour. Thirty gallons of oil were consumed by the turbine during the 44-day trip.

On her recent demonstration run, the load on the gas-turbine alternator was increased gradually to nearly full load, when the following gauge readings were noted: high-pressure turbine inlet temperature, 1,170 deg. F., outlet temperature, 850 deg. F.; low-pressure turbine outlet-temperature, 670 deg. F.; heat-exchanger gas outlet-temperature, 410 deg. F.; high-pressure turbine inlet gauge-pressure, 42 lb. per square inch, outlet pressure 7.1 lb. per square inch, shaft speed, 5,750 r.p.m.; speed of low-pressure turbine shaft, 2,550 r.p.m.; power output, 840 kW.

It is understood that the overall thermal efficiency of the gas-turbine unit at sea is approximately 21 per cent. It is clear from these results, which may be read in conjunction with those published earlier in *ENGINEERING*, and referred to above, that the gas-turbine alternator set is performing satisfactorily.

The success of the experiment, indeed, reflects credit on all concerned. Although much remains to be accomplished, the day may not be far distant when gas-turbine propulsion machinery in ships will rival existing methods of propulsion both as regards reliability and efficiency. It is understood that on her next Atlantic trip the Auris is to be propelled solely by the gas-turbine unit, burning the heavier grade of fuel oil used recently.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

INTERNATIONAL RADIO AND ELECTRONICS EXHIBITION OF INDIA.—Saturday, February 9, to Friday, February 29, at Bombay. For further information, apply to the secretary, Radio and Electronics Society of India, Fateh Manzil, Opera House, Bombay, India.

INTERNATIONAL AGRICULTURAL MACHINERY EXHIBITION.—Sunday, February 17, to Sunday, February 24, at Brussels. Apply to the secretary, Société de Mécanique et d'Industries Agricoles, S.A., 29, Rue de Spa, Brussels, Belgium.

BUSINESS EFFICIENCY EXHIBITION.—Tuesday, February 19, to Friday, February 29, at Bingley Hall, Birmingham. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENTral 7771.)

GERMAN INDUSTRIES FAIRS, HANOVER.—*Light Industries:* Wednesday, February 27, to Sunday, March 2, at Hanover. *Heavy Industries:* Sunday, April 27, to Tuesday, May 6, at Hanover. *Agents:* Schenkers, Ltd., 27, Chancery-lane, London, W.C.2. (Telephone: HOLborn 5595.)

INTERNATIONAL AGRICULTURAL MACHINERY EXHIBITION.—Tuesday, March 4, to Sunday March 9, at the Parc des Expositions, Paris. Organised by the Union des Exposants des Machines et Outillages Agricoles, 38, Rue de Chateaudun, Paris (9c.)

"DAILY MAIL" IDEAL HOME EXHIBITION.—Tuesday, March 4, to Saturday, March 29, at Olympia, London, W.14. Organised by the *Daily Mail*, New Carmelite House, Carmelite-street, London, E.C.4. (Telephone: CENTral 6000.)

VIENNA SPRING FAIR.—Sunday, March 9, to Sunday, March 16. *Agents:* British Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

GENEVA INTERNATIONAL MOTOR EXHIBITION.—Thursday, March 20, to Sunday, March 30, at Geneva. For further information, apply to the secretary of the exhibition, 1, Place du Lac, Geneva, Switzerland.

SECOND UNITED STATES INTERNATIONAL TRADE FAIR.—Saturday, March 22, to Sunday, April 6, at the Navy Pier, Chicago. Representative for the United Kingdom and Ireland: Mr. A. P. Wales, 12, St. George-street, London, W.1. (Telephone: MAYfair 4710.)

MANCHESTER BUILDING TRADES EXHIBITION.—Tuesday, March 25, to Saturday, April 5, at the City Hall, Deansgate, Manchester. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363), or to the London agent at 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANDyke 5635.)

ASLIB, NORTHERN BRANCH.—Thursday, March 27, at the Central Library, Sheffield. Apply to the secretary of the Association, 4, Palace-gate, Kensington, London, W.8. (WESTern 6321.)

FIRST SUPERVISING ELECTRICAL ENGINEERS NATIONAL EXHIBITION.—Friday and Saturday, March 28 and 29, at the Royal Horticultural Society's new hall, Greycoat-street, Westminster, London, S.W.1. For further information, apply to the conference secretary, Mr. P. A. Thorogood, 35, Gibbs-green, Edgware, Middlesex. See also our issue of August 31, 1951, page 266.

INSTITUTION OF NAVAL ARCHITECTS, ANNUAL MEETING.—Wednesday, Thursday and Friday, April 2, 3 and 4, on the "Wellington," Temple Stairs, Victoria-embankment, W.C.2. Details obtainable from the secretary of the Institution, 10, Upper Belgrave-street, London, S.W.1. (Telephone: SLOane 4622.)

EXHIBITION OF BRITISH COMPONENTS, VALVES AND TEST GEAR FOR THE RADIO, TELEVISION, ELECTRONIC AND TELECOMMUNICATIONS INDUSTRIES.—Monday to Wednesday, April 7 to 9, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and

Electronic Component Manufacturers' Federation, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 6740.)

SWISS INDUSTRIES FAIR.—Saturday, April 19, to Tuesday, April 29, at Basle. Apply to the Division Economique, Swiss Legation, 18, Montague-place, London, W.1. (Telephone: PADdington 0701.)

SYMPOSIUM ON DIAMOND DRILLING.—Monday, Tuesday and Wednesday, April 21, 22 and 23, at Johannesburg. Organised by the Chemical, Metallurgical and Mining Society of South Africa and the Diamond Research Laboratory. Apply to the director of the Laboratory, P.O. Box 916, Johannesburg.

ROYAL SANITARY INSTITUTE HEALTH CONGRESS.—Tuesday, April 22, to Friday, April 25, at Margate. Apply to the secretary, the Royal Sanitary Institute, 90, Buckingham Palace-road, Westminster, London, S.W.1. (Telephone: SLOane 5134.)

LIÈGE INTERNATIONAL FAIR.—Saturday, April 26, to Sunday, May 11, at Liège. Apply to the Fair secretariat, 17, Boulevard d'Avroy, Liège.

TELEVISION CONVENTION.—Monday, April 28, to Saturday, May 3, at Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Radio Section of the Institution of Electrical Engineers. Apply to the secretary of the Institution at the address given above. (Telephone: TEMple Bar 7676.) See also our issue of September 21, 1951, page 371.

INTERNATIONAL FOUNDRY CONGRESS AND SHOW.—Thursday, May 1, to Wednesday, May 7, at Atlantic City, New Jersey, U.S.A. Organised by the American Foundrymen's Society, 616, South Michigan-avenue, Chicago 5, Illinois, U.S.A.

BRITISH INDUSTRIES FAIR.—Monday, May 5, to Friday, May 16, at Earl's Court, London, S.W.5, and Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or the general manager, British Industries Fair, 95, New-street, Birmingham, 2. (Telephone: Midland 5021.)

INTERNATIONAL EXHIBITION OF ELECTRICAL APPLIANCES.—Tuesday, May 13, to Tuesday, May 27, at Bologna. Apply to the Ente Autonomo Fiera di Bologna, via Farina 6, Bologna.

SWEDISH INDUSTRIES FAIR.—Saturday, May 17, to Sunday, May 25, at Gothenburg. Agents: John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

GERMAN EXHIBITION OF CHEMICAL APPARATUS.—Sunday, May 18, to Sunday, May 25, at Frankfurt-on-Main. Organisers: Dechema Deutsche Gesellschaft für Chemisches Apparatewesen E.V., Frankfurt.

ELECTRICAL ASSOCIATION FOR WOMEN, 27TH ANNUAL CONFERENCE.—Monday, May 19, to Saturday, May 24, at Scarborough. Apply to the director, the Electrical Association for Women, 35, Grosvenor-place, London, S.W.1. (Telephone: SLOane 0401.)

INTERNATIONAL HIGH TENSION CONFERENCE.—Wednesday, May 28, to Saturday, June 7, at the Fondation Berthelot, 28, Rue Saint Dominique, Paris. Apply to Mr. R. A. McMahon, secretary, British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. (Telephone: Leatherhead 3423.)

CANADIAN INTERNATIONAL TRADE FAIR.—Monday, June 2, to Friday, June 13, at Toronto. Apply to Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. (Telephone: WHItchall 8701.)

MECHANICAL HANDLING EXHIBITION.—Wednesday, June 4, to Saturday, June 14, at Olympia, London, W.14. Apply to the exhibition organisers, Iliffe and Sons, Ltd., Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

CONFERENCE ON CIVIL ENGINEERING PROBLEMS IN THE COLONIES.—Monday, June 16, to Friday, June 20, at the Institution of Civil Engineers, Great George-street, Westminster, London, S.W.1. Details obtainable from the secretary of the Institution at the address given above. (Telephone: WHItchall 4577.)

ROYAL AGRICULTURAL SHOW.—Tuesday, July 1, to Friday, July 4, at Newton Abbot. Organised by the Royal Agricultural Society of England, 16, Bedford-square, London, W.C.1. (Telephone: MUSeum 5905.)

WELDING DESIGN AND ENGINEERING SUMMER SCHOOL.—Wednesday, July 16, to Sunday, July 20; and Sunday, July 20, to Friday, July 25, at Ashorne Hill. Organised by the British Welding Research Association, 29, Park-crescent, London, W.1. (Telephone: LANgham 7485.)

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, FOURTH INTERNATIONAL CONGRESS.—Monday, August 25, to Friday, August 29, at Cambridge. For further information, apply to the secretary of the Association, Swiss Federal Institute of Technology, Zürich, Switzerland.

LABOUR NOTES.

SOME interesting comments on steel production and employment are contained in the January issue of *Man and Metal*, the official journal of the Iron and Steel Trades Confederation. Mr. Lincoln Evans, the secretary of the Confederation, regards 1951 as a "year of set-back," for, as the months passed, a break in the steady rise in steel production became apparent, for the first time since 1945. There had been every hope that the upward trend of production would have continued until the middle 'fifties, by which time Britain would have had the capacity to produce 18 million tons of steel a year. If there had been a plentiful supply of raw materials, particularly scrap, there is no doubt, Mr. Evans states, that production in 1951 would have reached the record figure of nearly 17 million tons. The capacity, the man-power and the will to achieve this were there. As it was, the output will be probably somewhere in the region of 16 million tons (actually it was 15,638,500 tons), and the loss will not be due to any defaults or shortcomings in the industry, but to factors over which it had little control. It is useless to clamour for more steel unless the industry is provided with the materials for its production.

One of the consequences of the lack of supplies, Mr. Evans continues, is that in some plants there is an emergence of short-time working which is on a scale reminiscent of the pre-war years. It is sobering to reflect that the principal economic factor responsible for this state of affairs is exactly the opposite of that which was held to be the reason for so many idle furnaces and mills during the 'thirties. Unemployment and under-employment at that time were caused through a surplus of goods for which buyers could not be found. Now the country is likely to run into unemployment, not owing to too much being produced, but because too little is produced of the kind of goods which are required for exchange for the raw materials which Britain needs. "And the irony of it all is that the shortage of coal, which is not a scarce material, for we have abundant reserves beneath our feet, is the one thing which is having the most crippling effect on our economy."

Mr. Evans considers that the significance of this should not be lost on those who still cling to the old belief that the more they produce, the more quickly they work themselves out of a job. It is being increasingly realised, in the conditions which exist at the present time, and which are likely to continue, that this doctrine is, in fact, true in reverse, and that the less the country produces, the greater are the chances of unemployment. The pattern of world trade has so changed since the pre-war years, with its consequent alteration of Britain's trading position, that unemployment can show its ugly head in the steel industry because the mining industry is not able to produce sufficient coal to enable this country to export it to Sweden in exchange for iron ore. Britain's inability to import timber from Finland, for the same reason, can have equally disastrous effects on the building industry.

