

THE PROPAGATION OF FRACTURES IN MILD-STEEL PLATES.

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IN recent years, the need for a better understanding of the mechanics of fracture, particularly in mild steel, has been brought forcibly to the attention of engineers by the disturbingly frequent, often spectacular and not readily explainable, fractures which have occurred in some large structures, notably ships^{1,2,3} bridges,^{4,5} and containers,⁶ many of which have been of welded construction.* These fractures have been characterised by their suddenness, extensiveness, high rate of propagation, and almost complete absence of reduction in thickness at the fractured edges. In all the cases in which the origins have been traced they have been found

gating the factors, such as composition and heat treatment, which affect the "notch ductility" of the metal, which property is variously defined, and assessed by means of a wide variety of notched-bar tests.⁷ The engineering approach has been concerned with such factors as design and workmanship, and more particularly with efforts to explain the observed differences in behaviour of metals under different stress and strain conditions.

The subject has developed into a branch of science which has become known as "the flow and fracture of metals."^{8,9,10,11} Unfortunately, however, the available theoretical equipment, such as the theory of elasticity¹² and the mathematical theory of plasticity^{13,14} has been found inadequate to trace the behaviour of metals up to the point of fracture, except in a few simple cases, which do not include the propagation of fractures in wide plates. The present article is concerned only

in the fracture of polycrystalline metals by a sparkling "crystalline" appearance. Cleavage cannot occur in non-crystalline materials. It can occur in metals after considerable deformation, and should not therefore be confused with absence of ductility. Cleavage fractures are often called "transcrystalline."

"Silky fracture" denotes the texture of fractures which occur on surfaces of maximum shear in metals. Typical examples are the 45-deg. fractures in fully ductile tension specimens, and the walls of cup-and-cone fractures.

"Mat fracture" denotes the dull fibrous texture found in fractures which are substantially flat and perpendicular to the direction of the tensile stress.

"Fibrous fracture": this term is used indiscriminately in connection with the silky and mat textures, both of which can be described as fibrous, although they may both contain scattered crystalline facets, indicating that some of the crystals have ruptured by cleavage. It will be seen later that in fibrous fractures, whether of the silky or mat type, individual crystals stretch and fracture by reduction of their cross-section, after the manner of tiny tensile specimens.

Description of Fractures Considered.—The fractures to be considered are of the type involved in the extensive failures referred to above. Their characteristic appearance is shown by Fig. 1; the arrows indicate the direction of propagation. Their main features, which are indicated diagrammatically in Fig. 2, on page 66, may be summarised as follows: (1) There is a substantially flat middle portion, of mat or crystalline texture, or a mixture of these, marked by ridges and hollows forming a "chevron pattern" as in Fig. 1. The chevrons are coarse and well marked in mat fractures, and faint or absent in fully crystalline fractures. (2) Along both edges, between the flat portion and the plate surfaces, there are borders of silky texture at about 45 deg. to the plane of the flat part. These borders vary in width, and in many cases are so narrow as to be almost imperceptible.¹⁵ (3) The plate surfaces near the fracture are deformed, and the thickness is reduced, after the manner of the necking of tensile specimens, but in many cases this necking is very slight. (4) The fracture front is curved, and the "spearhead" at the middle of the plate thickness is in advance of the end of the visible crack at the plate surfaces.^{16,17} (5) The chevron curves are apparently orthogonal to the fracture front; that is to say, if successive positions of the curved front were drawn, they would be found to be everywhere at right-angles to the chevron curves.

Previous Work.—De Leiris¹⁵ carefully studied what he termed the "morphology" of fractures in plates, and made some important observations. In particular, he noted that the apices of the chevrons point towards the origin of the fracture, an observation which he ascribed originally to Ch. de Freminville¹⁶ in 1914. De Leiris also observed that in cases of very brittle fracture the character and appearance are determined by the properties of the material and are not related to the process which produced the fracture. He noted that the chevrons are curved, and that they are usually symmetrical about the middle line of the plate, but that bending displaces the line of symmetry from the middle line. He coined the term "semi-fragile" to indicate that in this kind of fracture the degree of brittleness may vary, and drew attention to the "lips" or "borders" of silky shear fracture which are usually to be found on the plate edges, as shown in Fig. 2. These borders diminish in width, he remarked, as the brittleness of the fractures increases. He also noted that the propagation of this type of fracture is often discontinuous, occurring in "jumps" or "spurts" of alternately crystalline and fibrous appearance.

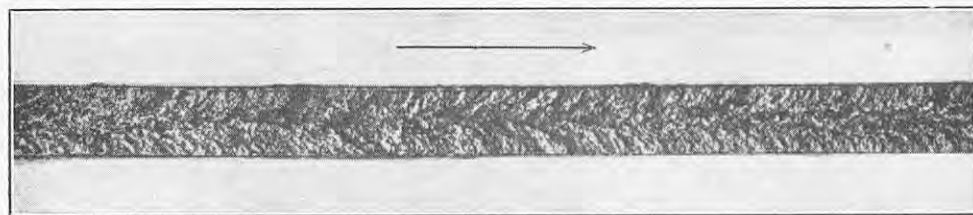


FIG. 1 (a). FRACTURE OF SHIP PLATE 0.339 IN. THICK.

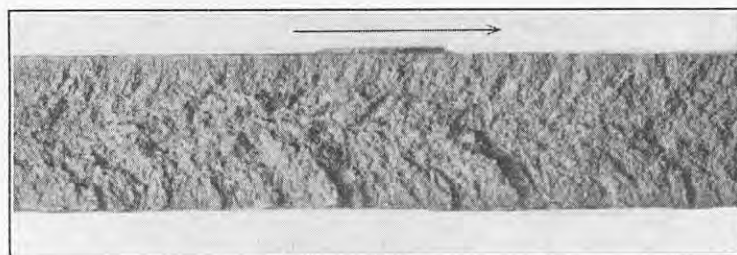


FIG. 1 (b). FRACTURE OF SHIP PLATE 0.91 IN. THICK.

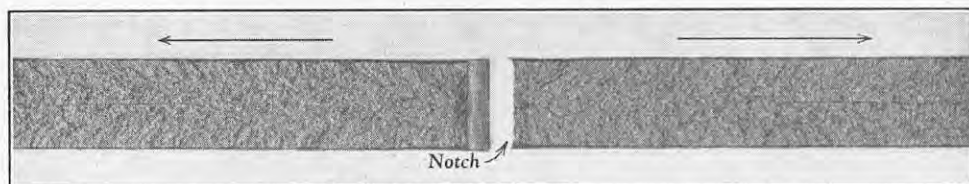


FIG. 1 (c). FRACTURE PRODUCED IN LABORATORY 0.532 IN. THICK.

at notches, such as structural discontinuities, incipient cracks, or defects in welds. The fractures have not been confined to the welds, or to their vicinity, but, on the contrary, there has been a tendency for them to run off into the plating.³ There has been a marked tendency for such fractures to be more common and more extensive at low temperatures.

It has not been possible to explain these fractures by inadequacies in strength as normally assessed, or by excessive loading, or by deficiencies in the properties of the material or workmanship as judged by the normal specifications. Their commencement has often been explainable by defective design or workmanship, or by accidental notch effects, but their catastrophic spread has not been explainable on such grounds.

The enormous research effort to which these failures have given rise has been directed to many aspects, which may be roughly divided into three main categories, namely, the fundamental, metallurgical, and engineering aspects. The fundamental approach has been mainly concerned with the micro-mechanisms on an atomic scale; the metallurgical aspect has been concerned with investi-

with the latter restricted aspect, and endeavours to approach the problem on the basis of simple assumptions in terms of mechanical concepts, without resorting to theories involving the ordinary concepts of stress and strain.

Definitions.—Before proceeding farther it is desirable to state the definitions of certain terms which appear frequently in the literature, and will be used in this article. These definitions are to some extent arbitrary, but are given to avoid ambiguity.

"Brittleness" is understood to be the converse of "toughness."

"Toughness" is defined as the intrinsic resistance which a material offers to the propagation of fracture, and its dimensions are those of work per unit area of fracture, which area is defined as that of one of the two new surfaces created by the fracture.

"Ductility" is a measure of the plastic deformation which occurs before and during fracture. It is not necessary here to assign units to ductility, which, however, is usually measured by such quantities as the elongation, reduction in thickness, reduction in area, etc., in tensile tests, and is usually expressed as a percentage.

"Cleavage" is a technical term used in the science of crystallography to denote direct separation of the material on crystallographic planes called "cleavage planes." Such separation is evidenced

* A list of numbered references is given at the end of the article.

The mechanisms by which such fractures propagate were closely studied and described by Tipper^{17,18} who arrested brittle fractures produced in the laboratory, and examined the structure in detail by sectioning near and beyond the end of the fracture, as in Fig. 3, reproduced from a Crown Copyright photograph. This showed clearly that the fracture front is curved, and at the middle of the plate thickness is considerably in advance of the end of the visible crack at the surface, as indicated in Fig. 2. Just ahead of the point where the fracture front cuts the plate surface, the centre part of the fracture is flat, like the middle part of a cup-and-cone fracture, and the walls between this flat part and the plate surface "hang on" until ruptured by shearing, as do the walls of a cup-and-cone fracture. Tipper described the process as an alternation of cleavage and shear fracturing. Ahead of the main front, within the body of the material, groups of crystals fracture by cleavage, forming internal cracks and lacunæ. The walls between some of these lacunæ and the main front rupture by shearing, so that the fractured surface is formed of ridges of fibrous texture separated by valleys of crystalline texture. The ratio of fibrous to crystalline areas may vary with the brittleness of the fracture. Tipper also confirmed De Leiris's observation that the borders of silky 45-deg. shear fracture along the edges vary in width from very narrow in brittle fractures to a considerable proportion of the thickness in tough fractures. Fig. 4, on page 68, reproduced from Dr. Tipper's report¹⁷, shows this effect diagrammatically, and points the analogy between plate fractures and the cup-and-cone fracture. Tipper's work, moreover, clearly established the discontinuous character of these fractures, and this has since been confirmed by other workers.

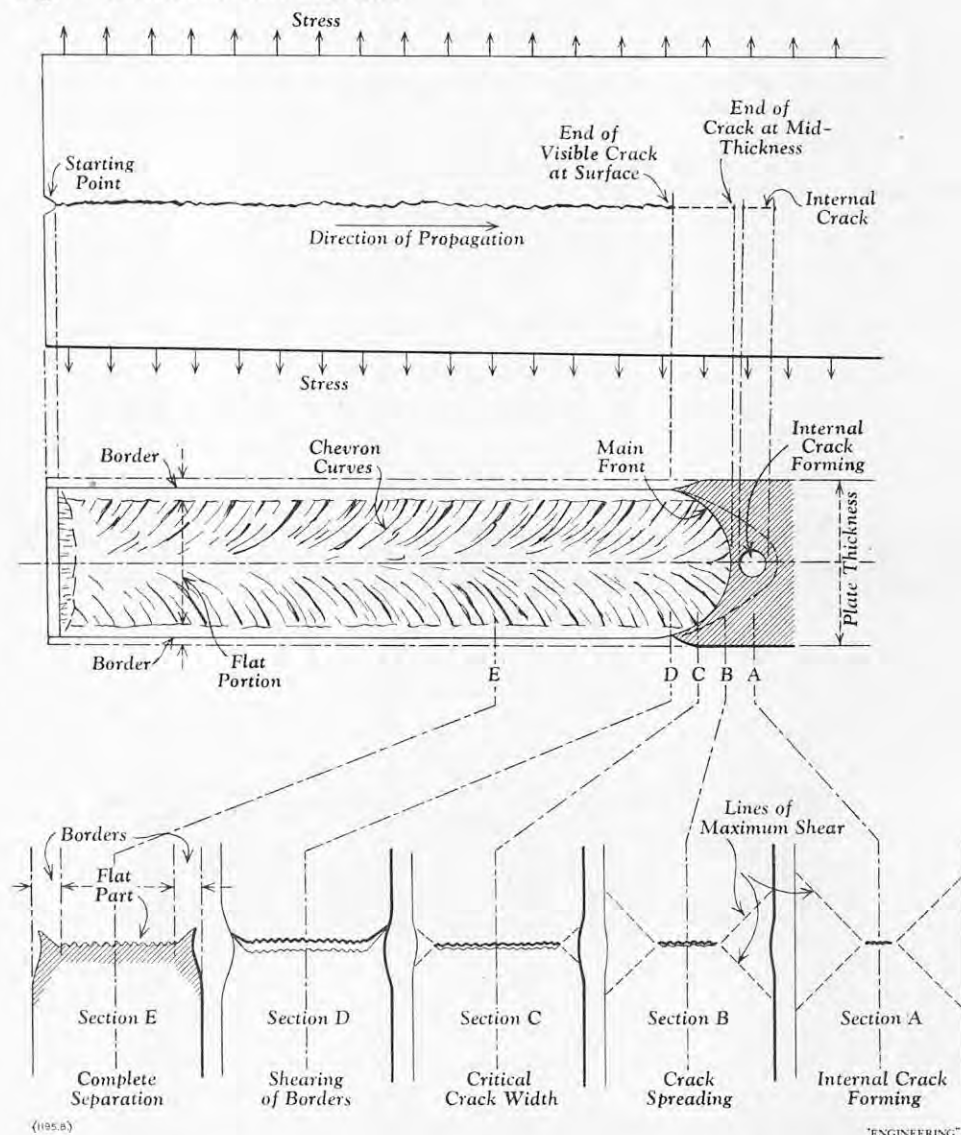
Kies, Sullivan and Irwin,¹⁹ in a paper entitled "Interpretation of Fracture Markings," studied the propagation of fracture in several materials, and particularly in transparent substances, in which the details in the vicinity of the front could be examined while the fractures were actually progressing. This further confirmed that the fractures originate from multiple foci, and progress by steps or jerks. Their paper gives some excellent photographs showing the geometrical figures, mainly conic sections, which develop when fronts radiating from many origins are overwhelmed by the main front. In these transparent materials, such as Lucite and cellulose acetate, the fractures were caused to progress by a wedge action, produced by forcing a knife-edge into the fracture, and the process was examined microscopically. A chevron pattern similar to that found in the fracture of steel plate was produced in tensile fractures of these substances, as can be seen in Fig. 5, indicating that the chevron pattern is not a consequence of the crystalline structure of metals. Similar patterns have been observed in fractures of many non-crystalline substances.