So the need for greater production is not only necessary in order to provide a higher standard of living, Mr. Evans states, but it is also the antidote to unemployment in a period in which the nation is seeking to expand its industrial capacity. "No Government, however well-intentioned, or however hard it tries, can maintain a policy of full employment unless this increased production is forthcoming, for, in the last resort, the answer is not going to be found, or the issue determined, in the polling booths, but in our mines, factories and fields."

The Ministry of Labour and National Service announced on Tuesday last that the Minister, Sir Walter Monckton, had decided to set up a committee of investigation into the labour dispute at the works of the E.N.V. Engineering Company, Limited, Willesden, London, N.W.10, where over one thousand employees have been on strike for approximately eleven weeks. This action has been taken owing to the delay in essential production which has been caused by the stoppage. The Engineering and Allied Employers' National Federation and the executive committee of the Amalgamated Engineering Union have accepted a suggestion put forward by the Minister that any recommendations made by the investigating committee shall be accepted by both sides as constituting a settlement of the difficulty and that normal working at the factory shall be then resumed. Both parties have also expressed their intention of seeing that there shall be no victimisation. The stoppage is understood to have resulted from the refusal of the firm to dismiss a particular foreman at the request of their employees.

A spirited discussion on the attitude of the trade unions to the national industrial policy is reported to have taken place at a meeting of the National Council of Labour, which was held in London on Tuesday last. Both Mr. Arthur Deakin, C.B.E., the chairman of the Trades Union Congress, and Sir Vincent Tewson, the general secretary, addressed the Council on this subject. The Council comprises representatives of the T.U.C., the Labour Party and the Co-operative Union, and last Tuesday's meeting was attended by Mr. C. R. Attlee, Mr. Herbert Morrison and other former Ministers. Other subjects which are understood to have been discussed were the proposed Order requiring managements to notify employment exchanges of vacancies on their staffs, and the suggested lowering of the school-leaving age. The T.U.C. is believed to feel some dissatisfaction on the Government's proposals regarding both these matters.

An increase of one point took place during the month ended December 11, 1951, in the all-items figure of the interim index of retail prices, according to an announcement of the Ministry of Labour and National Service on Monday last. The index level on that date was 130, compared with 129 on November 13, 1951, and 116 at mid-December, 1950. The all-items figure increased by one point in January, February and March last, and by two points during the month ended mid-April, when a level of 121 was reached. The figure then increased to 124 at mid-May, and thereafter showed a steady increase of one point per month until mid-October, when a level of 129 was recorded. There was no change in this figure between mid-October and mid-November.

The index figure for food only was 144 on November 13, 1951, compared with 143 in mid-October and 125 in mid-November, 1950. The rise in the all-items figure for the month ended December 11, 1951, was recorded by the Ministry as being due to increases in the average prices of a considerable number of articles including milk, fish, coal, and some kinds of clothing, together with increases in local fares in certain areas. The interim index measures, for the United Kingdom, the average changes, month by month, in the prices of the goods and services which entered into working-class expenditure before the war, the goods and services covered being those recorded in family budgets collected by the Ministry during 1937 and 1938. The index was commenced on June 17, 1947, the level at that date being taken as 100 for both the all-items figure and the figure for food only.

Officials of trade unions catering for employees in Government Departments are reported to be concerned at the demands being made by the Treasury for substantial reductions in the number of civil servants during the coming months. It seems generally recognised, however, that these staff cuts are necessary and that a considerable proportion of the reductions will be achieved automatically as a result of retirements and deaths. It is understood that the union leaders are anxious to put forward proposals to the Treasury that civil servants should be allowed to retire whenever they may desire on reduced pensions, and that they should not be permitted to remain in the service after reaching the age of 60, except in very special cases. Departments which are expected to reduce their staffs include the Ministries of Agriculture, Works, Labour and National Service, and National Insurance, and the saving of man-power by these four Ministries should reach a total level of about four thousand. It is anticipated also that the Customs and Excise service will be able to effect a reduction of nearly three hundred by the end of next June. Recruitment for the civil service during the present year is likely to be substantially reduced.

Encouraging increases in colliery man-power are reported for the weeks ended January 5 and January 12 last. Provisional figures issued by the Ministry of Fuel and Power on Tuesday last indicate that there was an increase of 1,800 employees in the first week of this year and of 1,900 in the second. During the fortnight ended January 12, the weekly average number of persons employed was 700,700, of whom 287,000 were engaged on work at the coal face, while the average weekly number of persons employed during the first fortnight of 1951 was 690,400, of whom 285,500 were engaged at the coal face. The average number of shifts worked per wage-earner was 4.25 for the week ended January 5, 1952, and 5.18 for the week ended January 12, 1952, against 4.96 during the week ended January 13, 1951. Absenteeism, which totalled 16.86 per cent., including 10.13 per cent. voluntary, during the week ended January 5, 1952, decreased to 10.77 per cent., including 4.92 per cent. voluntary, during the week ended January 12, 1952.

TRAILERS AND SEMI-TRAILERS.

Fig. 18. STEERING SYSTEM OF 24-WHEEL TRAILER.

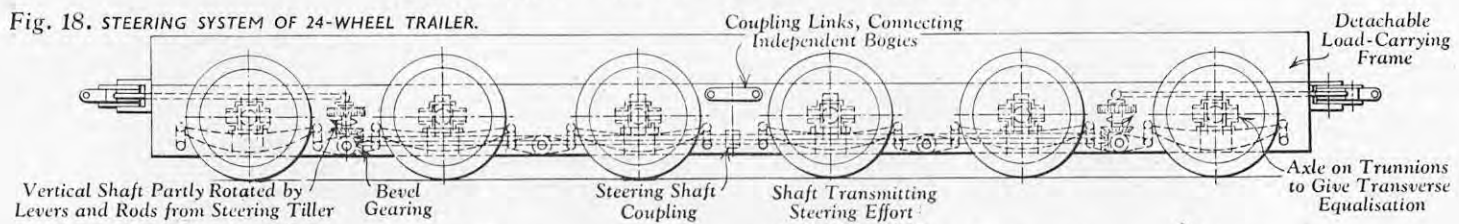


Fig. 19.

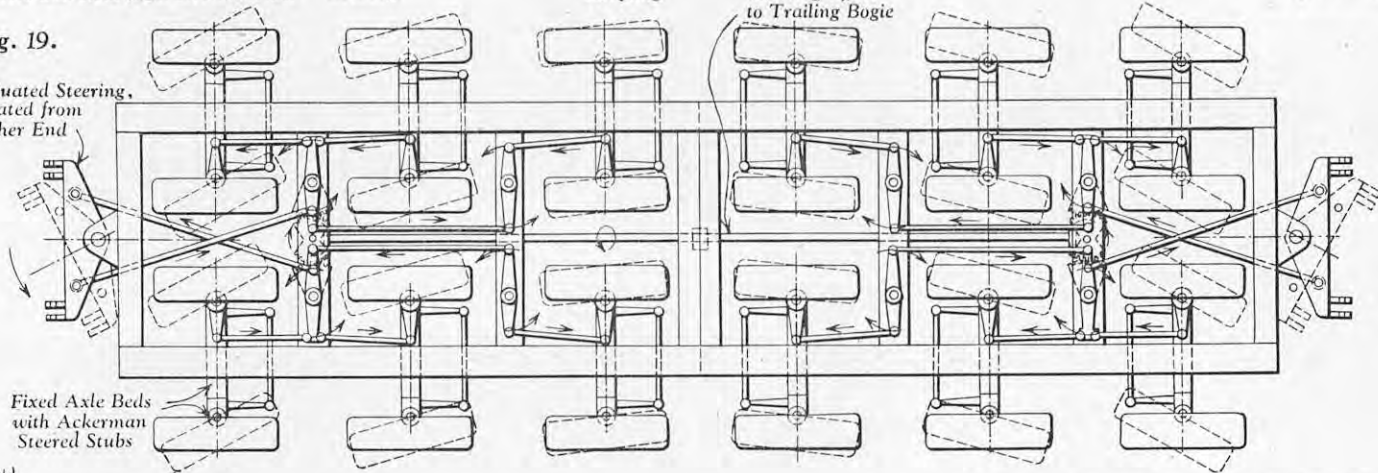
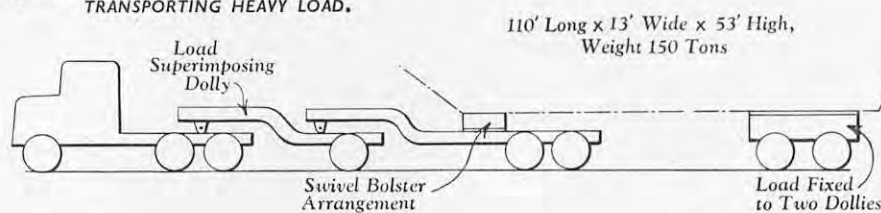
Tiller-Actuated Steering,
Operated from
Either EndFig. 20. IMPROVED METHOD OF
TRANSPORTING HEAVY LOAD.

Fig. 21.

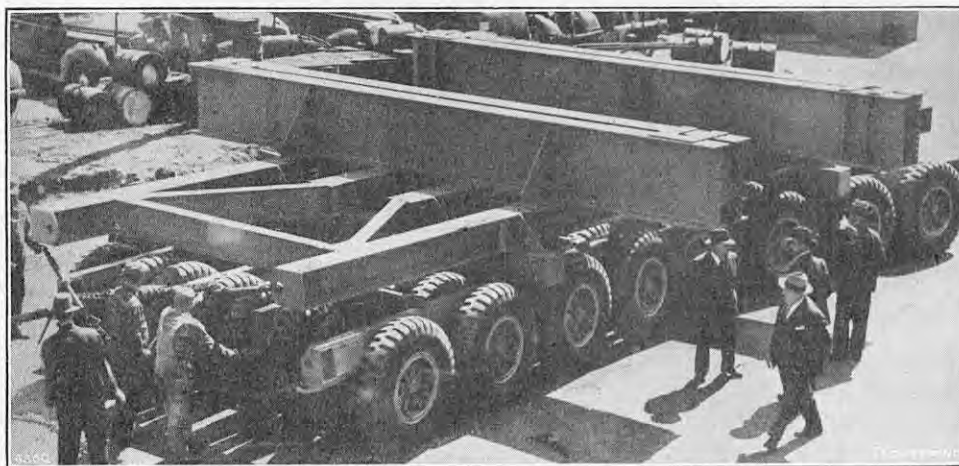
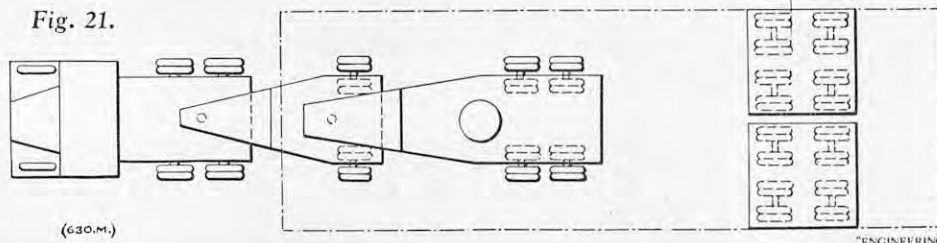


FIG. 22. ROGERS 300-TON TRAILER.

ATTACHMENT FOR FILLING 12 SACKS SIMULTANEOUSLY.—Dallow Lambert & Co., Ltd., Spalding-street, Leicester, have introduced an equipment which enables 12 sacks to be filled with granular materials discharged from a vertical outlet; the sacks are filled simultaneously with the minimum of attention. The discharged material is allowed to fall on to a cone, whence it is distributed into the sacks, which are clipped to a frame with 12 segment-shaped holes arranged around the periphery of the cone. The frame is supported on a circular base (which also takes the weight of the sacks as they are filled), and castors on the base enable the equipment to be moved slightly out of concentricity with the discharge outlet so that one or two of the sacks can be removed or replaced while the material is being deflected into the other sacks.

ELECTRICITY SUPPLY IN WEST SCOTLAND.—Details have been published of a hydro-electric scheme which is to be carried out by the North of Scotland Hydro-Electric Board in the Loch Awe district in west Scotland. The work will involve the construction of a weir across the River Awe a short distance downstream of its outflow from the loch and the conveyance thence of water through a tunnel to a power station on Loch Etive. This station will have an installed capacity of 55 MW and an annual output of 1 to 5 million kilowatt-hours. In addition, a dam will be built at the outlet of Loch Nant and water supplied from there through a tunnel to a station near Inverinan on Loch Awe. A third station, also on Loch Awe, will be supplied from a reservoir formed by building a dam across the Cruachan Burn on the mountain of that name.

TRAILERS AND SEMI-TRAILERS.*

By ARTHUR MARENBO.

(Concluded from page 91.)

By fitting small-diameter tyres it is possible to produce a straight-frame low-loading full trailer. However, the height of the front end of the semi-trailer is controlled by the diameter of the tractor wheels, and cranking the chassis becomes necessary if the loading level is to be reduced. In the most simple case, the platform extends over the wheels and the loading level is dependent upon the tyre diameter. Some semi-trailers, however, have wheel-arches or a wheel tunnel; the loading level, as a consequence, is independent of wheel diameter, and can be reduced by fitting a cranked axle. An arrangement popular in the United States of America, but usually associated with multiple unsprung axles, employs platform cut-outs over the wheels and the load is carried forward of these. On axle deflection the wheels rise above the platform level, and, for loading, the cut-outs are either covered in or a piece of equipment such as an excavator can ride over the tyres. In Great Britain, detachable back-axle models are very popular for the transport of heavy machinery, but curiously enough in the United States the common practice is to leave the wheels in position and to detach the lower deck from the forward crank. In another American design the crank collapses to form a ramp.

A sloping deck offers a useful compromise where a reduction in overall length is important, and it is ease of getting the load aboard that matters rather than the final height at which it is carried. An alternative is to have a pivoted platform which can be tilted down to the rear for loading and brought back to the horizontal for travelling. For the "Self-loading" semi-trailer, another popular American type, the tractor is equipped with a power-driven winch and a tail roller, which is used to lower the front end of the semi-trailer to ground level and to pull it back into position. If necessary, the tractor can station itself at the rear of the semi-trailer and winch the load up the inclined platform.

At first sight it may often appear that the design of trailers for very heavy loads is either too complicated or too simple, but it must be remembered that heavy-duty trailers are usually built for carrying specific loads under specific operating conditions. The necessity of being able to manoeuvre in restricted spaces, ease of getting the load aboard, and keeping the width down to a minimum, often force complications upon the designer, and are frequently just as important factors as the weight of the load. Probably the largest capacity pneumatic-tyred trailer yet to be built is the American Rogers 300-ton model illustrated in Fig. 22, herewith, though a relatively simple construction sufficed. Basically it consists of two carriages with a superimposed load-carrying frame. There are two lines of four four-wheeled compensated bogies on each carriage, that is, 32 wheels on each carriage, making a total of 64 wheels on the complete trailer.

* Paper presented at a meeting of the Automobile Division of the Institution of Mechanical Engineers, held in London on Tuesday, December 11, 1951. Abridged.

TRAILERS AND SEMI-TRAILERS.



FIG. 23. SCARI 200-TON TRAILER.

The vehicle is 39 ft. long and 17 ft. wide, and steering is effected by cross tie-chains and a steamboat ratchet. It was built during the second World War to carry a secret load over sandy soil, and the main problem was to provide a sufficient number of wheels so that tyres operating at a very low pressure, namely, 40 lb. per square inch, could carry the required weight. The Rogers 100-ton trailer employs two four-wheel bogies front and rear, but here again the design is relatively simple by European standards as there is no independent steering arrangement for the rear wheels. Generally speaking American manufacturers do not appear to concern themselves over-much with rear-wheel steering on these heavy units, but road conditions will usually force British manufacturers to incorporate such a feature.

An interesting example of double superimposition is furnished by the French Coder 90-ton trailer. In effect there is a main semi-trailer superimposed on a short semi-trailer, usually called a "dolly," which is itself superimposed on the tractor. This device of inserting a dolly between the tractor and semi-trailer is often employed in the United States and on the Continent to increase the capacity of an articulated vehicle, as usually the limiting factor is the load which can be carried on the tractor rear axles. If the vehicle has to carry a comparatively small load, the dolly can be removed and the main semi-trailer coupled directly to the tractor. On the French Scari 200-ton trailer, illustrated in Fig. 23, there is one dolly interposed between the rear carriage and the rear end of the main frame, and another between its front end and the tractor. There is a tracking device so that when going forward the wheels on the front dolly follow the path of the tractor rear wheels while the first and third line of wheels of the rear assembly are steered by two steersmen.

Some German multi-wheeled trailers have been built up in the manner shown diagrammatically in Figs. 18 and 19, page 121. This shows two 12-wheeled bogies attached to a common load-carrying frame and it will be noted that the wheels are evenly spaced, not divided into bogies as shown in the previous types. The arrangement may well be a development of the original Cullemeyer wagon transporter and is one of a number of variations all characterised by a central steering transmission shaft. It is possible, by altering the direction of the steering movements, to couple four of these units together and still retain the wheel tracking feature; Fig. 24, on this page, for example, shows how a French haulage concern has adapted some of these units for transporting heavy electrical equipment. As will be seen, there are two main trailers with a superimposed load-carrying frame. Each complete trailer is built up from four of the 12-wheeled bogies described above, and has 48 steered wheels.

The Dyson 100-ton trailer illustrated in Fig. 25, herewith, is shown fitted with solid-rubber tyres, but pneumatics could be fitted without any radical design modification. It was built to transport dragline excavators, and the main frame members can be set at different widths so that the excavators can be carried either with their tracks resting on these members or to each side of them. For ease in loading, both the front and rear cranks are detachable, and an arrangement of eccentric securing pins enables the centre platform to be fixed at two different loading levels and increased ground clearance obtained if hump-back bridges have to be negotiated. Independent steering mechanism is fitted to the rear carriage, and both carriages can be turned through 90 deg. and the trailer moved sideways. A hydraulic pumping unit with a 3-h.p. motor operates the jacks which raise and lower

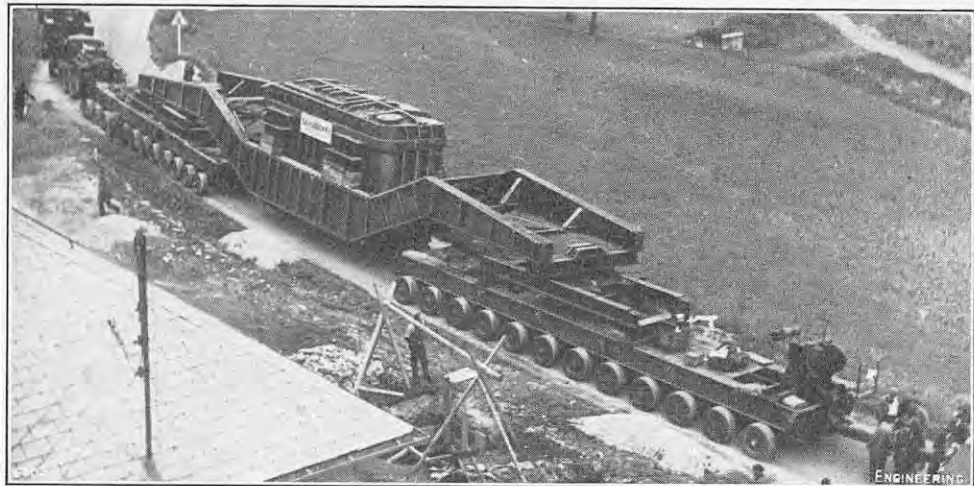


FIG. 24. TRAILER BUILT UP FROM FOUR 12-WHEEL BOGIES.

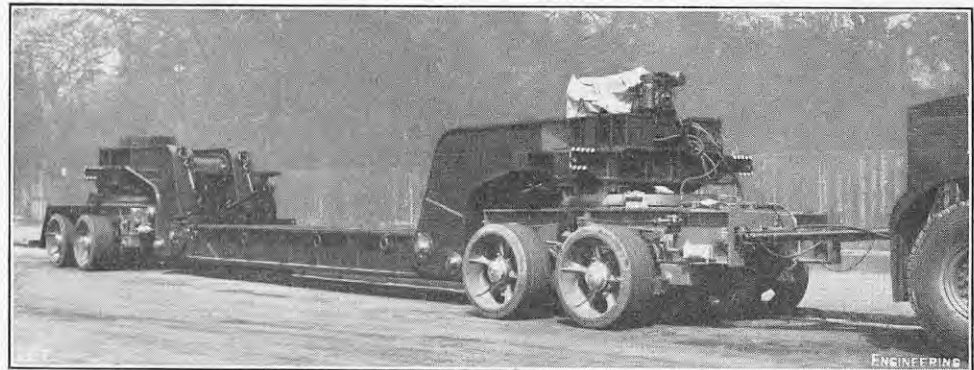


FIG. 25. DYSON 100-TON TRAILER.



FIG. 26. TRAILER FOR CARRYING OIL DERRICKS ACROSS DESERT.

the main bed. Each crank has a central ball-joint connection with the carriage upon which it rests, but there are additional side stabilisers. The stabilisers resting on one carriage are solid, but those on the other incorporate a series of alternate rubber and

steel discs, so that a limited amount of side rock is possible and three-point suspension obtained. A recently-constructed Crane 120-140-ton trailer also has eight-wheeled front and rear carriages, although in this case pneumatic tyres are fitted. The frame also is

TRAILERS AND SEMI-TRAILERS.

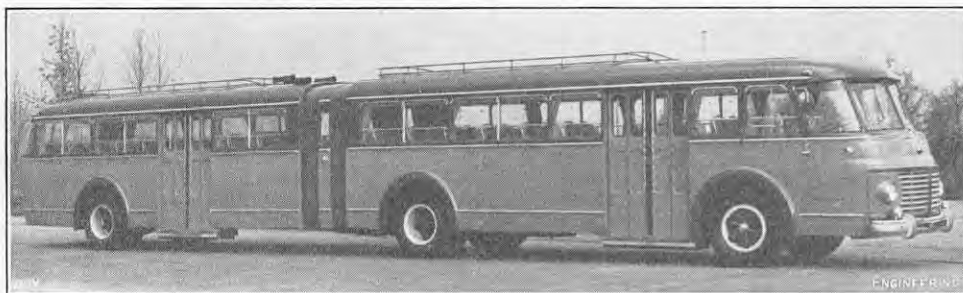


FIG. 27. "VIBERTI" TWO-WHEEL TRACKING PASSENGER TRAILER.



FIG. 28. GAUBSCHAT FOUR-WHEEL TRACKING PASSENGER TRAILER.

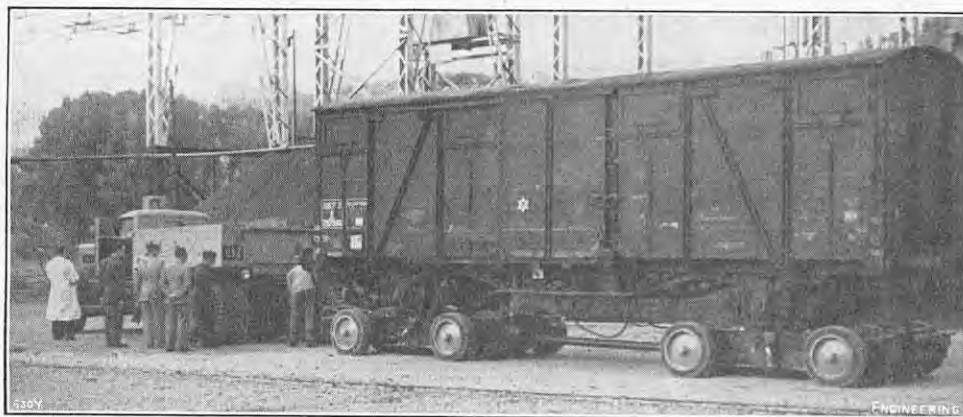


FIG. 29. CULLEMEYER WAGON TRANSPORTER.