The mechanical reasons for the chevron pattern have been discussed by several investigators. Thus, De Leiris¹⁵ suggested that they were the traces of the directions in which the fracture tends to progress perpendicularly to a curved front. Tipper¹⁷ suggested that the chevrons were formed by the ridges between alternate shear and cleavage zones of the fracture, and that their shape should be related to that of the curved surfaces of maximum shear stress which must be associated with the notch-effect due to the curved fracture front. R. W. Bailey²⁰ gave a qualitative description of the development of a fracture in a plane normal to the plate surface in terms of stresses, showing that the front would tend to become curved and should leave traces of the same general form as the observed chevrons.

Irwin²¹ discussed the dynamical conditions for "slow," i.e., controllable, and "fast," i.e., self-

FRACTURES IN MILD-STEEL PLATES.

Fig. 2. FEATURES OF PLATE FRACTURES.



controlling, fractures by means of a development of Griffiths's theory.²² He showed that the essential difference between the slow and fast fractures is that, in the former, the work required to extend the fracture is greater than the elastic energy released by the extension, whereas in the fast fracture the work done in extending the fracture is equal to or less than the elastic energy released. The fast fracture is therefore an instability phenomenon, in which the elastic potential energy "runs down" at a rate which is controlled only by the resistance offered by the material to the propagation of the fracture.

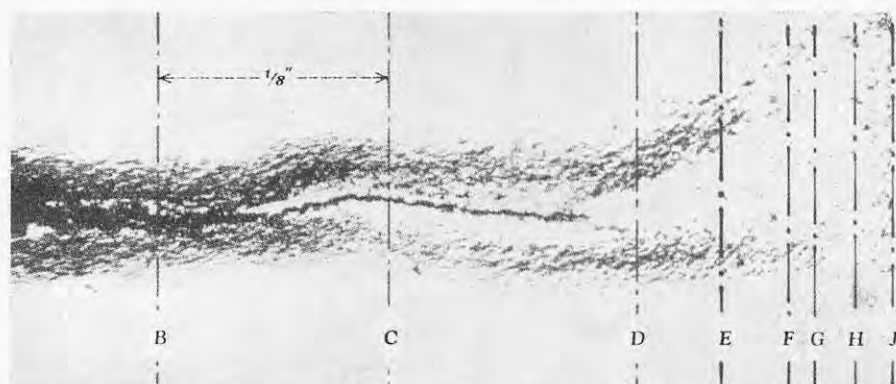
It appears that the catastrophic fractures referred to at the outset were of the fast type. They certainly progressed at very high speed, even when initiated by static loading, and appeared to be propagated by the elastic energy stored in the structure rather than by the maintenance of the external loading. The high speed of propagation, and the near absence of deformation at the fractured edges, denoting that little work was required to maintain the propagation, has led to the descriptive term "brittle" being applied to such fractures. In the following discussion, it will therefore be assumed that the fractures considered are of the "fast" type, as defined by Irwin.²¹

Formation of the "Borders."—Referring to sections A to E in Fig. 2, it can be seen that the successive stages of development of the plate fracture closely resemble those of the cup-and-cone fracture of tensile specimens, as described by Parker and co-workers.²³ In such specimens fracture commences on the axis and spreads as a disc-shaped

crack towards the surface, but before reaching this the mode of fracture changes and rupture is completed on the conical surfaces of maximum shear at about 45 deg. to the specimen axis. These surfaces of maximum shear, which extend from the edges of the disc crack to the specimen surface at all stages, as shown dotted in sections A, B and C of Fig. 2, are surfaces of potential shear fracture, which will develop upon them if and when the necessary stress and strain conditions develop. These conditions involve not only a critical shear stress, but also a certain minimum plastic shear strain, with which is associated an opening up of the central crack, and a local reduction of the specimen diameter, i.e. necking. The close analogy in the development of a plate fracture can be seen by regarding successive sections from right to left in Fig. 2 as sections through a cylindrical specimen at successive stages in its rupture. The borders in a plate fracture therefore correspond to the walls in a cup-and-cone fracture.

Formation of the "Flat" Part.—In Fig. 6 (a), the development of a simple tensile fracture is represented diagrammatically. As the necking progresses, regions of plastic deformation develop as suggested by the shaded portions, with lines of maximum shear strain at roughly 45 deg. to the axis. If the extent of these plastic regions is sufficient, a complete shear fracture can occur, as suggested in Fig. 6 (a) 3. If, on the other hand, the length of the neck is restricted as indicated in Fig. 6 (b), shearing fracture cannot develop on a single plane, but a multitude of small shear fracture surfaces, forming serrations, will develop as sug-

FRACTURES IN MILD-STEEL PLATES.



END OF FRACTURE IN 0.339-IN. SHIP PLATE, INDICATING POSITIONS OF SECTIONS SHOWN BELOW.

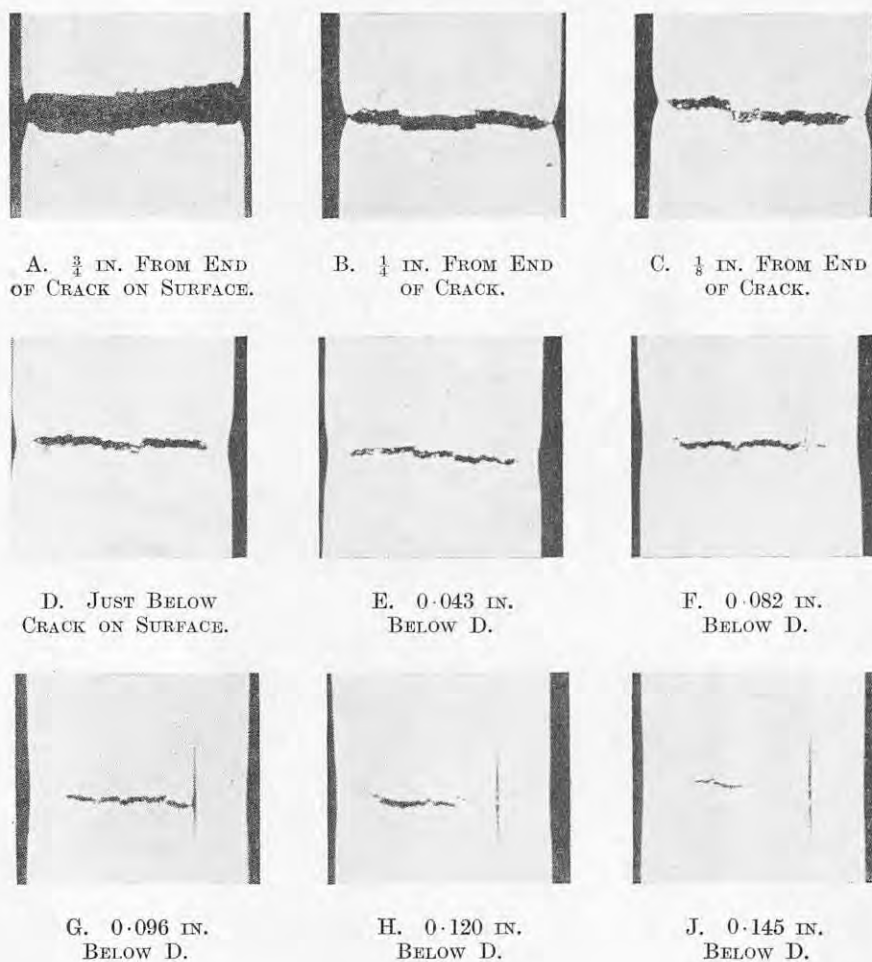


FIG. 3.

gested in Fig. 6(b) 3. This process is clearly shown by Dr. Tipper's photograph, reproduced in Fig. 7(a), which shows a section through a cup-and-cone tensile fracture. The serrations can be seen, and the microphotographs, Figs. 7(b) and 7(c), show unmistakably that the fractures in this case are fibrous in character, i.e., that the individual crystals have behaved like miniature tensile test specimens.¹⁷

It appears, therefore, that cleavage is not an essential feature of the flat portion, and this view is supported by the occurrence of similar flat portions in non-crystalline materials.¹⁸ Cleavage does, however, frequently intervene to varying extents in these "flat" fractures in metals, and indeed it is not uncommon in the literature to find them described, and even defined, as "cleavage fractures."

The serrations which occur in the surfaces of flat fibrous fractures, as mentioned earlier, appear to lie mainly along lines at right-angles to the fracture front. This effect is clearly shown, for the case of a cup-and-cone fracture, by Fig. 8, which is repro-

duced from the paper by Kies, Sullivan and Irwin¹⁹. The origin can be seen slightly to the right of the centre, and the ridges can clearly be seen, forming radial straight lines, orthogonal to the expanding circular front. It is suggested that the chevrons of plate fractures are simply a particular case of the effect just described. Incidentally, the border of silky shear fracture forming the walls of the cup can be seen around the periphery in Fig. 8, and the border is seen to be upwards in some parts and downwards in others. The direction is, of course, a matter of chance, owing to the symmetry of the surfaces of maximum shear, as indicated in Fig. 2.

According to the foregoing explanation of the nature of the chevrons, they are a characteristic of fibrous fracture, and should not appear in fully crystalline fractures. This is, in fact, the case, since, as noted earlier, the chevron pattern is known to diminish in clarity as the amount of crystallinity increases, and to disappear when the fracture is fully crystalline.

Geometry of Fronts and Chevrons.—In order to

relate the formation of the flat portion and the shape of the chevrons to simple mechanical concepts, the following reasoning is suggested.* Consider a loaded specimen of any shape, in which a "fast" fracture is progressing in a plane perpendicular to a tension field. A "natural" front will develop, with an associated characteristic stress-strain pattern, which will travel with the front in the manner of the bow-wave of a ship travelling in calm water, or the "shock wave" of a bullet travelling through the air. Owing to the high speed of the fracture, the stress pattern a little ahead of the front will not be disturbed. The stress-strain pattern in the immediate vicinity of the front will clearly be determined only by the properties of the material, i.e., the threshold conditions for propagation of the fracture. The resultant of the stress pattern may be conveniently regarded as a "propelling force" causing the fracture to progress. This propelling force must, of course, be equal and opposite to the resistance, so that it can alternatively be regarded as the specific resistance which the material offers to the propagation of a fracture, i.e., as the "toughness" of the material.

Denoting this force, per unit length of front, by f , the length of the front by l , and the position coordinate normal to the front by x (Fig. 9), the work done in an elementary extension of the fracture will be

$$\delta W = f \delta l \delta x. \quad (1)$$

Now, in a uniform material, the threshold conditions for fracture will be the same at all parts, so that f will be the same at all positions along the front, and will therefore be a constant in equation (1). This means that although f has been regarded as a force, it is numerically equal to the work done against the resistance of the material in extending the area (A) of the fracture by unity, so that

$$f = \frac{\delta W}{\delta A}, \quad (2)$$

where W is the work done in producing the fracture. This definition of the coefficient f can be seen to be identical with the definition of "toughness" given earlier. Equation (2) can be written

$$\frac{\delta W}{\delta t} = f \frac{\delta A}{\delta t}, \quad (3)$$

which expresses that the rate at which work is done is directly proportional to the rate of increase of fracture area.

If the fracture originates at a point within the body of an isotropic material, the shape of the front would tend to be circular, since the resistance is the same in all directions, and for this case we have (see Fig. 10)

$$\frac{\delta W}{\delta t} = f 2 \pi R \frac{\delta R}{\delta t}. \quad (4)$$

It will now be assumed that the time-rate at which work is done against the resistance of the material is constant, i.e., that this rate is controlled by the properties of the material. This amounts to an assumption that the rate of energy release tends to a "natural" constant value, analogous to the "terminal velocity" of bodies falling through fluids. With this assumption, and the notation $\frac{\delta W}{\delta t} = c$, equation (4) becomes

$$\frac{\delta R}{\delta t} = \frac{c}{f 2 \pi R}, \quad (5)$$

which expresses that the velocity of the circular front is inversely proportional to its radius. Integrating this equation gives

$$\pi R^2 = \frac{c t}{f}. \quad (6)$$

* The essence of the theory given here was communicated to the Admiralty Ship Welding Committee, Shipbuilding Steel Panel, in April, 1951, and to the International Welding Congress, Oxford, in July, 1951.

PROPAGATION OF FRACTURES IN MILD-STEEL PLATES.

Fig. 4.

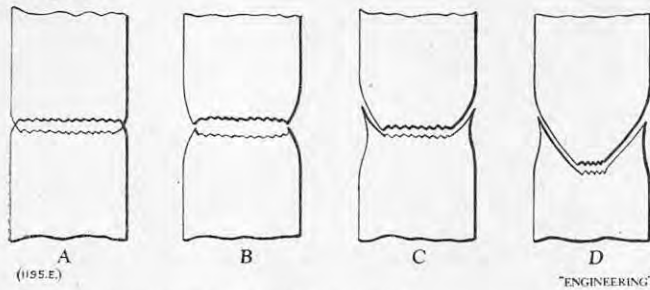


Fig. 6. DEVELOPMENT OF TENSILE FRACTURES.

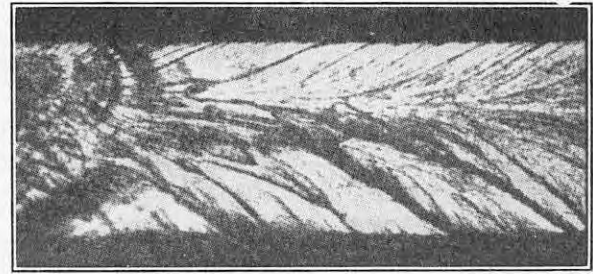
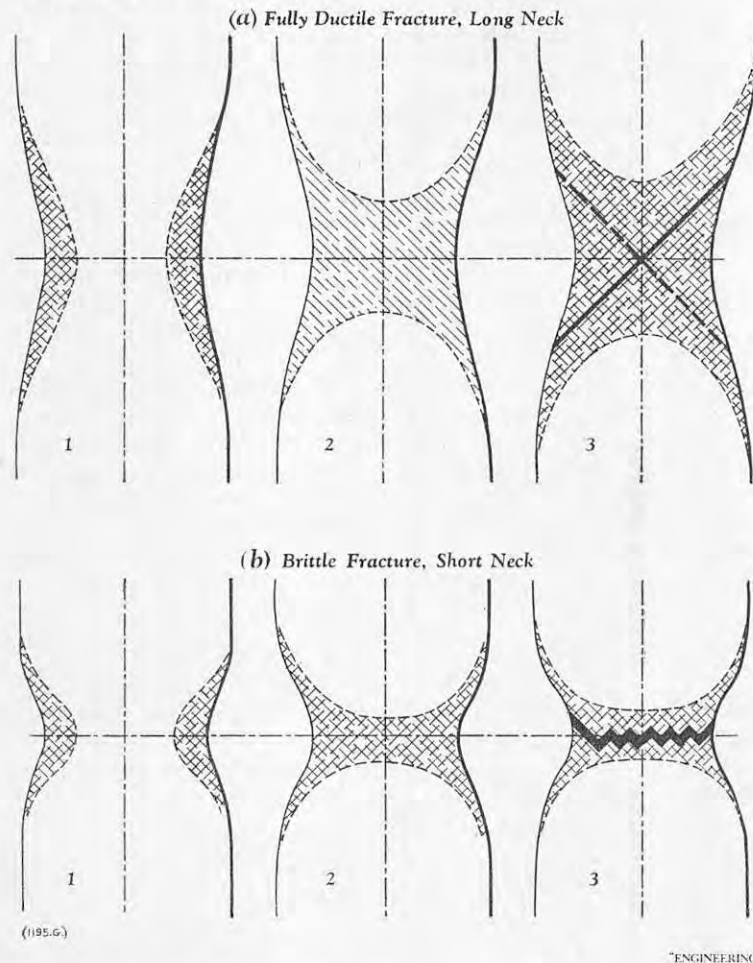
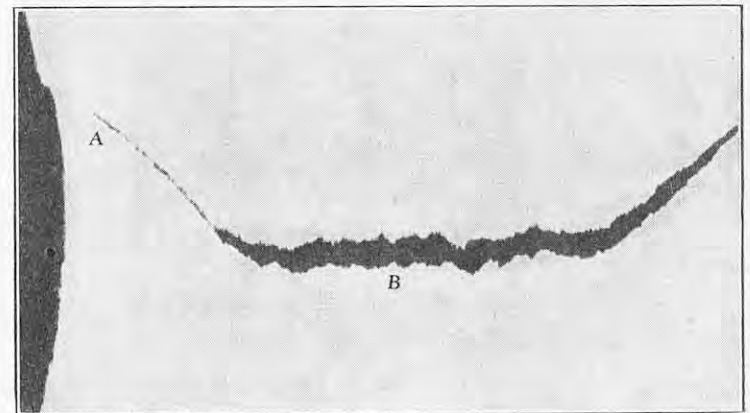
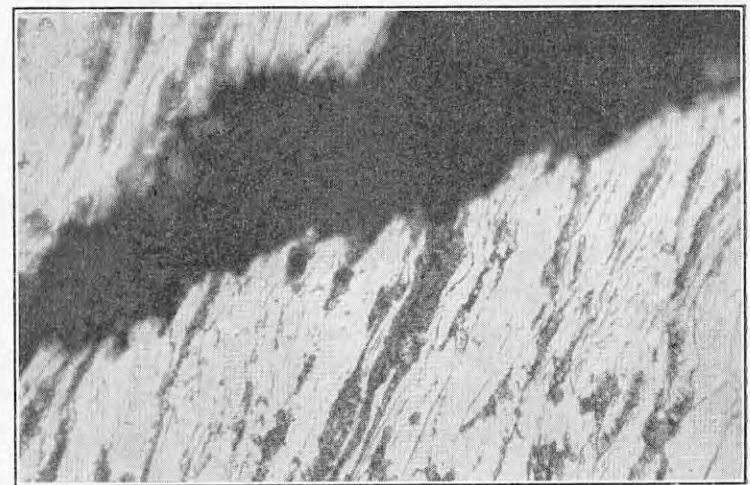
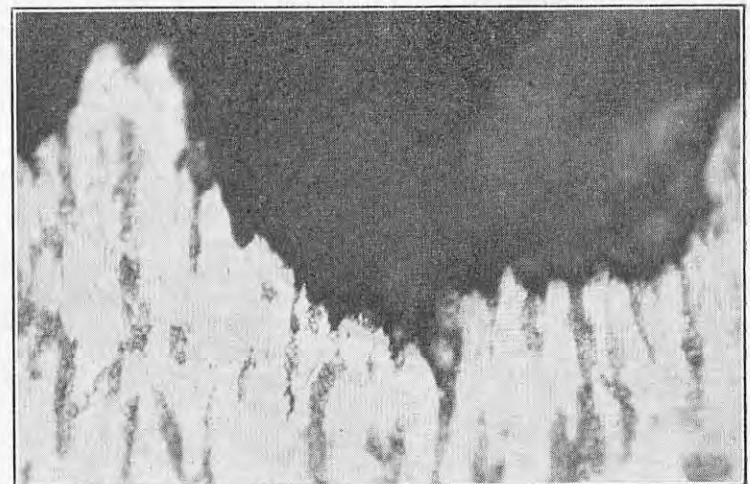


FIG. 5. FRACTURE IN 0.02-IN. CELLULOSE-ACETATE PLATE.

FIG. 7 (a). SECTION THROUGH CUP-AND-CONE FRACTURE. $\times 8$.FIG. 7 (b). DETAIL AT "A." $\times 500$.FIG. 7 (c). DETAIL AT "B." $\times 500$.

where $\frac{c}{f}$ is seen to be the constant rate at which the area increases.

If such circular fractures originate at intervals, which need not be equal, along a straight line, the result will appear as indicated in Fig. 11, which is analogous to the ripple pattern from pebbles dropped consecutively into a pond along a straight line, except that the envelope of the circles will be curved instead of being approximately straight as in the pebble analogy. The shape of the envelope can be found as follows. If the uniform velocity of the centres is V , then

$$D = Vt, \quad (7)$$

where D is the position co-ordinate of the most advanced centre, and if x and y are the co-ordinates of a point on the envelope, with origin at the foremost centre, we have by geometry (see Fig. 11),

$$R^2 = y^2 + (D - x)^2. \quad (8)$$

$$D = x + y \frac{dy}{dx}. \quad (9)$$

Combining these two equations, and using the values of R and D from equations (6) and (7) gives

$$\frac{c}{f\pi V} \left(x + y \frac{dy}{dx} \right) = y^2 \left[1 + \left(\frac{dy}{dx} \right)^2 \right], \quad (10)$$

which is the differential equation to the envelope. The solution, which can be verified by substitu-

tion, is

$$y^2 = \frac{c}{f\pi V} \left(x + \frac{c}{4f\pi V} \right) \quad (11)$$

The envelope is therefore a parabola of focal length

$$a = \frac{c}{4f\pi V}$$

with its focus at the origin. The axis of x coincides with the path of the centres, and x is measured in the opposite direction to the advance of the centres.

The shape of the corresponding chevron curves, which, as has been seen, should be the orthogonal trajectories of the successive fronts, can be found as follows: the condition for orthogonality is illustrated in Fig. 12, i.e., that for every value of y ,

$$\frac{dx}{dy} = -\frac{1}{\frac{dy}{dx}}, \quad (12)$$

FRACTURES IN MILD-STEEL PLATES.

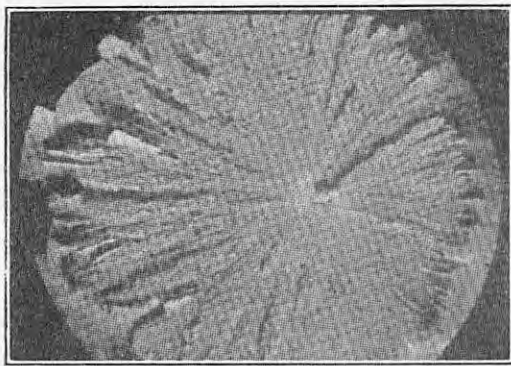
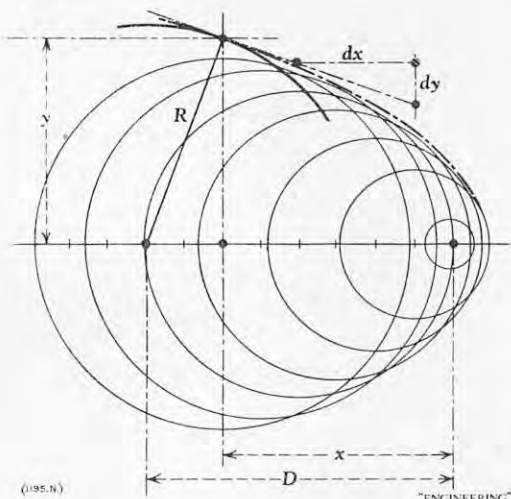


FIG. 8. CUP-AND-CONE FRACTURE.

Fig. 11.



where x and x_1 are the abscissae of the two orthogonal curves for the same value of y . Transposing equation (11) and using the notation $a = \frac{c}{4f\pi V}$

we have

$$x = \frac{y^2}{4a} - a, \quad \frac{dx}{dy} = \frac{y}{2a}, \quad (13)$$

so that

$$\frac{dx_1}{dy} = -\frac{2a}{y},$$

and

$$x_1 = -2a \log_e y + C. \quad (14)$$

The effect of the constant of integration is merely to shift the curve in the direction of the x axis, so that it can be chosen arbitrarily. Choosing it so that the curves intersect when $x = x_1 = 0$, i.e., when $y = 2a$, we have for chevron curves

$$y_1 = 2a e^{-\frac{x}{2a}}. \quad (15)$$

For consecutive positions of the envelope, equally spaced along the x axis, and similarly spaced chevron curves, we have the two families:

$$\text{For envelopes: } y^2 = 4a(x + nb). \quad (16)$$

$$\text{For chevrons: } y_1 = 2a e^{-\frac{1}{2a}(x + nb)}, \quad (17)$$

where n is any integer and b is the spacing along the x axis. For a plate of uniform thickness T , with the path of centres on the middle line, the resulting geometry is as shown in Fig. 13, in which

$$\left. \begin{aligned} a &= \frac{c}{4f\pi V}, \\ L &= \frac{f\pi V}{4c} T^2, \\ \tan \theta &= \frac{f\pi V}{c} T, \\ \frac{fV}{c} &= \frac{\tan \theta}{\pi T}. \end{aligned} \right\} \quad (18)$$

Fig. 9.