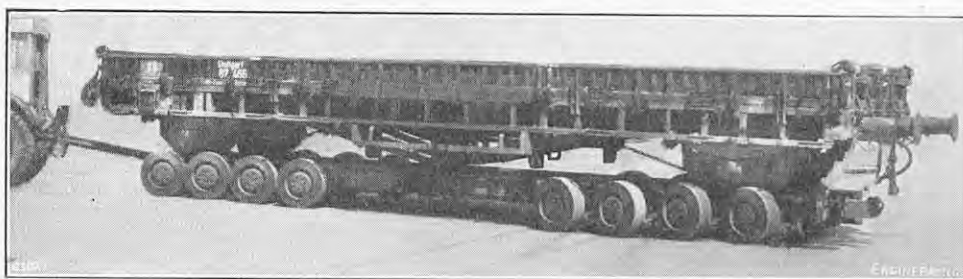


FIG. 30. GERMAN DEVELOPMENT OF WAGON TRANSPORTER.

adjustable for width and built with detachable cranks at each end. However, it incorporates a very interesting new development as the short oscillating axles are mounted on hydraulic rams which are connected in pairs to obtain load equalisation, and which can be operated to raise and lower the trailer. Each short axle is able to pivot and can be steered either by drawbar control or by power-operated hydraulic cylinders. Power steering is also a feature on a 200-ton trailer now being built in Sweden, but in this case compressed air boosts hydraulic cylinders which actuate the steering mechanism.

Hauliers are masters of the art of improvisation and sometimes several trailers will be linked together to form a heavy load carrying outfit. A good example of this is given in Figs. 20 and 21, on page 121, which shows diagrammatically how an American operator tackled the transport of a huge single piece load 110 ft. long, 13 ft. wide, and 53 ft. high, weighing more than 150 tons. Usually the trailer builder has to shape his design to suit the tyres that are available, and it is only during comparatively recent years that the production of suitable tyres has enabled British manufacturers to produce pneumatic-tyred 16-wheeled trailers in the 100-ton class. An example of what can

be done when the tyres are made to suit the trailer is provided by the unit illustrated in Fig. 26, opposite. The vehicle shown was built in the United States for carrying oil derricks across the desert. The 36-00 in. by 40 in. tyres are 9 ft. 6 in. in diameter and each can carry a load of nearly 25 tons.

Although trailers are not permitted to carry fare-paying passengers in Great Britain, they are widely used for this purpose in other parts of the world. Continental manufacturers in particular excel in this branch of trailer building, and have developed many outstanding models. The interconnected types, good examples of which are furnished by the Italian Autobus Viberti Articolato and the German Gaubschat, are of particular interest. The Viberti, a photograph of which is reproduced in Fig. 27, above, consists basically of a two-wheeled trailer attached to a towing vehicle, the body having flexible sections at the pivot. The trailer wheels are steered and at full lock there is only an angularity of 34 deg. between the two parts of the vehicle. In addition there is a system of segments which, in effect, halves the relative movement between the rotating parts of the platform. The Gaubschat, on the other hand, is a four-wheeled full-tracking trailer. It is illustrated in Fig. 28, on this

page, from which it will be seen that it has a corridor connection with the towing vehicle. On the Belgian Verleure semi-trailer passenger unit ten passengers are carried on the motive unit in addition to 65 passengers on the semi-trailer. This is rather an interesting development as the tractor is used to carry direct payload in addition to the superimposed load. There has been rather a similar development for goods transport in the United States, where weight limits vary from State to State. A well-known operator has commenced using semi-trailers with long wheel-base tractors, so that there is space behind the cab for a small removable container body to be fitted when the outfit is used in States where the higher limits apply.

The chassis frames on British-built trailers are usually constructed along normal lines from steel pressings or rolled-steel sections, although continental manufacturers often adopt backbone designs. In the D.A.F. trailer, for example, there is a central box-section main member with outriggers supporting the body frame. Several French and German concerns favour tubular construction of one form or another. American design appears to follow the same general lines as British except that production on a much larger scale makes possible the greater use of shaped pressings. Closed-top van semi-trailers actually constitute about half the total output, and the usual approach is to build the body integrally with the chassis; there is no separate chassis frame as such, although there may be some load-distributing members. Great use is made of horizontally-corrugated or vertically-corrugated side panels, which produce a strong assembly on a comparatively simple framework. However, smooth-panel vans will usually incorporate an elaborate truss-type body frame built of rectangular section tubes or specially shaped extrusions. A more recent American trend is the development of all-aluminium van semi-trailers, in which the construction is mainly of light alloy. There has been little British development of integrally-constructed van semi-trailers, although frameless construction is often adopted for tankers, grain hoppers, and the like. However, some progress has been made in the development of light-alloy chassis and a 10-ton capacity semi-trailer of this kind shown at the 1950 Commercial Motor Transport Exhibition in London had a tare weight of only 26½ cwt., including a 21-ft. by 7-ft. platform body.

Within the limited space of this paper it is impossible adequately to deal with the subject of braking and, therefore, it is proposed only to make some comment upon one aspect of the problem. The ideal tractor-and-trailer or semi-trailer combination would be one in which the brakes were completely synchronised, operating simultaneously and producing the same retardation in each unit. With sufficient attention to detail design, there is no reason why this ideal should not be achieved within practical limits, as time-lag difficulties can be overcome by the use of one of the various methods of power application, such as inverted, single-line vacuum or pressure, two-line vacuum or pressure, continuous-flow hydraulic, or electrical. Where perfect time synchronisation cannot be achieved it may be arranged for the trailer brakes to operate just before those on the towing vehicle. However, while braking efficiency of a semi-trailer is often matched up to that of its prime mover, insufficient attention is given to this point in the case of a full trailer. Very obviously, perfect braking cannot be expected from a vehicle with a braking efficiency of 50 per cent. towing a trailer which has only 35 per cent. braking efficiency. To prevent "jack-knifing" and to give braking control during manhandling, if a trailer is fitted with brakes on one axle only, it is preferably the rear one which should be so equipped, in spite of the fact that load transference during braking may reduce efficiency. The retardation which can be obtained is limited, and if speeds of more than 20 miles an hour are contemplated it does seem desirable that four-wheeled trailers with a gross weight of more than 6 to 7 tons should be equipped with four-wheel brakes. It may well be argued that the trailer brakes should be more efficient than those of the towing vehicle in order to iron out any delay in their application. Another very desirable feature is the inclusion of some device which enables the power applied to the trailer brakes to be reduced when it is empty and the towing vehicle loaded.

Trailers play a very important part in the co-ordination of road and rail transport and a loaded trailer may be carried by rail or a trailer may carry either a loaded railway wagon or a mobile railway container. The Dyson system was first introduced in Great Britain nearly 20 years ago, and although so far its use has been confined to bulk liquid transport, its development for carrying general merchandise is quite practical. As it runs aboard the railway truck, steel wheels positioned either externally or internally alongside the pneumatically-tyred wheels engage with guides, which lead the trailer into its correct central position and remove the load from the pneumatic tyres. Adjustable scotches then lock it in

position. The U.F.R. trailers used by the French National Railways, which incorporate a collapsible swan-neck, operate on a rather similar principle. The Ulster Transport Authority has developed an arrangement wherein the rear end of the semi-trailer is first positioned on the truck and a portable motor coupled to the steerable jockey wheels then swings the front end into position. Some American railway undertakings give facilities for the transport of hauliers' standard highway semi-trailers. Guard rails are fitted to the rail vehicle, and chains, chocks, and jacks may be used to secure the semi-trailer in position. Many other instances can be cited of road trailers being carried by rail and there seems to be no doubt that road and rail co-ordination along these lines will continue to develop.

Apart from the U.F.R. system, the French National Railways also transport loaded rail trucks by road on specially-designed trailers. The first experiments were carried out in the early 1930's both in Germany and France. Although French experiments did not at that time proceed very far, the Cullemeyer transporter was developed in Germany, and built in quantities for the Reichbahn. During the second World War the German Army frequently used these transporters to carry petrol tank wagons from rail-head to the scene of operations. There are various types of Cullemeyer transporter and one of them, now in the service of the French National Railways, is shown in Fig. 29, on page 123. This 40-ton unit consists of two eight-wheeled bogies and a telescopic steering bar links together the steering on the two bogies so that all sixteen wheels are made to track. There is also an 80-ton model which has two twelve-wheeled bogies, and the arrangement is probably very much the same as the submarine carrier shown in Figs. 18 and 19. An alternative type of German transporter is illustrated in Fig. 30, on page 123; this embodies torsion-bar springing and steering for all wheels, and a rather similar 40-ton model has been developed by the French National Railways.

APPRENTICESHIP SCHEME OF THE LOCKHEED ORGANISATION.

MORE and more firms are attending to the provision of apprenticeships that are thoughtfully planned and supervised. Few young men are now committed to a works where they must fend for themselves if they wish to gain wide experience. The latest evidence of progress in this direction comes from the Lockheed group of companies, which consists of the Automotive Products Company, Limited, and their associated companies the Lockheed Hydraulic Brake Company, Limited, the Borg and Beck Company, Limited, and Avery Equipment, Limited, all with works at Leamington Spa; also at Liverpool and at Sydney, Australia. Their products, as is well known, include hydraulic brakes, Purolator oil and fuel filters, hydraulic equipment for aircraft, Borg and Beck clutches, Thompson steering-rod assemblies, and Avery hoses and couplings.

The most significant feature of the several courses which are offered is the inclusion, even as early as the second year, of a period in, for example, the drawing office, the planning department or the laboratory. Doubtless this will enable apprentices to take a broad view of mechanical engineering earlier in their careers. There are two main courses: general apprenticeship, for boys starting at 15 to 16 years of age, and student apprenticeship, for boys of 17 to 18. General apprentices are given one of three classes of training, namely, in engineering (production), leading to posts as production supervisors, jig and tool draughtsmen, estimators, etc.; in engineering (drawing office), for those who wish to become draughtsmen in the production design drawing offices; or in a skilled trade. Student apprentices choose between engineering (production and engineering (design and research). Both types of apprentices are first given a probationary period of three months in the training department; if they pass this they are accepted as apprentices and their indentures are signed. Part-time study at a technical college is undertaken by the apprentice to obtain either the external B.Sc. degree of London University, the Ordinary and Higher National Certificates in Automobile, Mechanical or Production Engineering, or the final City and Guilds examination in the appropriate trade. If he progresses satisfactorily the firm refund the technical college fees, and prizes are awarded annually to the apprentices whose work has shown special merit. Details of the scheme are given in a booklet, "A Career with a Future," which the firm have published recently.

FILM ON DEPOSITION OF STELLITE.—Messrs. Deloro Stellite Ltd. have recently produced a sound film, entitled "Depositing Stellite with the Oxy-Acetylene Flame," which shows how worn parts on machines may be repaired, and surfaces and edges which suffer wear protected. This film is of the 16-mm. type, has a running time of 20 minutes, and is available free of charge from the firm, at Highlands-road, Shirley, Birmingham.

ELECTRICITY IN NEWSPAPER PRINTING.*

By A. T. ROBERTSON.