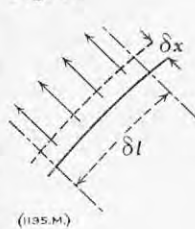


Fig. 10.

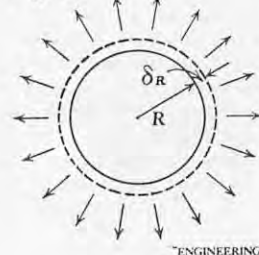


Fig. 12.

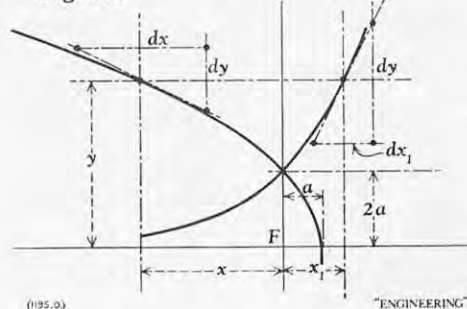
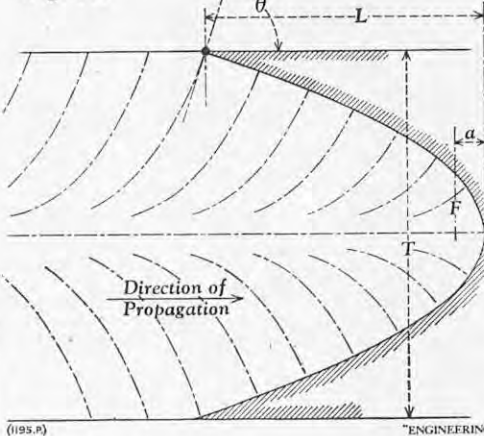


Fig. 13.



From the relations (18), which follow directly from equations (11) and (15), it can be seen that the theoretical geometry can be compared with that of actual fractures by means of the measurable quantities T and θ , and, in particular, the ratio $\frac{fV}{c}$ can be found.

The underlying assumptions of this derivation are simply that the "toughness," f , is constant, and that the rate at which work is done is also constant. In the case of the plate of thickness T , these assumptions require that

$$VT = \frac{c}{f}. \quad (19)$$

from which it follows that

$$\tan \theta = \pi. \quad (20)$$

or $\theta = 72$ deg. approximately, which should be independent of the thickness and properties of the material.

It can also be seen that the geometry (Fig. 13) is independent of the velocity, provided that the ratio $\frac{fV}{c}$ remains constant, as required by the assumptions for the case of a plate of uniform thickness.

In order to check these somewhat striking results, the angles θ have been carefully measured from photographs, rubbings, and Hilger projections of fractures covering a wide variety of materials and thicknesses. The results will be given and discussed in the concluding part of this article.

(To be continued.)

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- 18 Tipper, C. F. Elam, "The Fracture of Mild Steel," paper presented to Seventh International Congress for Applied Mechanics, London, September, 1948. See *Iron and Coal Trades Review*, February, 1949.
- 19 Kies, J. A., Sullivan, A. M., and Irwin, G. R., *Jl. Appl. Phys.*, vol. 21, page 716, July, 1950.
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- 22 Griffiths, A. A., "The Theory of Rupture," First International Congress for Applied Mechanics, Delft, 1924.
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EDUCATION IN TECHNICAL SUBJECTS BY HOME STUDY.—Unusual arrangements have been made by E.M.I. Engineering Development Ltd., to encourage technical education among young adult employees at their Penleigh works, Wells, Somerset. A special course of self-training by means of home study has been set up by the firm for workpeople who have passed the age for admission to apprenticeships and part-time day-release education schemes. Students enrolled under the new plan will work under the personal supervision of a qualified instructor and will also have the advantage of class tuition and individual instruction during working hours. Courses will normally run from September to the following June and will, in most cases, extend over three years.

CONFERENCE ON HYDRAULIC SERVO-MECHANISMS.—The Council of the Institution of Mechanical Engineers, in conjunction with the Hydraulics Group of the Institution, have arranged to hold an all-day conference on "Hydraulic Servo-Mechanisms," on Friday, February 13, at the Institution building, Storey's-gate, St. James's Park, London, S.W.1. Three papers will be presented at the morning session, which will last from 10.30 a.m. to 12.45 p.m., namely, "An Introduction to Hydraulic Servo-Mechanism Theory," by Mr. H. G. Conway and Mr. E. G. Collinson, "Variable Hydraulic Pump Servos and a Method of Impedance Testing," by Mr. C. D. Watson, and "Variable-Stroke Pumps for Power Transmission: Some Design Considerations," by Mr. T. E. Beacham. At the afternoon session, from 2.30 to 4.45 p.m., a further three papers will be presented, namely, "Hydraulic Servos," by Mr. R. Hadekel, "Industrial Applications of Hydraulic Servos," by Mr. T. Brading and Mr. G. Parks, and "Some Design Considerations of Jack-Type Hydraulic Servos," by Mr. N. F. Harpur. An evening session will be held from 5.30 to 7.30 p.m. for the discussion of all six papers. Seats will be reserved on this occasion for members of the Institution and others applying in advance for tickets of admission.

THE ENGINEERING OUTLOOK.

I.—RETROSPECT AND PROSPECT.

(Continued from page 11.)

ENGINEERING exports have more than doubled in volume since the war and now represent, by value, more than two-fifths of the total exports of the United Kingdom. While noting the fine achievement of engineering industries in 1951, the *Economic Survey for 1952* stated that "No satisfactory solution can be found for the balance of payments problem without a further substantial increase in the exports of the metal-using industries." The sharp decline during the past few months in the exports of textiles and other manufactures has made the importance of engineering exports even greater than seemed likely a year ago. The figures given in Table I, on page 10, *ante*, and the diagrams in Figs. 12 to 17, herewith, suggest that the vast increase required in 1953 will not be obtained if present conditions continue to prevail, or become—as they are likely to do—even more unfavourable.

Much of the post-war growth in the exports of metal products has taken place in consumer goods—motor cars, cycles, refrigerators, vacuum cleaners, radios, and other appliances. The leading makers of these products have generally expanded their capacity in a few years to supply the seemingly insatiable world demand, and, more particularly, the demand from Commonwealth countries such as Australia, New Zealand, India and the Union of South Africa. The prosperity of these countries, however, was mainly based on the boom commodity prices, which could not be permanent. When they began to fall, the governments concerned had no choice but to reduce imports in order to husband their dwindling reserves of foreign currency and to reduce home purchasing power to control inflation. These measures have tended to come too late, however, and have been labelled as "emergency," with the suggestion that they were not permanent. Colin Clark's penetrating analysis of the post-war developments in Australia show how that country must concentrate on the development of natural resources and staple industries to avoid economic collapse, and the neglect of seven years will take at least as long to make good. In all the best British markets, there is an obvious need to plan development on those lines which are, in any case, the most likely to attract the foreign capital so badly needed. Such a policy will mean retrenchment both in the import of consumer goods and in the development of uneconomic consumer goods industries under high tariff walls. Import demand, therefore, will tend to be for more agricultural and mining machinery and plant, heavy transport equipment, constructional engineering materials, harbour plant, and for fewer cars, refrigerators, machine tools and textile machinery. The next few years, if free from war, are likely to be austere ones in this respect; the capital goods in demand will be of the basic types mentioned above, and at the lowest possible prices. It is most unlikely that British manufacturers can look to increases in preferential tariffs to take the edge off the growing competition from Germany, Japan and the United States, which is likely to be much more acute than before the war. On the contrary, tariffs and preferences will almost certainly be lowered progressively as the Sterling Area and Europe attempt to solve their dollar problem through freer trade and a greater measure of currency convertibility.

THE NATURE OF DEMAND.

British engineering manufacturers must consider most carefully whether or not they are making the products likely to sell during the next decade in markets where they have sales organisations and good local knowledge. In the first part of this article it was suggested that manufacturers of metal goods in Britain are relying far too much on traditional designs and types. This is particularly true of the large number of small to medium firms, who have done very well indeed during the past eight years by treading the beaten track. Even in large and progressive concerns, research and development have not received adequate priority during

the boom, if only because the attention of executives was concentrated on overcoming shortages of materials and components or on devising a fair system for the allocation of their products to customers. This was not confined to engineering: makers of textiles, leather goods, furniture and many other products passed on to the engineering industries orders for machinery and plant that reflected the same technological inertia and lack of daring. For vehicle manufacturers, road regulations and taxation in Britain have become a serious handicap in the fierce competitive struggle that has already started. Some of the blame for Britain's failure to make all the engineering products of the

During the last quarter there was some recovery of the machinery groups, to the level of the second quarter of the year, but the reported decline in orders received for textile machinery and certain types of machine tools does not suggest that the recovery will be fully maintained in 1953. Exports of iron and steel were the only ones to continue high above the 1951 level during the third and fourth quarter of the year, and larger supplies are likely to be available for export in 1953.

The most striking, and alarming, feature of these statistics is the decline in the exports of vehicles, from 1391. million during the first quarter of 1952 to less than 1051. million (estimated) during the

FIGS. 12 TO 17. UNITED KINGDOM EXPORTS OF METAL GOODS.

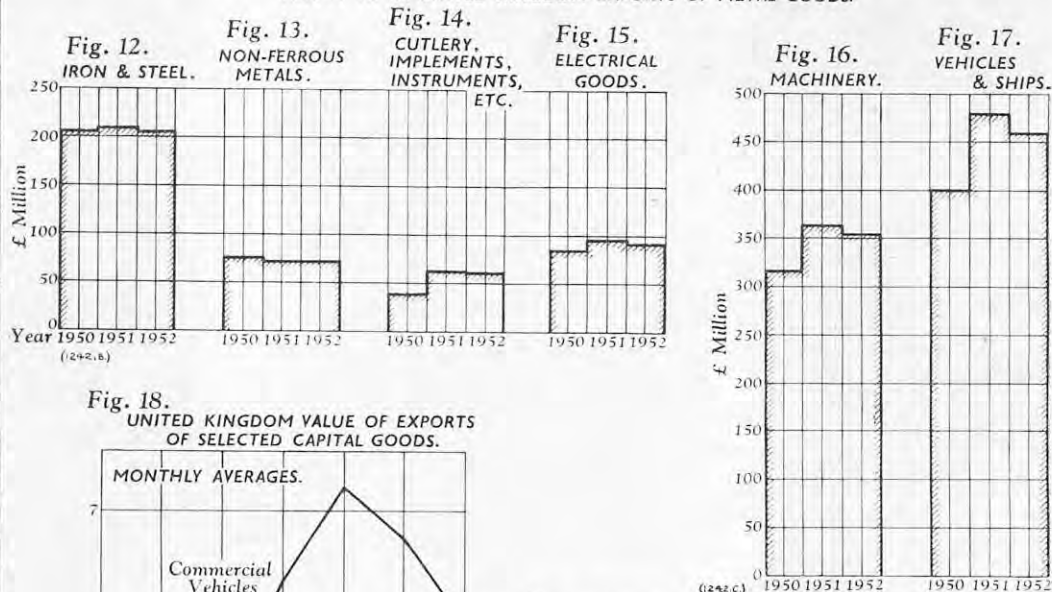
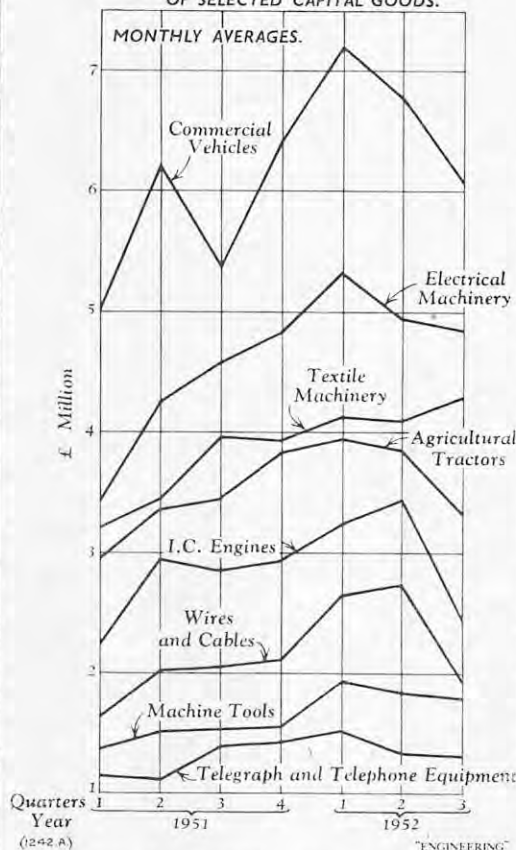


Fig. 18. UNITED KINGDOM VALUE OF EXPORTS OF SELECTED CAPITAL GOODS.



latest design at competitive prices can thus be laid at the door of their home customers. It is sad to reflect that, now that times have become more difficult for all, the tendency towards conservatism and technological inertia will tend to grow. Yet, without enterprise and deliberate risk-taking, without new ideas and much development expenditure, it is very unlikely that British engineering can succeed in bearing the very heavy burden assigned to it by the Government.

Table I showed that, during 1952, the increases in the exports of metals and metal products were substantial in four of the six main categories listed. The most important exception is the vehicles groups, which includes ships, where the increase was only 2 per cent.; the other was the much smaller groups constituted by cutlery, implements and instruments, where the increase was only 5 per cent. The quarterly figures are not so pleasing; they show that exports of all categories reached their peak during the first quarter of 1952 and have been declining since.

last quarter. This fall, of nearly 25 per cent., is much greater than was expected and reflects mainly the decline in motor-car exports. These continued to fall towards the end of the year, and the fall has not been confined to Australia. In November, 19,219 cars were exported, compared with 20,545 in October, 1951, and 31,521 in the following month. Seventy-eight per cent. of this fall was accounted for by the fact that Australia took in November only 430 cars, compared with 10,025 in November, 1951. Most of the remainder was accounted for falls in exports to Europe, Canada and New Zealand. Electrical goods and apparatus are another section of the engineering industry in which exports were hit by the import restrictions in Australia and elsewhere, and the overseas demand had shown no sign of reviving by the end of the year.

Fig. 18, herewith, shows the values of exports of selected capital goods during 1951 and 1952. Consumer or semi-consumer products, such as motor cars and electrical appliances, are omitted, so that the curves provide a useful picture of the relative value of the principal exports of capital goods. The general picture is not encouraging; the exports of each product listed reached a peak during the first or second quarter of 1952 and though, in some cases, the subsequent decline has been slight—for example, in agricultural tractors and textile machinery—it has been general. The sharp fall in the exports of internal-combustion engines, mostly Diesel, resulted mainly from import restrictions imposed by the Indian Government. These restrictions must be relaxed if the country is to continue to develop its agriculture; already there are some signs of a recovery. The main danger in this case, as in that of commercial vehicles, which constitute by far the most important category, is competition from Germany. Most of the products shown in Fig. 18, except possibly textile machinery and machine tools, are likely to continue to be in good demand in most primary countries unless a world slump develops. Increased competition is inevitable, and if the finance for these countries' development is provided mainly by the United States, British manufacturers may find it difficult to maintain their share of the markets. If the United Kingdom is to expand its exports and wipe off its adverse balance of payments, however, the bulk of the expansion must come from the categories of products shown in Fig. 18.

THE PRINCIPAL MARKETS.

The division of exports by principal areas was shown in Table II, on page 11, *ante*, which indicated clearly that the Commonwealth and Colonies were by far the most important markets. In the first nine months of 1952, they absorbed 45 per cent. of the total value of British engineering exports, slightly more than in 1951. Western Europe accounted for 24 per cent., dollar countries for 9 per cent., and South America for about 7 per cent.

The progress made by British engineering exports in the dollar markets since the war has been remarkable; the rate of expansion in 1952 was somewhat retarded, however, by the slump in demand for durable consumer goods which began to affect these markets in the autumn of 1951. British exports of motor vehicles to the United States nevertheless continued to increase, though sales of home-produced models were falling. In Canada, on the other hand, import restrictions, imposed to maintain employment in the home industry, resulted in a severe cut in imports from the United Kingdom. Exports of heavy capital equipment remained

falling noticeably in recent months. Engineering production in Western Europe has expanded greatly since the war and much of it has been exported. The difficulties in export markets, which have been experienced by the Germans, the French, the Italians and others, as much as by the British, have led to much larger quantities of engineering products being made available on home markets, where it is now becoming increasingly clear that arrears of demand are not so great as had been thought.

The danger of consigning nearly half of the engineering exports to a few Commonwealth countries became apparent when import restrictions were applied by one country after another during 1951 and 1952. The weakness has been that exports to these countries consisted to too large an extent of consumer goods and machinery for secondary industries which cannot work economically, even behind high tariff walls. The recent Commonwealth conference in London showed that there is an increasing awareness that further development of secondary industries is unwise until primary

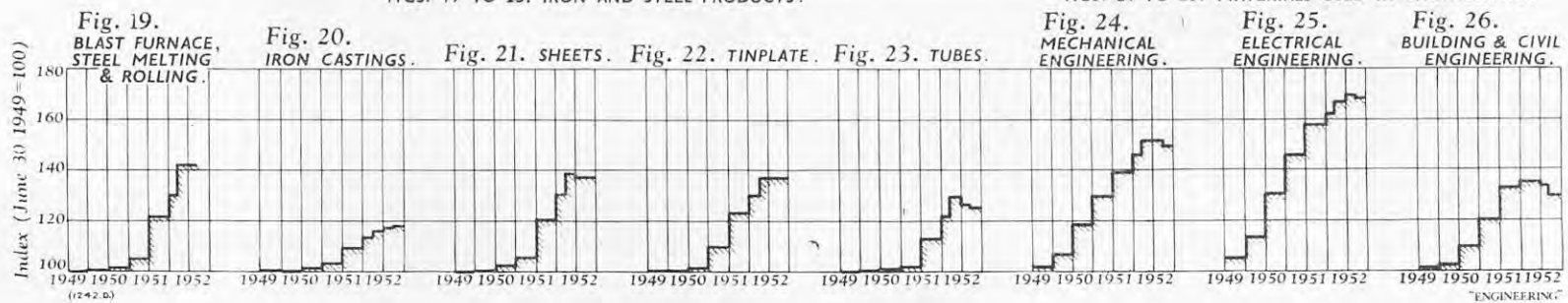
a high level. Ferrous metals, on the other hand, have been rising in price. The price of steel sheets and tubes weakened in 1952, but this was due partly to a rationalisation of the prices of various products within the iron and steel industry.

British Iron and Steel Corporation (Ore), Limited, who are responsible for buying all the imported iron ore for the iron and steel industry, have sold that ore, hitherto, to consumers at a lower price than they had paid for it. The resulting loss has been financed since 1950 by a levy on the producers of ingot steel. The manufacture of iron and iron products which are not used in steel making has thus been heavily subsidised. It has now been decided, however, that the makers of pig iron should be charged prices for imported ore more nearly approaching the true cost of purchase and transportation. Increases in the price of pig iron of about 10s. to 2l. 10s. a ton in October were intended to be the first steps towards making the iron consumer bear a larger share of the cost of his raw materials. The levy on the production of ingot steel was reduced at the same time and, as a result,

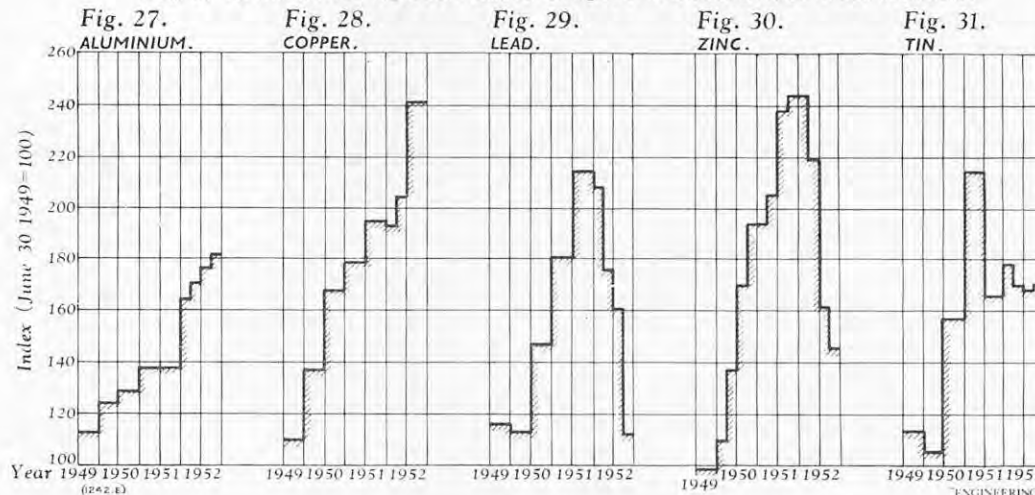
UNITED KINGDOM BOARD OF TRADE WHOLESALE PRICE INDEX NUMBERS.

FIGS. 19 TO 23. IRON AND STEEL PRODUCTS.

FIGS. 24 TO 26. MATERIALS USED IN ENGINEERING.



FIGS. 27 TO 31. UNITED KINGDOM BOARD OF TRADE WHOLESALE PRICE INDEX NUMBERS.



unaffected, however, and the demand is rapidly increasing as large projects for the development of Canada get under way. The Treasury's *Bulletin for Industry* for August, 1952, commented on the favourable opportunities for British manufacturers of heavy engineering plant as follows: "Who, for example, is to provide the equipment for the 500 million dollar Kitimat and Kemano hydro-electric project in British Columbia? Who is to get the contracts for dredgers, excavators, cranes, sluice gates and electric equipment for the St. Lawrence Seaway and power projects? It is vast schemes like these which offer both hope and challenge to British industry." Despite the vast increase in the Canadian demand for this type of equipment in recent years, the British share of Canadian imports, which had increased from 8 per cent. in 1947 to 13 per cent. in 1950, fell back to 8 per cent. in 1952.

Exports to Western Europe have been stimulated by the operation of the European Payments Union. It is estimated that, since the inception of E.P.U. in July, 1950, the volume of trade between member countries, their overseas territories and the Sterling Area has increased by about 30 per cent. The value of monetary and trade agreements should not, however, be over-estimated under present conditions; the level of effective demand has been

resources are fully exploited. The overall shortage of labour and capital in countries such as Australia and New Zealand, and their diversion since the war to manufacturing industry, has been one of the main causes of inflation and economic instability.

One of the features of world trade in 1952 has been the growth of German and Japanese trade to levels approaching pre-war, despite the loss of East European and Far Eastern markets. This has meant considerable gains at the expense of the United Kingdom and the United States, mainly in Latin America, India and Europe. The shrinkage of demand and the growth of competition suggest that 1953 will prove a very difficult year for exporters of many types of engineering products.

FEWER SHORTAGES OF MATERIALS.

In one respect, at least, the engineering outlook is favourable: raw materials are becoming increasingly abundant and, in many cases, the upward trend of prices has been reversed. As will be seen from Figs. 19 to 31, herewith, there was a marked drop in the Board of Trade wholesale price index numbers of some raw materials used in the main branches of the engineering industry in the fourth quarter of 1952. The prices of lead, zinc and tin are now back to, or approaching, the levels preceding the Korean War, though aluminium and copper have maintained

those companies who make their own pig iron have benefited greatly.

The fall in the price of steel tubes is due to the savings made in costs in this way at such works as those of Stewarts and Lloyds, Limited. British engineers can have little quarrel with the iron and steel industry on the score of prices paid for their products. While British steel remains the cheapest in the world (anything between 10 and 30 per cent. lower than foreign steel) engineering manufacturers are greatly assisted in keeping down their own prices in increasingly competitive export markets.

Supplies of steel should be adequate for most industrial users in 1953. The Steel Federation expect that the United Kingdom production this year will reach 17½ million tons, which is 750,000 tons higher than the record output achieved in 1950. Production in 1952 should reach at least 16 million tons, and there have been large imports (approaching 2 million tons) from the United States, Europe and Japan. Apart from certain grades of alloy steels and plates for shipbuilders, boiler-makers, locomotive and wagon builders, there have been few real shortages during the past six months. Even in the shipbuilding industry, supplies for the fourth quarter of 1952 improved considerably, though they were certainly not nearly so adequate as the statement of the First Lord of the Admiralty suggested when he said that they were at a level which would permit shipbuilders to achieve higher production than at any time since the war. The allocation for the first quarter of 1953 for shipbuilding has been increased by about 9 per cent., but, because of lack of balance in the types of steel supplied, shipbuilding output is not likely to increase proportionately. Steel supplies are now ample enough to permit a fairly large increase in the factory-building programme. Allocations in the first quarter of 1953 for this purpose are 15 to 16 per cent. higher than in the fourth quarter of 1952.