In normal newspaper printing, the letterpress copy is set up on lines of metal type, which are built up with the blocks for illustration into page size in a flat frame. This frame is impressed into a thick paper matrix, which is then curved to the shape of half a cylinder. From this half cylinder as many stereotype castings are produced as may be required on the presses for the simultaneous printing of the newspapers. These semi-cylindrical castings are locked on the plate cylinders of the press and, as they rotate, are thereby coated with ink, which is continuously fed to them by oscillating rollers. Modern presses are capable of being run at any speed up to a maximum of 60,000 copies per hour (500 cylinder r.p.m.), but it is usual to run them at about half this maximum. Plates weigh up to about 100 lb., so that each exerts a centrifugal force of nearly 6,000 lb. when running at 500 r.p.m. on a 16-in. diameter cylinder. The paper rolls are usually about 6 ft. long and 3 ft. in diameter and weigh up to 1 ton. The paper web is printed first on one side and then on the other by being pressed into contact with the rotating inked stereotypes by an impression or blanket cylinder driven at the same peripheral speed as the plate cylinders. Finally, the web is slit, folded, cut and delivered from the press in batches of 25 or 50. The tensile strength of the paper is important for high-speed printing and varies considerably with different manufacture, with age and with moisture content. The breaking stress for normal newsprint is not less than 2 lb. per inch width, but it should not be deliberately tensioned to more than about half this amount. Special care has also to be taken to ensure equal loading across the web.

Most newspapers are printed on presses using webs about 6 ft. wide and each unit of the press has two plate cylinders and two impression cylinders, one pair for each side of the paper. Each plate cylinder for a normal double-width press is fitted with eight stereo plates, arranged so that the two plate cylinders print eight pages of a full-sized paper twice per revolution. Thus, two printing units and a folder are required for 10-page to 16-page papers, three units and a folder for 18-page to 24-page papers, and so on. Newspapers in Great Britain use about 500,000 tons of newsprint per annum.

Electricity is now used for all the power and lighting requirements of newspaper printing offices, and is often used for type-metal melting in addition to the heating and ventilation of the premises. The connected load, the annual consumption of electricity and the maximum demand are given in Table I for a number of newspaper offices, together with particulars of their production. The Table shows some resemblances between the load characteristics of the different offices; it is surprising to find so small a variation in the ratio of connected load to average load and in demand factor, in view of the large differences between the offices in their equipment and production. It also shows that from 500 to more than 2,000 pages of newspaper can be printed for a total expenditure of 1 kWh, indicating that a reliable supply is more important than a cheap one. For the offices listed, the monthly consumption is within ± 10 per cent. of the average over the year, and does not show any particular seasonal variation. With the exception of one office, the night-load maximum demand is from 1.5 to 6 times that of the day load, and the load-factors are between 0.69 and 0.92 when calculated on the basis of annual consumption and of maximum day-time demand over the same period.

Apart from standby plant, which is provided to make sure that editions are produced on time in the event of trouble on some part of the equipment, more plant is provided than would otherwise be necessary if time were not so vital a factor in newspaper production. A failure of the power supply for even a short time may delay production sufficiently to make an edition worthless, and everything possible must be done to prevent such a failure. Alternative supplies from different sub-stations are usually insisted upon, and sometimes standby generating plant is installed as a further safeguard. The reduction in production time enables later news to be included, or papers with special news items made available earlier than would otherwise be possible. The effect of this is to increase the maximum demand without materially affecting the consumption of energy. The amount of energy consumed in the various processes is approximately proportional to the number of pages in the newspaper, and the end of paper restriction would inevitably mean a demand for, perhaps, double the present load. It is unlikely that this would involve any increase in generating-plant capacity, either for morning papers printed during the night or for Sunday papers printed during the off-peak period on Saturday.

* Paper read before the Institution of Electrical Engineers on Thursday, January 10, 1952. Abridged.

Most of the electrical energy used is for driving the presses, as shown in Table II, opposite, which gives a list of motor drives in typical newspaper offices. A considerable quantity is, however, employed for melting the stereo metal and for other parts of the process and for services. Fig. 1 shows the torque and horse-power required to drive a double-width printing unit of modern design at various speeds. At 50,000 copies per hour, the motor shaft runs at 1,750 r.p.m. Double-delivery folders are usual in high-speed presses, and they require about the same amount of power as a printing unit. The total power required to drive two such printing units and a double folder is thus three times that shown in Fig. 1. A single-width unit requires about 80 per cent. of the power for a double-width unit, and a single-delivery folder about 70 per cent. of that for a double one. Electrically-driven conveyors carry the papers from the press to the dispatch benches, and electric counters with selenium photocells are often used to count the copies or the bundles. Electric lifts are normally employed for lowering the rolls from the delivery level into the basement. Plate conveyors are required for delivering the stereo plates from the foundry to the press, where it has not been possible to arrange these parts of the plant adjacent to each other.

Table III, on page 126, lists the heating and lighting equipment installed in typical newspaper offices and shows that the electrical melting of the stereo-plate metal adds considerably to the amount of electricity consumed. This metal is usually maintained in its molten state at about 500 deg. F. during non-casting periods, because crystal-separation takes place in time at lower temperatures, and because, if the metal is allowed to solidify, repeated expansion and contraction may injure the pot and the heating elements. Very much less heat is required to maintain the metal at the standby temperature with immersion heaters than with gas or oil flames. A 7½-ton pot requires only about 11 kW when it is well lagged, but this accounts for an annual consumption of some 100,000 kWh per pot. Actually, there would be very little saving in radiation loss if the heaters were switched off between casting periods, because the temperature falls very slowly, to about 400 deg. F. in 12 hours and to about 300 deg. F. in 20 hours. Every ton of metal cast requires about 25 kWh of power, so that the annual consumption per machine, in kilowatt-hours, is 25 times the number of tons cast per year plus 100,000. Interruption of supply prevents the use of a casting machine, whatever the metal temperature may be, but on the resumption of the supply the temperature can be raised in 5 minutes by as much as it has fallen in an hour or so through radiation loss. Although there may be a casting period immediately before printing, it is usual for casting to be continued for subsequent editions while the presses are being run. For morning papers, all the heating load is taken during an off-peak period. Electricity is also used to heat the Linotype metal and to dry the matrices, both processes being automatically controlled.

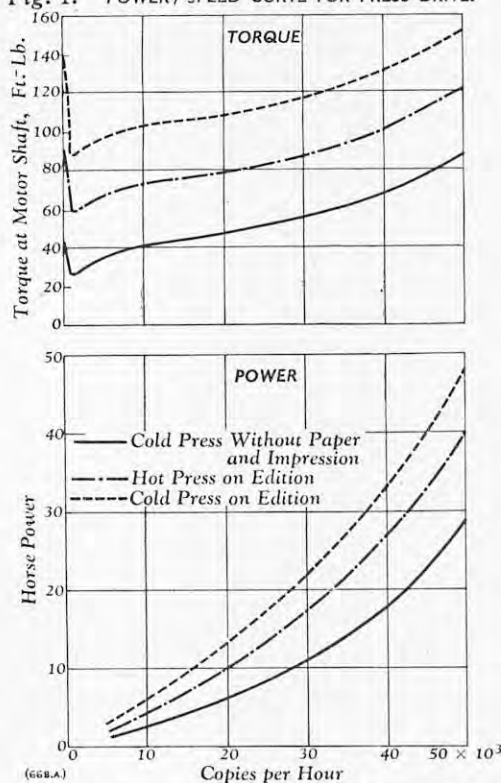
Modern lighting can do much to improve the product, the working conditions and the safety of the operators. Some recent installations of fluorescent lighting on presses, giving a uniformly high intensity of light all round and inside the press without glare, are very impressive. Any possible objection to the use of these tubes due to stroboscopic effects may be precluded by using twin tubes with chokes and capacitors to give phase displacement between the currents in each tube, or by connecting adjacent tubes across different phases.

Modern newspaper presses are usually of the line type, in which a number of similar printing units are arranged along the press-room with folders interposed at intervals, as shown in Fig. 2, opposite, where the motors are shown at *a* and the gear boxes at *b*. Linotype presses with paper-web feed from the floor below and double-delivery folders are now accepted as the best for high-speed production. They are also readily adaptable for the production of papers having different numbers of pages. It is quite usual for presses to be arranged to produce newspapers with from four to 32 pages, requiring one, two, three or four printing units feeding into one folder. Common shafts run the full length of these presses, with clutch couplings arranged so that the shaft can be divided into sections with as many printing units grouped to a folder as may be required. Usually, the units are driven by vertical shafts through bevel gears from the main shaft.

A group drive has as many motor and control equipments as there are folders, the motors being large enough to drive the folder and the maximum number of printing units that may feed into it, whereas a unit drive has a motor for each printing unit—and often for each folder—with simultaneous control of all motors associated in each press group. With a unit drive, the electrical breakdown of a motor does not interfere with the running of the complete press, and, even with a mechanical breakdown, the uncoupling of the motor often allows the press to be run by the other motors. The accommodation of large group-drive equipments is often difficult and may involve deep

ELECTRICITY IN NEWSPAPER PRINTING.

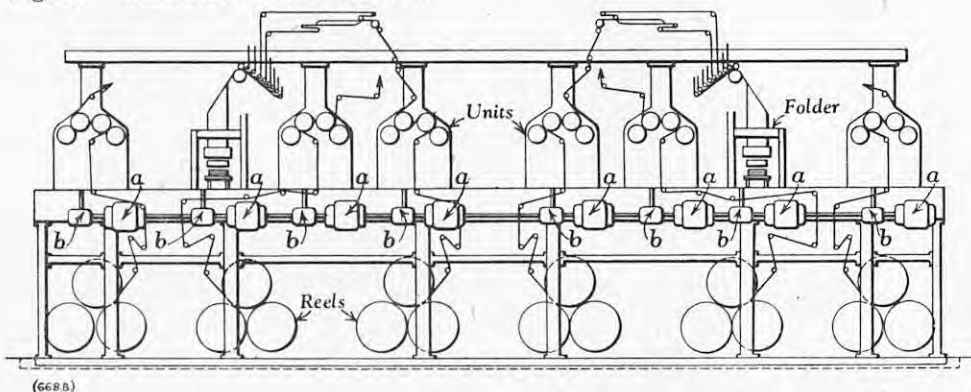
Fig. 1. POWER/SPEED CURVE FOR PRESS DRIVE.



excavation, whereas the smaller unit-drive equipments can usually be disposed about the press.

Since the first unit drives were installed in Britain 20 years ago, presses in most of the large offices have been driven by them, either by chain or gear drive on to the press shaft, chain drive direct on to the press cylinder, or coupling drive with the motor coaxial with, and forming part of, the press shaft.

Fig. 2. PRINTING PRESS ARRANGEMENT.



additional complication and of higher capital and maintenance costs. If lengths of chain are included in the mechanical coupling between units, the register is not as good as it is with couplings and gears. If chains cannot be avoided, they should be provided with adjustable jockey pinions to eliminate slackness.

It is essential that presses and their driving equipment shall be made as safe and reliable as possible, and, owing to the large masses of the moving parts, smooth control of the driving equipment is necessary to prevent breakage of the mechanically weak paperweb. Operators need to be able, by suitable manipulation of control push-buttons, to inch the press round by just the amount that may be necessary during making-ready and plating-up, and to obtain a uniform crawling speed for leading-in, i.e., threading the paper from the roll through the press to the folder. A torque in excess of that needed to run the press at a uniform speed is required to overcome its static friction. Soon after it has started to move, however, the torque will drop to a fraction of that needed to run it at full speed, but even at this light load the speed must not exceed that required for leading-in the sheet, which is probably 2 per cent. of the full printing speed. The driving equipments under push-button control must also be capable of accelerating and decelerating the

it is producing unsaleable papers. When webs are broken at high press speeds and after passing over the cylinders, the paper will wrap round the cylinders until the press is stopped. This causes considerable delay and possible damage to the press. In these circumstances, brakes minimise the trouble by reducing the number of layers of paper wrapped on to the cylinders. Brakes are sometimes also provided to prevent the press being moved by gravity when it is being plated-up. This can happen when operators unbalance the cylinders by fixing plates on one side of them.