The first stage of one of the steel industry's major development projects, the expansion of the Shotton works of John Summers and Sons, Limited, was completed in 1952. This is to cost 27l. million and will eventually yield a million ingot tons of steel a year. A new tinplate mill of the Steel Company of Wales at Trostre, which will ultimately produce 400,000 tons of tinplate a year, was officially opened in October; and a start was made on the new tube

mill of Stewarts and Lloyds, Limited, which will cost about 4L. million and give a weekly output of 3,000 tons by 1955. These and other expansion plans of the iron and steel industry will give an output of 20 million tons of steel and 15 million tons of pig iron within five years. The attainment of this output must depend, of course, upon a steady increase in steel consumption of 5 per cent. per annum over the next five years, which may not now materialise. On the whole, the industry is no doubt justified in planning boldly on the basis of an optimistic appreciation of industrial prospects, and, in any case, it is only by adequate plant replacement and new investment that productivity can be raised and prices kept down. There is still much scope for raising productivity: it is now about 50 per cent. higher than in 1938, but the output per man-year is only about 1,241 tons of ingots, compared with 2,306 tons in the United States. Failure to undertake investment on a bold enough scale would result in an even more serious gap between American and British standards of achievement.

Supplies of copper and zinc have improved so much that it has been possible to modify the restrictions on their use imposed by the Copper and Zinc Prohibition Uses Orders of 1951. Restrictions on the use of alloys which contain nickel are still continued, but supplies are now considerably easier as a result of the acceleration in the nickel production programme in 1952. World output in 1952 is estimated at 315,000,000 lb. compared with 295,000,000 lb. in 1951. Supplies are inadequate at present to meet the large Government "stock-pile" objectives and unrestricted civilian programmes, but, as in the case of the other non-ferrous metals, the demand should slacken considerably as a result of the slowing down of world re-armament programmes.

SOME UNEMPLOYMENT.

At one time, it seemed that one of the most serious obstacles to the prosecution of the re-armament programme would be the difficulty of attracting suitable labour to the engineering industry. According to plans formulated in the autumn of 1951, it was calculated that an extra 400,000 to 500,000 workers would be required for defence production. It was estimated that 150,000 new workers would be required for the aircraft industry alone by the end of 1952. In the event, a movement of labour on this scale has not occurred. The total number employed in the engineering, shipbuilding and electrical goods industries declined by 23,000 in the twelve months to the end of October, 1952. Some companies, of course, increased their labour strength, notably manufacturers of machine tools, whose total employment increased by 16,000. The vehicle industry increased its labour force by 69,000 and about half of this increase was accounted for by the aircraft industry. All these increases were much smaller than was scheduled, but this is a criticism more of the planning of the re-armament programme than of the mobility of labour. The Notification of Vacancies Order, introduced in February, has worked satisfactorily on the whole. In the first few months of the operation of this Order, which requires all personnel changing their jobs to do so through the employment exchanges, the number of workers placed by the exchanges doubled and the number placed in "first preference" employment on defence and export more than doubled.

The slowing down of the re-armament programme and the fall in demand for a wide range of engineering products have already led to some unemployment in most large industrial centres. The major problem in 1953 is likely to be that of keeping people employed and avoiding unrest and the pre-war tendency to make work last. There are few indications, so far, that the re-emergence of unemployment is helping to raise productivity. The total number unemployed in the engineering, shipbuilding and electrical goods industries at November 10, 1952, was 31,679, compared with 18,949 on November 12, 1951. In the vehicle industry, the number unemployed in November, 1952, was 10,461, compared with 5,265 in November, 1951. Other sections of engineering affected are those making household appliances, bicycles, internal-combustion engines and textile machinery. Towards the end of the year, some sec-

SURFACE-FINISH PROJECTOR.

TECHNE (CAMBRIDGE), LIMITED, CAMBRIDGE.

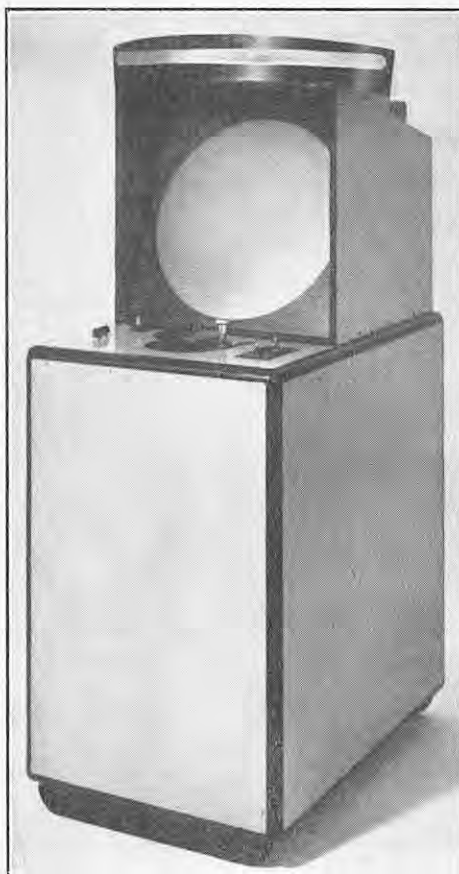


Fig. 1.

tions of the aircraft industry began to dismiss workers. The present difficulties of the engineering industries were beginning to manifest themselves towards the end of 1949, when commodity prices fell and the post-war sellers' market broke up. The Korean War re-established boom conditions, and the production of almost all types of engineering goods was limited only by shortages of materials and labour. The vast expansion of manufacturing capacity in the United States, which almost sufficed to supply the needs of the Korean War and world re-armament without seriously reducing the output for civilian use, has further strengthened the dominance of that country's engineering industries. This immense potential for manufacturing engineering goods at prices often below European levels makes the realisation of free trade and convertibility very difficult. This is, however, the goal towards which the Sterling Area must strive. The major task, therefore, of British engineering in 1953 will be to make itself more competitive *vis à vis* the United States, as well as Japanese, German and other European manufacturers. It will require a much more thorough study of the needs of markets for particular types and designs of plant and machinery. It will also mean considerably increased selling outlay. Too often it is assumed that price and credit facilities are the only important factors.

SURFACE-FINISH PROJECTOR.

A NOVEL form of episcopic projector, specially suitable for examining the surface finish of metal and other objects, has been introduced recently by Techne (Cambridge), Limited, of Duxford, near Cambridge, and is shown in Fig. 1. The novel feature of the instrument is that it employs the optical system of the Schwarzschild reflecting microscope instead of the microscope-type objective generally used in profile projectors. The obvious advantage of the former is that, since reflection is used instead of refraction, chromatic aberration is entirely eliminated.

The principle of the reflecting microscope is

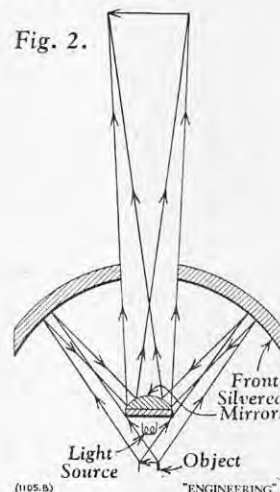


Fig. 2.

illustrated in the diagram, Fig. 2. As there shown, the principal optical elements are a relatively large concave mirror silvered on its concave surface and a smaller convex mirror silvered on its convex surface. The object to be examined, which is brightly illuminated, is located below the convex mirror, which rests on a disc of opaque material, and the light diffusively reflected from the object passes upwards in the form of a wide-angle cone round the edge of the convex mirror on to the inner surface of the concave mirror. From this it is reflected downwards on to the convex mirror which reflects it upwards through an aperture in the centre of the concave mirror to form an enlarged image on a translucent screen placed at a convenient distance above the concave mirror.

In the projector the optical components indicated in Fig. 2 are inverted, the object to be examined being placed above the plane surface of the convex mirror and the concave mirror being fixed below the convex mirror. The optical components are enclosed in a rectangular casing which forms the base of the projector, as shown in Fig. 1. The casing also contains two plane inclined front-silvered mirrors which reflect the light passing through the aperture of the concave mirror so that the image is formed on an inclined translucent screen mounted on top of the casing in a hood which serves to cut off extraneous light. The object to be examined is placed on a transparent table in front of the screen, just visible in Fig. 1, and is illuminated by a 24-watt gas-filled lamp, the light from which is of sufficient intensity to give a bright image on the screen, but, on account of the low wattage, the heat dissipated is not enough to cause the troubles sometimes experienced with episcopes. The translucent screen is 16 in. in diameter and the standard magnification is about 38 diameters. One of the advantages claimed for the optical system is that, as the light from the object reaches the concave mirror in the form of a wide-angle cone, any surface irregularities or cracks on the object tend to be exaggerated. On the other hand, the makers point out that there is a small amount of curvature in the image field and for this reason the Techne projector is not recommended for tolerance inspection, for which an accurately rectilinear field is essential.

The surface finish of objects can be examined visually as described above, but the instrument can also be employed for the quantitative comparison of surface roughness against a standard specimen. For this purpose, dark-ground illumination is used, instead of the normal illumination, for which purpose a slit-shaped slot is inserted between the light source and the object. The light scattered from the latter and from the standard surface are indicated on a combined galvanometer and photo-electric cell, and as the intensity of the scattered light is proportional to the surface roughness the galvanometer readings enable the surfaces to be compared directly. The makers state that reliable comparisons can be made in this way with surface roughnesses covering the whole range of surfaces for which information on finish is of value.

WELDING IN MARINE ENGINEERING.

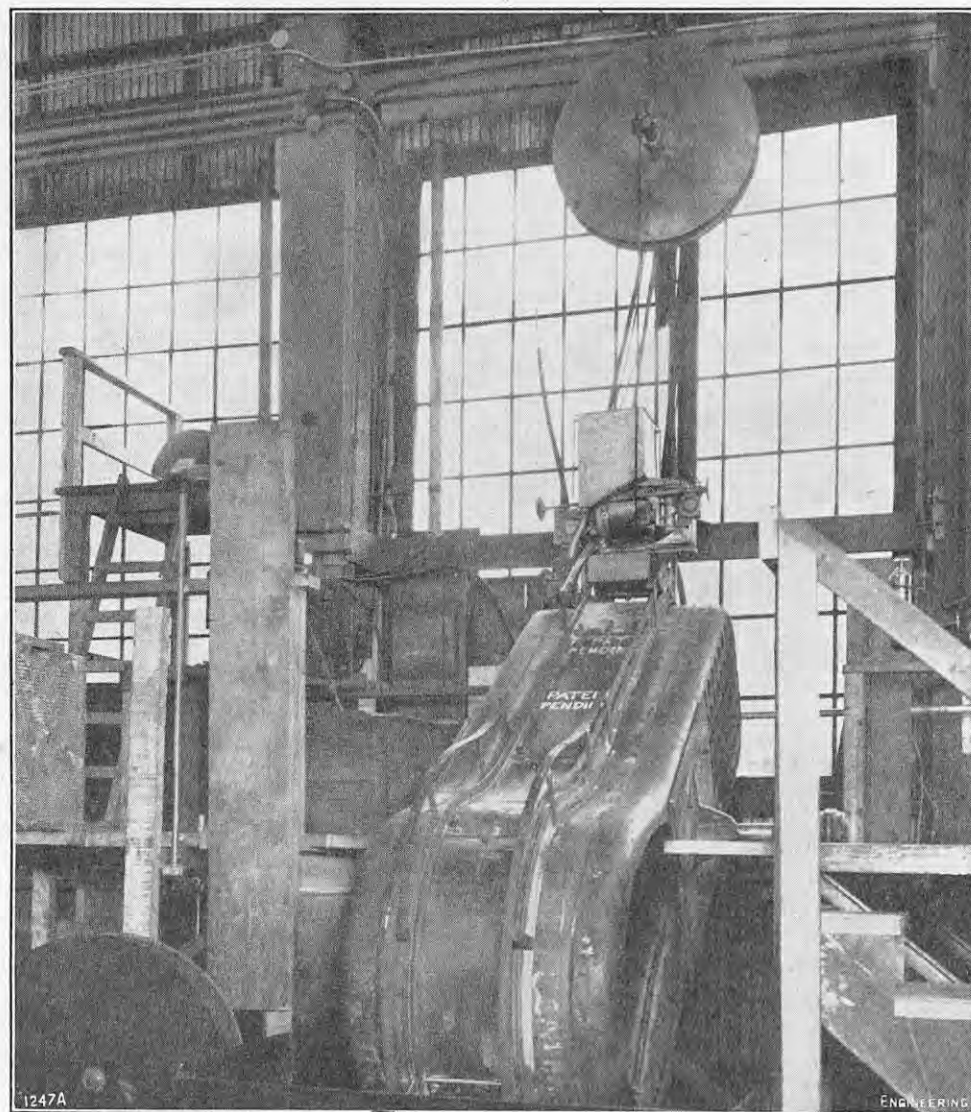


FIG. 1. MANIPULATOR FOR WELDING COMBUSTION CHAMBERS.

WELDING IN MARINE ENGINEERING.*

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

IN summarising welding practice as applied in marine engineering to-day, it is proposed to divide the subject under two main heads, namely, "New Construction" and "Repairs." A further subdivision will be made under "New Construction" so that boilers, steam pipe-work, engines, and auxiliary plant may be dealt with in that order.

NEW CONSTRUCTION.

Boilers.—The confidence in welding which has grown during recent years, particularly in the use of welding for the construction of water-tube boiler drums, led thoughtful engineers to consider the advantages to be gained in welding Scotch multi-tubular marine boilers. For certain classes of ships and certain types of machinery installation, the Scotch boiler is still the most suitable steam generator. "All-welded" multi-tubular boilers were made for the 4,700-ton standard cargo ships built in Canada during the 1939-45 war. All seams were welded, but the stays were screwed and fitted with nuts in the conventional way.

Mr. A. E. House, of Vancouver, designed an interesting manipulator which enabled combustion-chambers to be welded by the automatic process. The device, shown in Fig. 1, above, consisted of a light fabricated guide-track, loosely fitted, and conforming to the profile of the combustion-chamber wrapper plate. The track was held firmly in line

with the seams to be welded, by means of set-screws. The combustion-chambers were assembled, tack-welded by hand, then mounted in the manipulator between two faceplates and rotated about the centre of gravity. The welding head remained stationary, relative to the axis of the rotation of the combustion-chamber, but, being supported on the track, it moved up and down in the vertical plane as it followed the contour of the wrapper-plate. The welding-head drive was obtained through a rack-and-pinion device, in which a sprocket-wheel in the head engaged with a roller-chain fixed round the combustion-chamber. Variable-speed motors were necessary for rotating the work and for driving the welding-head, since perfect synchronism had to be obtained between the speed of travel of the welding-head and the speed of rotation of the combustion-chamber.

Much attention has been given by designers to the welding of combustion-chambers. By using "corner" welds of the types shown in Fig. 2, the flanging of tube-plates and back-plates may be eliminated. The riveted seams of combustion-chambers have always provided a source of leakage and edge-cracking in service, and the avoidance of these defects, in addition to any economy in manufacture, is a real advantage. Corner welds have been adopted for the joints between shell and end plates with satisfactory results in service. Some manufacturers, however, prefer to retain the curved flange, which is butt-welded to the shell-plate with the object of reducing stress concentration at the corners.

Mention has previously been made of the forge-welding of plain and corrugated furnace tubes. The trend to-day is to adopt fusion-welding for the longitudinal joints in these tubes. Both processes

Fig. 2. COMBUSTION-CHAMBER WELDS.

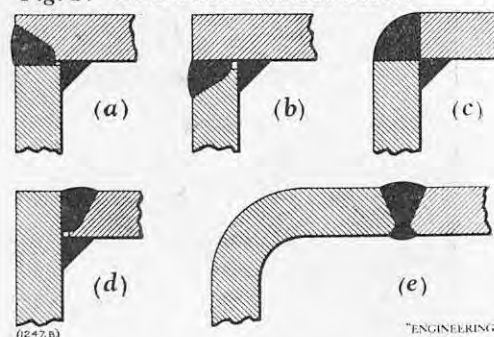
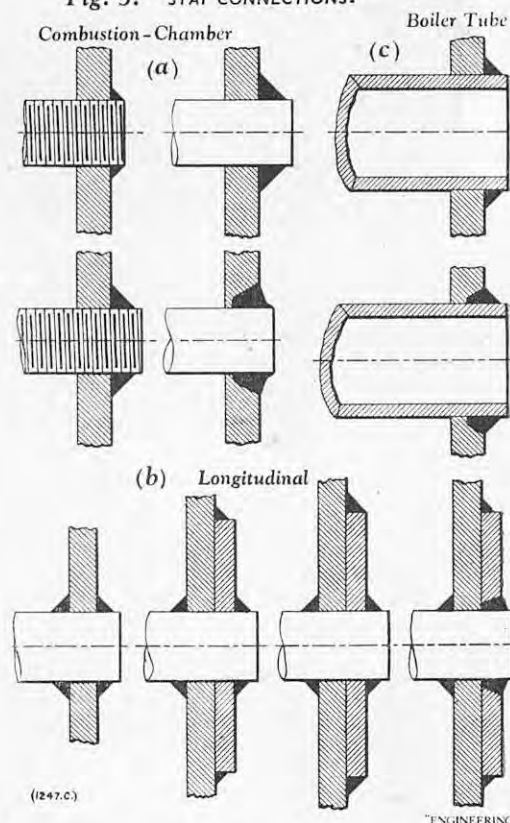


Fig. 3. STAY CONNECTIONS.



have been proved satisfactory over many years, and only on very few occasions has trouble been experienced which could be attributed to defective welding. A further advantage of welded seams over riveted seams in boilers is the elimination of all interstices in which alkaline concentrations may occur and cause caustic cracking between rivet holes, with expensive, and sometimes disastrous, results.

It is the requirement of most authorities that welded joints in tension in the shell-plates of boilers must be stress-relieved by heat-treatment. This necessitates placing the complete boiler shell in a furnace, and few furnaces are available capable of accommodating cylinders greater than 10 ft. in diameter.* In consequence of the limitations of stress-relieving furnaces, the longitudinal joints in the shells of large Scotch boilers must be riveted. Because of the advantages to be gained with welded longitudinal seams in boiler shells, there is need for the development of portable heat-treating appliances, such as an electric-inductance heater which can be applied locally to the welded joints of large boilers, thus obviating the need for a large furnace or for an arrangement of supports which would be necessary for larger boilers.

It is now fairly common practice to secure combustion-chamber and longitudinal stays in Scotch boilers by means of welding. The methods used for this purpose are shown in Fig. 3 (a) and (b). These connections (equivalent to various normal screwed

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

* Table I in the Lecture shows the capacity of stress-relieving furnaces installed at some of the works in Britain where welded boilers and other pressure vessels are made. The three larger sizes are, section by length, 18 ft. by 48 ft., 16 ft. by 50 ft. and 14 ft. by 60 ft.

WELDING IN MARINE ENGINEERING.

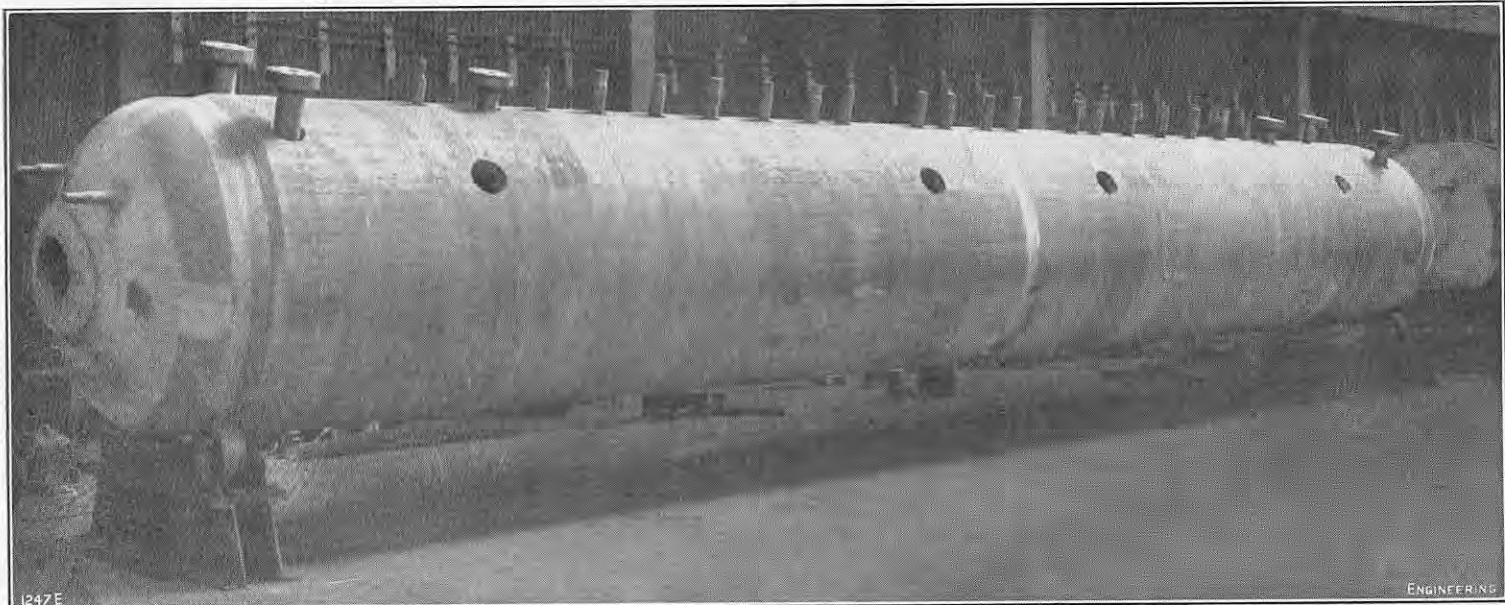


FIG. 4. LARGE WELDED STEAM DRUM FOR WATER-TUBE BOILER.

arrangements) have been based on the results of experiments, carried out by Lloyd's Register of Shipping in 1943, to establish the degree of support given to flat plate surfaces by different methods of welded stay attachments. One advantage claimed for welded stay attachments is that the stay bars need not be machined. They are usually round enough as rolled to provide a reasonable fit in the stay holes. The rolled surface of the bar resists corrosion better than does a machined surface, but it is well to note that broken mill-scale will accelerate corrosion.

A peculiar defect has sometimes occurred in welded stay-bars. The bars show no defect on visual examination before welding, but develop leaks from small radial cracks when boilers are put under hydraulic test. Investigations have shown that the cracks, or fissures, emanate from reeds in the billets from which the bars are rolled. In screwed stays these very fine longitudinal surface fissures are machined out. Stays for welding, however, are not usually machined and the process of welding tends to open up the fissures and, in consequence, leakage occurs. These defects can be avoided if the billets from which the bars are rolled are "deseamed" by flame gouging. A suitable test on a finished stay-bar is to crop a piece from the end of the bar, of length equal to the diameter of the bar, and, after heating to redness, compress it axially to half its length. No signs of fracture or "fissuring" should appear.

It is not usual to weld the smoke tubes into the front and back tube-plates of Scotch boilers. It is true that a light sealing weld round each tube end would prevent leakage, but in principle the sealing should be effected on the water side and not on the dry side of the tube-plates. It is wiser to rely on the orthodox methods of expanding the tubes rather than on a light weld which might obscure serious wastage between tube and plate. This might be particularly serious in the case of the stay-tubes, where the load might be transferred to the weld as the screw threads corroded away. Stay-tubes secured only by welding have been accepted, as shown in Fig. 3 (c).

No comments on welded boilers would be complete without a reference to vertical boilers. These boilers, which are of very many different designs, ranging from partially-welded to all-welded construction, have benefited from the application of welding. Being of smaller dimensions than the Scotch boiler, the outer shell presents little difficulty in construction, welding, or stress-relieving. It is in the construction of the inner shells, so common in many designs, that greatest advantage is obtained from welding. Many examples could be produced, but it may suffice to refer to Fig. 5, opposite, which shows the inner and outer shells for a

boiler of the thimble-tube type, the clean appearance of which is obvious. It should be noted that by welding the circumferential joints of the inner shell considerable saving of riveted joints may be effected. The whole of the outer shell is also welded, with the exception of the top and bottom circumferential joints between the inner and outer shells. In some designs these joints are also welded.

Water-Tube Boilers.—The higher steam temperatures and pressures which obtain in modern turbine-driven ships necessitate the use of water-tube boilers. For these advanced steam conditions the drums and headers of water-tube boilers must be either solid-forged or fusion-welded. The former has the great merit of simplicity—having no joints, except girth seams, when the drums are made up from a number of solid-forged cylinders. The solid-forged drum is suitable for the highest pressures and temperatures at present obtained in steam boilers. The size of the drum, however, is limited by the maximum size of ingot available. Thus the forging process is generally applicable to the smaller drums only. Manufacture is more costly than for welding, and this disadvantage increases with the size of the drum.

Whether or not the water-tube boiler drum is forged or welded, it is the usual practice to weld on the stand-pipes and pads to which the boiler mountings will be attached. Stand-pipes may be "set in" or "set on." Typical methods are shown in Fig. 6, opposite. For very thick drums and stand-pipes, the set-on type of welded attachment offers the advantage of less restraint during welding than the set-in type. In consequence, it is less prone to root cracking in the weld.

The largest boiler drum yet constructed by welding in the United Kingdom is shown in Fig. 4, above. The drum is 43 ft. long and 60 in. in diameter. The shell-plate, made of steel 34 tons to 40 tons per square inch, is $5\frac{1}{8}$ in. thick, and the finished weight of the drum is 80 tons. It is true that the drum was intended for land service and not for a marine boiler, nevertheless, it illustrates the extent to which welding can be applied to-day, as regards both the thickness and tensile strength of welded steel plates. It is considered that greater use could be made of this higher tensile steel for the construction of welded drums for marine water-tube boilers, for which higher working stresses could be allowed than in the more commonly used steel of 28 tons to 32 tons per square inch.