Preferably, both stopping and holding brakes should work when there is no power available; and brakes for stopping must be applied gradually, otherwise they may cause the web to be broken, when more time will be lost in leading-in again than has been saved by stopping the press quickly. Most of the stored energy is in the press cylinders and the rotors of the driving motors, and if rapid stopping is necessary brakes should be applied to both. Either hydraulic or electric friction brakes are regularly used in preference to dynamic brakes, which cannot be maintained down to slow speeds. Motor-operated hydraulic and electric friction brakes have the advantage of more gradual application, but are not so rapid as those operated by solenoids.

TABLE I.—EQUIPMENT AND LOAD OF TYPICAL NEWSPAPER OFFICES.

Office.	Publications.	Production Capacity.	Actual Production.	Annual Consumption.	Annual Cost at 1d. per kWh.	Number of Pages per kWh.	Connected Load.†	Ratio Connected Load/Average Load.‡	Maximum Demand in 1950.				Demand Factor (Maximum Demand/Connected Load)	Annual Load Factor (Average Load/Maximum Day-time Demand)
									Night Maximum.	Night Minimum.	Day Maximum.	Day Minimum.		
A	M. E. and S§	21.6	68.2	5,810	24,200	610	5,200	7.65	1,340	1,180	960	800	0.26	0.69
B	M and S	8.6	46.4	2,130	8,900	1,130	2,570	10.5	920	680	330	230	0.36	0.74
C	M and E	9.8	19.2	1,920	8,000	520	2,920	13.3	440	400	640	500	0.22	0.34
D	M and S	13.4	36.4	1,890	7,900	1,000	3,280	15.2	690	547	232	195	0.21	0.92
E	M and S	7.3	54.0	1,460	6,100	1,920	1,940	11.6	570	489	210	70	0.29	0.80
F	M and S	7.8	31.9	600	2,500	2,760	1,137	16.6	400	330	90	60	0.36	0.76
G	M and S	46.4	150	3,884	16,200	2,000	4,380	9.9	1,600	1,200	500	200	0.37	0.89
H	S	33.6	52.6	—	—	—	4,506	—	1,638	1,170	257	115	0.36	—
I	M. E. and S	6.05	17.3	610	2,540	1,470	1,263	18.1	—	—	—	—	—	—

* Standard page of 24 in. by 18 in.; this is equivalent to two tabloid-size pages.

† Average load = $\frac{\text{annual consumption}}{365 \times 24}$

‡ Motors, heaters and lights.

§ Morning, evening and Sunday.

TABLE II.—MOTORS INSTALLED IN THE NEWSPAPER OFFICES ANALYSED IN TABLE I.

Office.		Number and Horse-power of Motors Installed.																			
		Press.				Reel Stand.		Paper-roll Lifts.		Newspaper Conveyor.		Linotype.		Casting and Shaver.		Ventilation Fan.		Others.		Totals.	
		Main.	Inching.																		
A	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	No.	Total H.p.	
B	78	3,120	—	—	120	240	4	70	18	18	120	30	15	85	9	110	47	176	411	3,849	
C	10	1,120	10	88	—	—	1	30	3	9	30	20	11	41	26	64	190	170	1,524	—	
D	13	1,775	13	228	45	75	2	35	4	8	56	15	7	40	7	55	110	211	257	2,442	
E	14	1,800	14	346	48	96	6	10	23	23	37	18	13	52	17	110	114	354	286	2,809	
F	26	1,170	26	52	100	350	4	48	14	20	57	30	15	46	11	40	95	163	348	1,919	
G	6	740	6	144	12	24	—	—	—	—	31	15	13	42	—	—	74	132	142	1,097	
H	34	3,325	—	—	—	—	10	150	13	65	46	23	8	70	12	120	206	618	329	4,371	
I	61	3,325	61	974	168	252	7	87	31	70	30	15	14	43	9	75	36	105	417	4,946	
	6	900	6	45	—	—	—	—	—	—	—	—	—	71	—	14	—	110	—	1,180	

With any of these drives, the various units are usually maintained in register by the mechanical coupling, and only the paralleled motors need share the load. In unit drives, an electrical tie-in, using Selsyn machines for registering the units instead of mechanical couplings, has sometimes been used to enable the make-up of the press (for papers of different numbers of pages) to be controlled by switches; but it has not been widely used, probably on account of the

press smoothly between crawling and any desired speed, and of driving it efficiently at any printing speed, usually down to about one-half of the maximum.

All modern high-speed presses are provided with brakes, which, in addition to giving operators a sense of security, are required to save the time taken to bring the press to rest during normal printing operations, as well as to save waste of paper when the press is being stopped because for one reason or another

The required operating performance of printing presses can be obtained by the use of variable-speed motors, either with or without a geared inching-motor, but most driving equipments now in use have motors for inching and crawling in addition to those on the main drives. The inching motors drive the press through a speed-reduction gear and a clutch, and by this means, and using only a small motor, ample torque can be provided to start the press and any desired

ELECTRICITY IN NEWSPAPER PRINTING.

Fig. 3. A.C. SERIES-COMMUTATOR-MOTOR DRIVE WITH SQUIRREL-CAGE MOTOR INCHING.

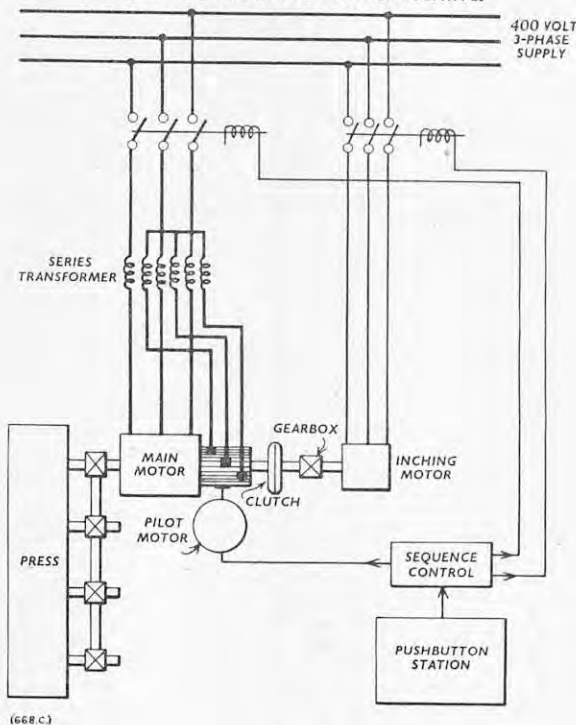


Fig. 4. A.C. SERIES-COMMUTATOR-MOTOR DRIVE WITH LOW FREQUENCY INCHING.

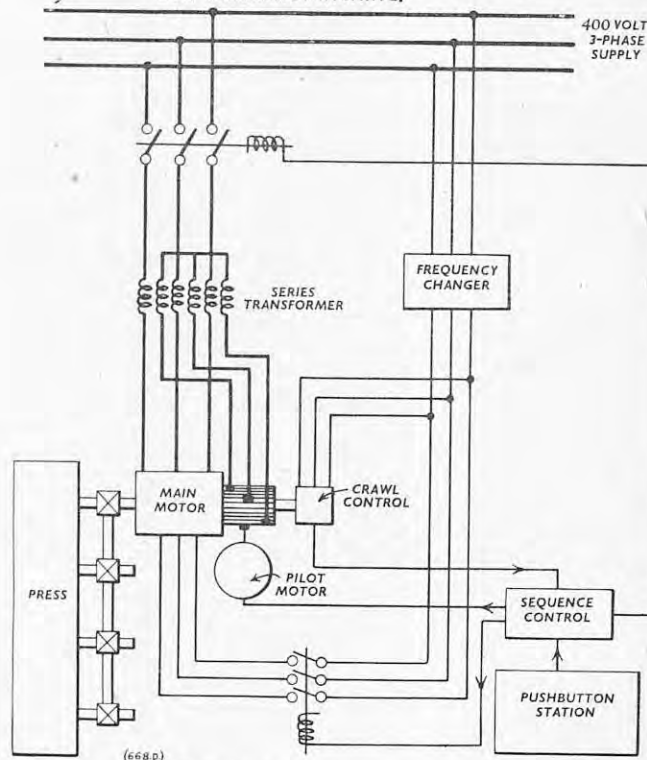


Fig. 5. SCHRAGE-MOTOR DRIVE WITH SERVO BRUSHGEAR CONTROL FOR INCHING AND CRAWLING.

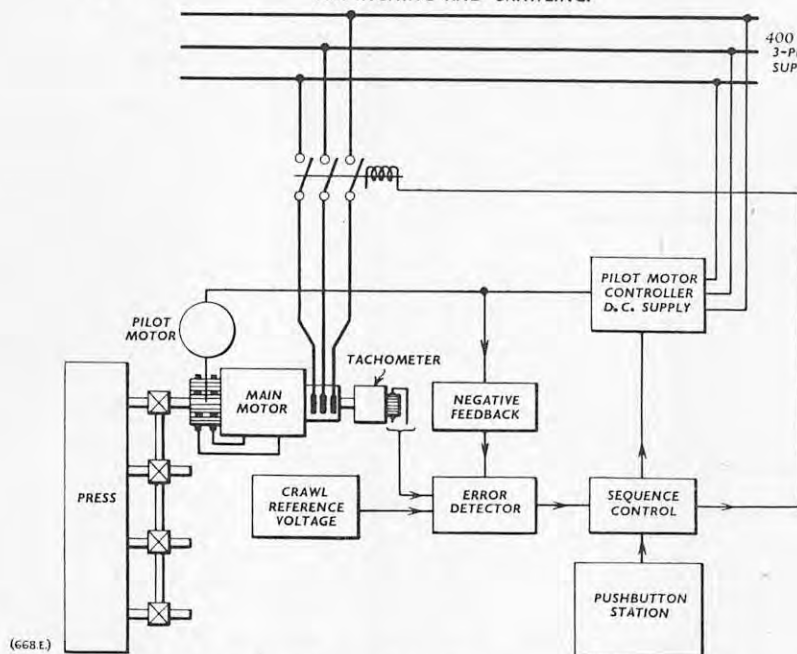
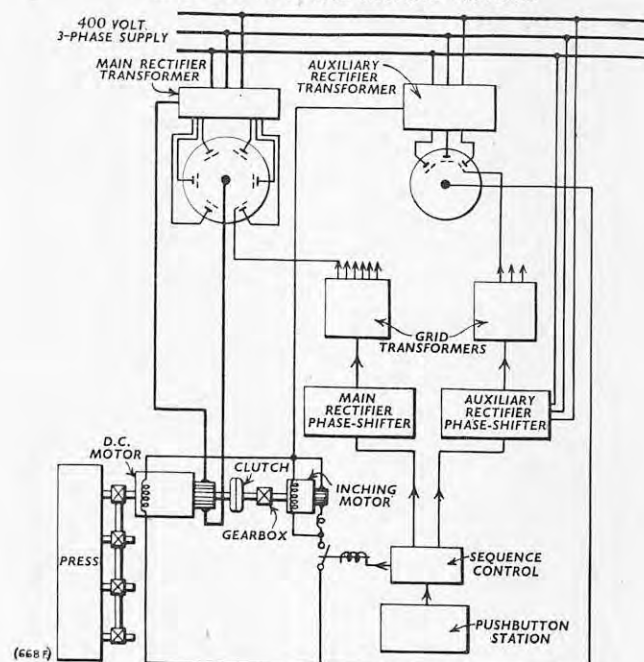


Fig. 6. GRID-CONTROLLED MERCURY-ARC RECTIFIERS WITH D.C. MAIN AND INCHING MOTORS.



uniform low speed can be obtained for crawling. The clutch allows the main motor to accelerate the press above crawling speed without overspeeding the geared inching-motor, which can be shut down when the main motor has taken over the load. Such equipments are usually referred to as "duplex," to distinguish them from single-motor drives in which the main motor is used for inching and crawling speeds. Only by the use of recent developments in the servo-control of motors can the performance of a single motor be made to compare with that of a duplex drive.

A separate control-board is required for each section of a press that includes a folder, so that they can be operated independently. It is usual to provide some form of motor-driven sequence controller for equipment of all types, to ensure that the various control operations occur in the correct sequence when any push-button is operated.

Fleet Street newspaper offices are mostly supplied with direct current, but, apart from these and a few provincial offices, the supply in Great Britain is now alternating current. Acceleration from crawling to the minimum printing speeds for a duplex-motor equipment on a constant-voltage direct-current supply is obtained by cutting out series resistances. Experience has shown that only three or four steps are necessary to prevent paper-web breakage due to excessive

TABLE III.—HEATING AND LIGHTING INSTALLED IN THE NEWSPAPER OFFICES ANALYSED IN TABLE I.

Office.	Number and Rating of Heaters.								Lighting.	Total Load.
	Stereo Melting.		Linotype Melting.		Others.		Heater Totals.			
	No.	Total kW.	No.	Total kW.	No.	Total kW.	No.	kW.	Total kW.	kW.
A	5	1,248	120	240	51	70	176	1,558	266	1,824
B	7	808	30	53	34	218	71	1,079	155	1,234
C	4	421	57	83	53	134	114	638	138	774
D	6	491	42	67	49	126	97	684	128	812
E	3	24	40	80	2	12	45	116	134	250
F	—	—	31	46	9	26	40	72	100	172
G	4	150	46	70	25	118	75	338	200	538
H	—	—	30	51	—	—	30	51	104	155
I	1	20	4	10	10	33	15	63	160	223

acceleration. Efficient speed control over the printing range is invariably obtained by shunt regulation of the motors, and a large number of steps are required to enable operators to adjust the speed exactly. Inching and crawling can be obtained with single-motor drives, by providing a separate low-voltage supply for the driving motors, but this involves heavy-current switching in both supplies. The cost of the low-voltage motor-generator and its control gear is at least as much as that of the inching equipment of a duplex

set, and generally the operation is not so satisfactory. Motor-generators with Ward-Leonard control have been used to enable the whole speed range to be obtained by shunt regulation, but these cost more than the alternative drives, without worthwhile advantages.

With an alternating-current supply at any normal voltage and frequency, efficient control over the printing-speed range can be obtained either by the use of variable-speed commutator motors, or by rectification and direct-current motors, and it is in both these

TEST OF TIMBER ROOF TRUSS.

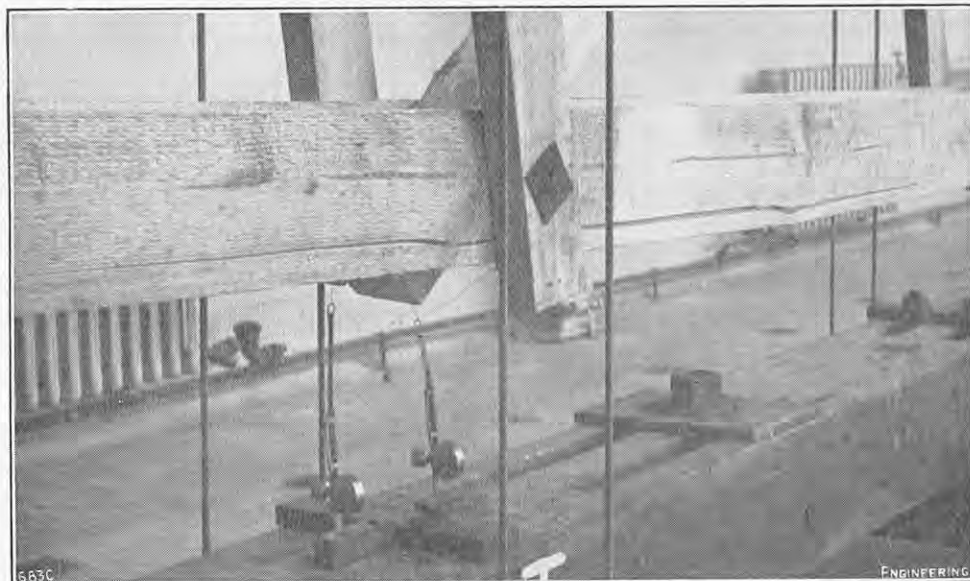


FIG. 3. CRACK IN BOTTOM TIE MEMBER AFTER TEST.

directions that rapid developments have taken place during the past decade or so. Induction motors with rotor-resistance speed regulation are rarely used in Great Britain, except for driving small presses, but they are used extensively in the United States, where presses are more often run at their maximum speed, and where alternating-current commutator motors are not readily available. The design, construction and performance of alternating-current commutator motors have improved to such an extent that they are now at least as good as direct-current motors.

The capital and running cost of rectification to constant voltage with direct-current motors is more than that for alternating-current motors, and should be considered only when an existing direct-current drive and control switchboard are to be changed over to alternating-current supply. If, on the other hand, the existing direct-current motors are in good condition, there is not the slightest doubt that variable-voltage rectification with electronic or magnetic amplifier control should be adopted when changing over to alternating current. If completely new equipment is required, and a variable-voltage rectifier is used to control a number of motors, as in a unit drive, there is not much difference in total cost between this and a scheme using commutator motors; but the latter is less complicated and takes up less space than the electronic or magnetic amplifier-controlled rectifier for the direct-current motors. Several large newspaper presses in the United States are now being driven by direct-current motors from a rectified supply, and equipments are being installed in Great Britain, but some time must elapse before a true assessment of the merits of the scheme can be judged from operating experience.

Alternating-current commutator motors of three distinct types have been used for driving newspaper presses, namely, the Schrage type, with a supply to its rotor slip-rings and two sets of oppositely-moving brushgear on its commutator; the shunt type, with a supply direct to its stator, and also through an induction voltage-regulator to stationary brushgear on its commutator; and the series type, with a supply to its stator through the primary of a transformer, the secondary being connected to a single set of moving brushgear on its commutator. The power factor and efficiency of all three types are equally good, but the series motor, without either slip-rings or induction regulator, and with no voltage on the commutator at synchronous speed, is the best for most drives. In addition to its simple construction, it has the outstanding feature of automatically sharing the load with any paralleled motors without need for ancillary equipment.

Fig. 3, opposite, shows the simplicity of the control for a duplex drive with alternating-current series main motors and squirrel-cage inching motors with direct-on-line starting. These give ideal inching and a positive break-away from rest that can be adjusted by stator resistance or reactance without materially changing the crawling speed. Inching motors, gears and clutches have been eliminated in at least one installation by the use of a separate low-voltage low-frequency supply to a winding on the driving motor, the control-scheme for which is shown in Fig. 4. In this installation, the six-pole commutator winding gives a maximum speed

of 1,250 r.p.m. at 50 cycles, and the small amount of low-frequency power required for inching is generated by a commutator-type frequency converter and fed to a 16-pole slow-speed winding at 3 cycles to give a crawling speed of 22 r.p.m. The inching equipment can also be eliminated with Schrage motors if they are made large enough to give the full speed range from crawling to top speed, and a servo scheme is used to control the crawling speed. Fig. 5 shows such an arrangement, using a Schrage motor with a tachometer-operated electronic error-detector and negative feedback to ensure that the motor gives sufficient torque for starting against the static friction of the press, and to adjust the brush position automatically to give the required constant crawling speed, whatever the load.

The main direct-current power can be obtained from the alternating-current supply either by ignitrons or by any of the various forms of mercury-arc rectifiers, and the voltage can be varied by induction regulation of the supply or by control of the ignitron firing or of the grid potential of the mercury-arc rectifiers. Ignitrons have the important advantages that they take up very much less space, are more easily replaced, and can be connected to the supply without a transformer. On the other hand, their firing-control is more complicated than the grid-control of a multi-anode rectifier and they need to be cooled by water, which must be kept above a fixed temperature. Grid-controlled thyatrons are convenient for the supply of the variable voltage required to give the shunt-regulation range, but if valves are considered too vulnerable there is the alternative of transducers with metal rectifiers or of motor-generators. For constant-voltage auxiliary supplies for control circuits and the like, metal rectifiers are usually the most convenient. Shunt regulation is generally used over the full printing range to obtain a good power-factor, but, if it is unnecessary, the size of the motor can be reduced and the control simplified.

Because reliability is of prime importance, some engineers prefer inching motors to the alternative of more complicated controls, even when variable voltage is used for running-up and for speed control; such a scheme, using two grid-controlled rectifiers, is shown in Fig. 6, where an auxiliary rectifier is used to supply full voltage to the inching motor for inching and crawling, and to the main-motor field for running up to the lowest printing speed, and variable running by grid control for speed regulation over the printing range.

(To be continued.)

ELECTRICITY SUPPLY STATISTICS.—During December 1951, 5,762 million kilowatt-hours were generated by the stations of the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company, compared with 5,902 million kilowatt-hours during the corresponding month of 1950, a decrease of 2.4 per cent. During the year 1951, the same stations generated a total of 59,971 million kilowatt-hours, compared with 54,559 million kilowatt-hours in the previous 12 months, an increase of 9.1 per cent. The total installed capacity at the end of 1951 was 16,328 MW, compared with 15,075 MW in December, 1950, an increase of 8.3 per cent.

LABORATORY FOR TESTS ON TIMBER STRUCTURES.

A TIMBER roof truss was last week tested to destruction in a new test house at the Forest Products Research Laboratory, Princes Risborough, Buckinghamshire. The test house has been built by the Ministry of Works for testing timber structures, such as floors, roof trusses and girders, and the truss used for the demonstration was provided under the aegis of the Timber Development Association as part of their plan to encourage the use of timber for such purposes. The Association maintain that building and other constructional work is to-day often delayed unnecessarily owing to the convention of insisting on steel where timber would serve equally well. The staff of the Forest Products Research Laboratory—a laboratory of the Department of Scientific and Industrial Research—now that they have a suitable test house, are undertaking further research on the properties of timber structures. They propose building up adequate data on the subject by commencing with tests on the elements of such structures, following these with tests on simple and then complex structures. The experiment with the T.D.A. truss, however, fitted in with the objects of the Timber Development Association, and provided a welcome opportunity for the staff of the laboratory to try out their new equipment on a large scale at an early stage.

The test house, or laboratory as it is called, is equipped for testing structures occupying a maximum area of 38 ft. by 26 ft., under a maximum load equivalent to a distributed load of 3 cwt. per square foot. Trusses, girders, etc., up to 70 ft. long can be accommodated, as well as arches up to 38 ft. span and 26 ft. high and tested with loads of $1\frac{1}{2}$ tons per foot of span. Fig. 1, on page 112, shows the T.D.A. truss after the test to destruction, and it also shows part of a side wall of the building; the opposite side wall contains large windows. Parts of the floor have threaded sockets embedded in the concrete, used for holding structures and applying loads.

The method of supporting and stressing the T.D.A. truss, which had a span of 57 ft. 4 in., is shown in Figs. 1 and 2, on page 112. Each end rests on a hydraulic thrust capsule, so that the load is obtained from the reading of the pressure gauge connected to it. Pin-jointed links attached to the truss at the purlin points hold the truss vertical. An equal load is applied at each purlin point by means of two hand-operated winches (Fig. 2), one at each end, each of which pulls on a shackle. A long wire rope, joined at its ends to form a continuous loop, is passed round both shackles and round a series of pulleys on the truss. As will be seen from Fig. 1, there is a pulley on each side of each purlin point, and the rope is guided up to it and down from it by a pair of pulleys which are mounted on a rigid timber frame bolted to the floor. The rope passes along one side of the truss, round a shackle, and then along the other side. When the winches are operated, the wire rope pulls down on all the purlin points with a substantially equal force. The difference due to friction at the pulleys is small—a maximum at the centre of the truss of about 3 per cent.—and by using a winch at each end the loss is only half what it would be with only one winch.

The design of the T.D.A. truss will be clear from Fig. 1. All members except the tension bracing members are double, with spacing blocks between each pair of timbers. The joints are made with $\frac{1}{2}$ -in. black bolts, square washers on the outside and Bulldog washers between mating faces of the wood. These washers have sharp crimped edges which "bite" into the wood so as to take the load which would otherwise be taken by the bolts in shear. Various woods were used in the construction of the truss, including Douglas fir and European redwood and whitewood. The timbers were selected for straightness of grain, but in other respects they were normal stock. In the test last week the load was applied intermittently to allow the structure to settle under stress. The design dead load at each purlin point was assumed to be 205 lb. of sheeting and 45 lb. due to the purlin, giving a total of 250 lb. The design live load per point was 600 lb. of snow (10 lb. per square foot in plan) with a truss spacing of 14 ft. 3 in. and a purlin spacing of 4 ft. 6 in. Starting with zero deflection at no load, then 0.29 in. deflection at the centre of the bottom tie with dead load only, the live load was applied in stages. The deflections and total loads were as follows: half live load, 0.66 in. and 3.19 tons; live load, 1.44 in. and 4.93 tons; $1\frac{1}{2} \times$ live load, 2.06 in. and 6.67 tons; $2 \times$ live load, 2.67 in. and 8.41 tons; $2\frac{1}{2} \times$ live load, 3.43 in. and 10.16 tons; and $3 \times$ live load, 4.32 in. and 11.90 tons. When failure occurred, the load was approaching $3\frac{1}{2} \times$ live load, representing a total load on the truss of 13.64 tons. The main point of failure is shown in Fig. 3; the crack originated at a small knot in the bottom tie member, and its propagation was accompanied by a loud report. There were also two other small cracks in the truss. The curved shape of the bottom tie member after the test is shown in Fig. 1.

USE OF HELICOPTER IN ERECTING TRANSMISSION LINE.

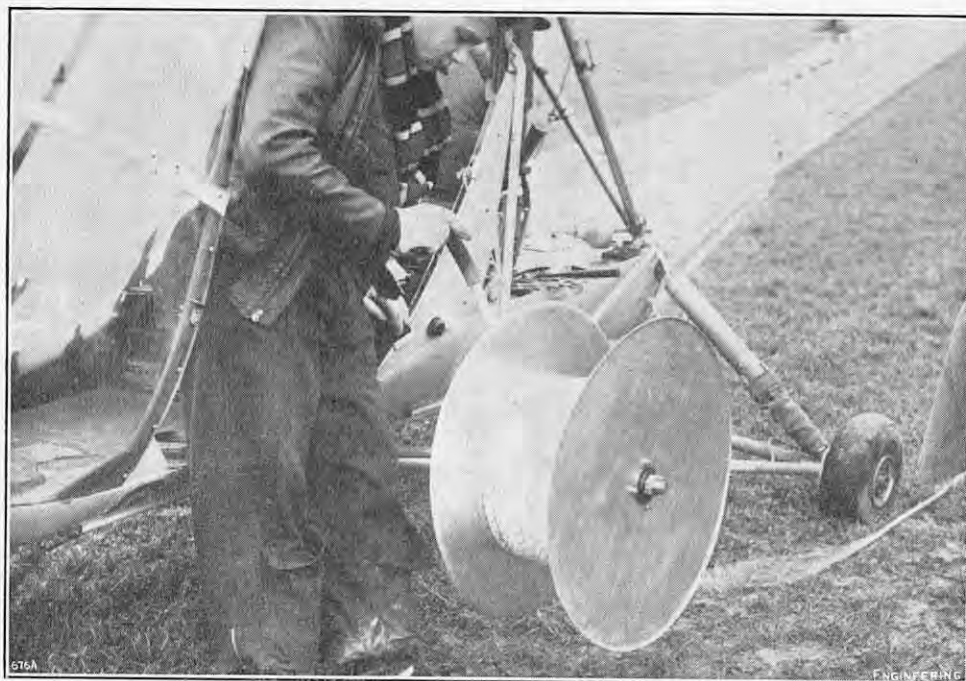


FIG. 1. SASH-CORD DRUM ON HELICOPTER.



FIG. 2. SECURING CORD TO POLE CROSS-ARM.

USE OF HELICOPTER IN ERECTING TRANSMISSION LINE.

As briefly noted on page 14, *ante*, the Midlands Electricity Board decided to use a helicopter to carry a light rope across a thickly-wooded valley on the Malvern Hills, Worcestershire, to enable a 66-kV three-phase overhead electric line, consisting of three 0.1 sq. in. steel-cored aluminium conductors, to be strung over a valley between two 50-ft. H-poles, which were 1,280 ft. apart. The poles are sited so that the conductors when strung are well above the dense wood covering the valley and no tree lopping will be necessary. The work was successfully completed on Tuesday, January 8, and it is now possible to give some further details of the proceedings.

The wooded valley in question is situated on the Eastnor Estate just south of the British Camp on the Malvern Hills; and the normal method of erection would have involved clearing trees from the route of the line and laying the conductors on the ground prior to hoisting them into their final positions. This would have been slow, costly and destructive. A Hillier helicopter was therefore chartered from Pest Control, Limited, Cambridge, the machine being fitted with a 178-h.p. Franklin engine and being one of the fleet used for spraying crops at a height of a few feet and at a speed of 15 to 40 m.p.h. The helicopter, which carried a crew of two, was fitted with a light outrigger to carry a drum (Fig. 1); and arrangement were made so that this drum could be jettisoned by pulling out a cotter pin. Incidentally, the fitting of the drum, and the fact that this was a pioneer effort, made it necessary to obtain a new certificate of airworthiness and to pay a special insurance premium. The line is being constructed by the Board's own staff and the only other equipment obtained from outside, in addition to the helicopter, was an ex-War Department winch lorry. This lorry, which was fitted with a balloon cable provided by British Insulated Callender's Cables, Limited, considerably accelerated the pulling out of the conductors.

Field telephones were set up between a control point, from which the whole space could be viewed, and the two "H" poles and the winches. A 500-yard length of sash cord weighing 52 lb. and having a breaking strength of 700 lb. was wound on the drum and a sock filled with earth was attached to its end as a weight. After a trial run along the route to test the air conditions (which were far from ideal) the weighted cord was successfully dropped over the cross-arm of one pole and secured by men standing on a platform, as shown in Fig. 2, while the helicopter flew over at a speed of about 5 m.p.h. 20 ft. above it. The cord was then secured to the pole and the helicopter flew along the route of the line, which was marked by yellow discs on the tree tops, paying out the cord. The other pole, 1,280 ft. away, was reached in 1 min. 20 sec., when the speed was again reduced to 5 m.p.h. and the cord dropped over the centre of the cross-arm as shown in Fig. 1. In spite of the unfavourable weather condi-

tions, which included a gusty wind of from 15 to 20 m.p.h., blowing at 45 deg. across the port bow, the cord was at no time more than 15 ft. off the direct line as it lay along the tree tops.

The sash cord was next attached to the balloon cable, which had a breaking strength of $4\frac{1}{2}$ tons and was drawn across the valley by winches, the speed of which was limited so that the tension did not exceed 350 lb. The balloon cable was drawn across the valley in 18 min. and was then attached by a special fitting, which prevented twisting, to two of the steel-cored aluminium conductors and a light steel wire. The two conductors were next pulled across the valley in 20 min., being kept clear of the trees by adjusting the rate of paying out. During this operation the tension in the balloon wire averaged 1,200 lb. The steel wire was used to pull the balloon wire back again when the third conductor was attached and the operation repeated. It would have been possible to string all three conductors at the same time except for the fact that facilities were only available for the controlled braking of two cable drums. Nevertheless, all three conductors were in position and tensioned within three hours of the helicopter first taking off.

LAUNCHES AND TRIAL TRIPS.

M.S. "BARRINGTON COURT."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the United British Steamship Co., Ltd. (Managers: Haldin & Co. Ltd.), London, E.C.3. Main dimensions: 445 ft. between perpendiculars by 59 ft. 9 in. to 29 ft. 1 in.; deadweight capacity, about 10,000 tons on a draught of 25 ft. 9½ in. Kincaid-Harland and Wolff-B. and W. six-cylinder four-stroke single-acting Diesel engine, developing 3,300 b.h.p. at 110 r.p.m. in service, constructed and installed by J. G. Kincaid & Co., Ltd., Greenock. Launch, December 1.

M.S. "CORATO."—Single-screw oil tanker, built by the Greenock Dockyard Co., Ltd., Greenock, for the Hadley Shipping Co., Ltd. (Managers: Houlder Brothers & Co., Ltd.), London, E.C.3. Main dimensions: 512 ft. between perpendiculars by 69 ft. by 38 ft. 6 in.; deadweight capacity, 16,500 tons on a mean draught of 29 ft. 9 in.; gross tonnage, 11,400; oil-carrying capacity, 802,000 cub. ft. Scott-Doxford five-cylinder engine, provisionally arranged for burning heavy oil and developing 5,500 b.h.p. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne, and installed by Rankin and Blackmore, Ltd., Greenock. Speed, 13½ knots. Launch, December 14.

S.S. "HOWARD SMITH."—Single-screw tug, built and engine by Hall, Russell & Co., Ltd., Aberdeen, for the Australian Steamships Proprietary, Ltd., Sydney. Main dimensions: 125 ft. between perpendiculars by 32 ft. by 17 ft. 3 in. Triple-expansion direct-acting steam engines developing 1,320 i.h.p. at 118 r.p.m., and two cylindrical multitubular coal-burning boilers. Launch, December 14.

BOOKS RECEIVED.

- Hutchinson's Pocket Technical Encyclopaedia.* Compiled by DR. L. E. C. HUGHES and JEAN P. BREMNER. Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 7s. 6d.]
- The Practical Engineer Pocket Book. With Technical Dictionaries in German, French and Spanish.* Edited by N. P. W. MOORE. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12s. 6d. net.]
- Reviews of Petroleum Technology.* Volume II, covering 1949. Edited by DR. F. H. GARNER, DR. E. B. EVANS and GEORGE SELL. The Institute of Petroleum, Manson House, 26, Portland-place, London, W.1. [Price 27s. 6d., including postage.]
- Advanced Engineering Mathematics.* By PROFESSOR C. R. WYLIE, JUNR. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 64s.]
- Southampton Harbour Board. Official Tide Tables for the Port of Southampton, 1952.* Offices of the Board, Town Quay, Southampton. [Price 2s.]
- Spring Design and Calculations.* Fifth edition. Compiled by JOHN A. ROBERTS. Technical Research Laboratory, Herbert Terry and Sons, Limited, Redditch. [Price 12s. 6d.]
- Internal Ballistics.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 25s. net.]
- Selected Government Research Reports. Volume 3. Protection and Electrodeposition of Metals.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 30s. net.]
- Overseas Economic Surveys. Economic and Commercial Conditions in Italy.* By E. R. LINGEMAN. [Price 5s. net.] *Economic and Commercial Conditions in Venezuela.* By A. C. MARY. [Price 7s. net.] Published on behalf of the Commercial Relations and Exports Department of the Board of Trade. H.M. Stationery Office, Kingsway, London, W.C.2.
- The Post Office London Directory for 1952.* With maps. Kelly's Directories, Limited, 186, Strand, London, W.C.2. [Price 51.]
- Canada. Department of Mines and Technical Surveys. Mines Branch. No. 830. The Canadian Mineral Industry in 1949.* Mines Department, Ottawa, Canada. [Price 25 cents.]
- Power System Analysis.* By DR. J. R. MORTLOCK and M. W. HUMPHREY DAVIES. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 45s. net.]
- Principles of Lighting.* By W. R. STEVENS. Constable and Company, Limited, 10-12, Orange-street, London, W.C.2. [Price 35s. net.]
- Pipe Resistance for Hydraulic, Lubricating, and Fuel Oils, and Other Non-Aqueous Liquids.* By T. E. BEACHAM, B.Sc., M.I.C.E. E. and F. N. Spon, Ltd., 22, Henrietta-street, London, W.C.2. [Price 18s. net.]
- Introduction to Electronic Circuits.* By DR.-ING. R. FEINBERG. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 18s. net.]