Welded drums for marine boilers were first accepted by Lloyd's Register of Shipping in 1938, following extensive experience gained in land service. The first passenger ship having welded boiler drums went into service about a year later, but by that time several oil tankers, built in the United States and classed with Lloyd's Register,

were in service, with water-tube boilers having welded drums, and working at steam pressures of 400 lb. to 625 lb. per square inch and superheat temperatures of 750 deg. to 835 deg. F. It must be emphasised, however, that the welding of boiler drums is a specialised branch of the welding industry. So far as Lloyd's Register of Shipping is concerned, this class of work can be accepted only provided the drums are made by firms who have proved, by comprehensive tests, that their welding work is of the highest standard as regards both quality and consistency.

For the superheater headers and water-wall headers associated with water-tube boilers, the end-plates are in many cases secured by welding. Some alternative methods of weld preparation for these ends are shown in Fig. 7, opposite. Due to the rigidity of the header-walls, cases of basal cracking of these end welds have occurred, and Fig. 7 also indicates proposals which, by means of fluting and tapering the header towards the end-plate, would increase the flexibility of the walls in way of the weld.

Pipe-work.—Tubes made by means of electric-resistance welding are accepted by Lloyd's Register of Shipping for use in boilers and for pressure piping. Electric-resistance welded tubes are made from cold flat steel strip fed continuously to the mill, where a train of rolls forms the strip into tubular shape with a longitudinal gap. The tube, with the gap uppermost, then passes under the electrodes, where the passage of low-voltage current across the gap generates sufficient heat to melt the abutting edges of the tube. A pair of horizontal squeeze-rolls, which almost completely surround the tube, exert the pressure necessary to close the gap and make the weld. In this operation the rolls squeeze out the excess metal in the form of a fin, on the inside and outside of the welded tube; the fins being subsequently removed by cutters.

The most general application of welding in marine pipe-work is in the attachment of flanges. Fig. 8, on page 76, shows the various acceptable methods of securing flanges. The butt-welded flange-joint is the best, since it does not involve any change in direction of stress lines at the weld. It also has the advantages of being simple to weld, and that the welding can be carried out free of restraint, with consequent minimum distortion. A common defect in butt-welded pipe-joints is insufficient root-penetration. This defect can lead to the failure of the joint, and must be avoided entirely in high-pressure steam-pipe joints. Two methods are normally used for overcoming this difficulty in welded pipes which are too small to "back chip" and be welded from the inside. One is to use a "backing ring" inside the pipe, fitting close up to the underside of the welding groove. This serves

WELDING IN MARINE ENGINEERING.

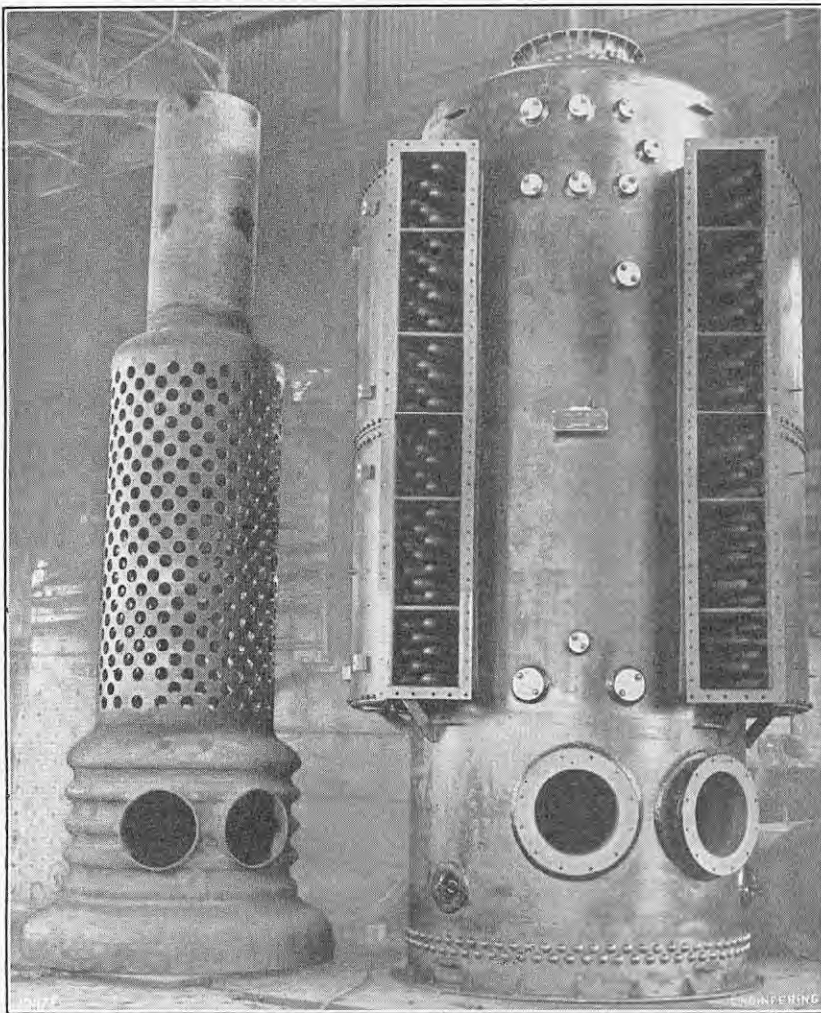


FIG. 5. INNER AND OUTER SHELLS FOR THIMBLE-TUBE BOILER.

to localise the penetration of the welding-arc, and by providing a heat conductor prevents the burning of the bevelled edges of the pipe at the root of the welding groove. The second method is to employ oxy-acetylene welding for the initial root run. This is the better method for mild-steel piping which cannot be welded from the inside of the pipe. The remainder of the welding groove is filled by arc-welding.

For certain alloy steels, oxy-acetylene welding is unsuitable for pipe-joints, and backing rings do not provide a satisfactory solution because of the tendency for basal cracking at the root. For these, the practice is to preheat the pipe ends to a suitable temperature and arc-weld the joint throughout. It is desirable that radiographic examination of the root run be carried out before proceeding to complete the weld. The "slip on" type of welded flange, though in common use for many pipe-joints, has the primary disadvantage of a directional change in stress lines concentrated in the fillet-weld at the back of the flange. There is also the tendency for distortion of the flange face. A serious possibility with this type of welded attachment is erosion of the inside fillet-weld, which is in contact with the flowing contents of the pipe-line.

Steam-pipe welds should always be stress-relieved by thermal treatment. This is of special importance with alloy-steel pipes, such as those made from carbon-molybdenum and chromium-molybdenum steel. It is not yet the practice in the United Kingdom to weld steam-pipe joints *in situ* on board ship, but the need to reduce the number of flange joints to a minimum in high-pressure steam lines will no doubt lead to the adoption of ship-board welding, in which case preheating and stress-relieving will best be carried out by means of induction or resistance heating-coils.

It will also be necessary to consider the use of "welded-in" valve bodies instead of flanged valves. Welded-in pipe fittings, such as branch pieces,

elbows, and distribution headers, also present advantages in the elimination of flange joints. It might be argued that the "welding-in" of a steam valve will impede its overhaul, but this need not be so, provided the valve is accessible and suitable tools are available for the purpose. Ideally, the whole of a superheated steam line from boiler to turbine should be welded. It must, however, be emphasised that ship-board welding of steam-pipe joints requires the most rigid control and supervision. Qualifying tests for welders and procedure would be necessary before such work could be undertaken and, in addition to the heat treatment required, the welds should be examined by means of radiography. In this connection, the use of gamma rays, using a cobalt-60 radiation source, has been found suitable in power-house work.

Some typical examples of welded branch pieces are shown in Fig. 9, on page 76. These suffer a common disadvantage due to stress concentration at the change of section between pipe and branch. Some mitigation of this disadvantage is obtained by reinforcing the branch as shown in Fig. 9 (d), but research has shown that this is by no means an ideal solution. The stress-concentration factor is considerably reduced by using an extruded type of branch connection, as shown in Fig. 10 (d). This type has the added advantage of permitting a simple butt-weld for attachment of the adjacent branch "leg."

The welding of pipe-lines is facilitated by the employment of standard types of pipe fitting specially designed for welding. In this respect, increasing use is being made of short-radius and long-radius elbow pieces, tube turns—180-deg. bends—T-pieces, and welding neck flanges. These fittings are illustrated in Figs. 10 and 11. A typical

Fig. 6. TYPICAL METHODS OF ATTACHING STAND-PIPES.

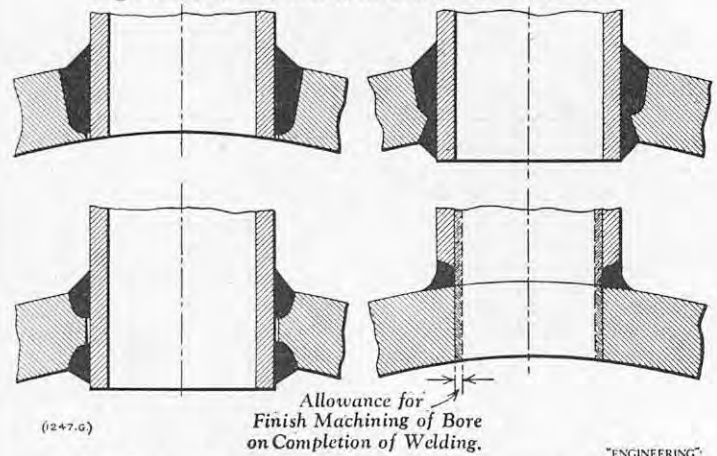
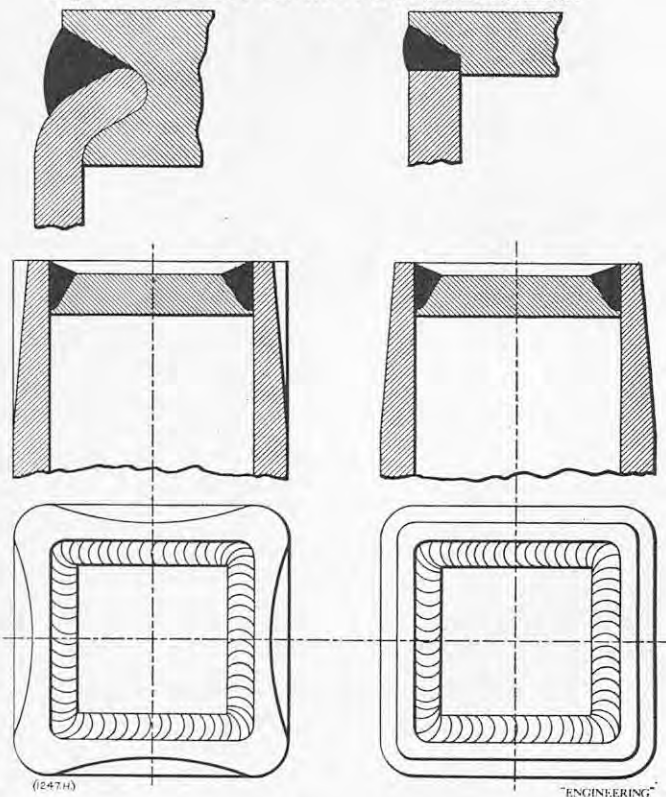


Fig. 7. END WELDS FOR STEAM AND WATER HEADERS.



portion of a steam-pipe arrangement incorporating welding fittings is shown in Fig. 11. It will be noted that only butt-welded joints are used, which lend themselves to radiographic inspection.

From time to time, proposals have been made to fabricate valve bodies in place of steel or iron castings. A special advantage can be claimed under war conditions, when fabricated "ship-side" valves offer better resistance to the effect of under-water explosions than cast-iron ones. Unfortunately, as regards corrosion in sea water, the mild-steel valve body is inferior to one of cast iron. Fig. 12 illustrates the method used by one manufacturer for fabricating steam valves from mild-steel pressings. This is not common practice, however, in marine engineering at the present time.

MACHINERY COMPONENTS.

Oil Engines.—Perhaps the most outstanding contribution welding has made in marine engineering is in its influence on the design and construction of Diesel engine bedplates and entablatures. The use of welding for this purpose received an impetus during the 1939-45 war, when under-water explosions were effecting serious damage to cast-iron engine bedplates in ships in the vicinity of the explosion. Before the war, however, some engine designers were already taking full advantage of welding in the fabrication of their engine structures.

There are two important interdependent advantages which can be claimed for welded engine

WELDING IN MARINE ENGINEERING.

Fig. 8. TYPICAL METHODS OF SECURING PIPE FLANGES.

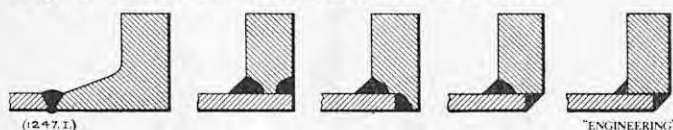


Fig. 9. TYPICAL METHODS OF ATTACHING BRANCH PIPES.

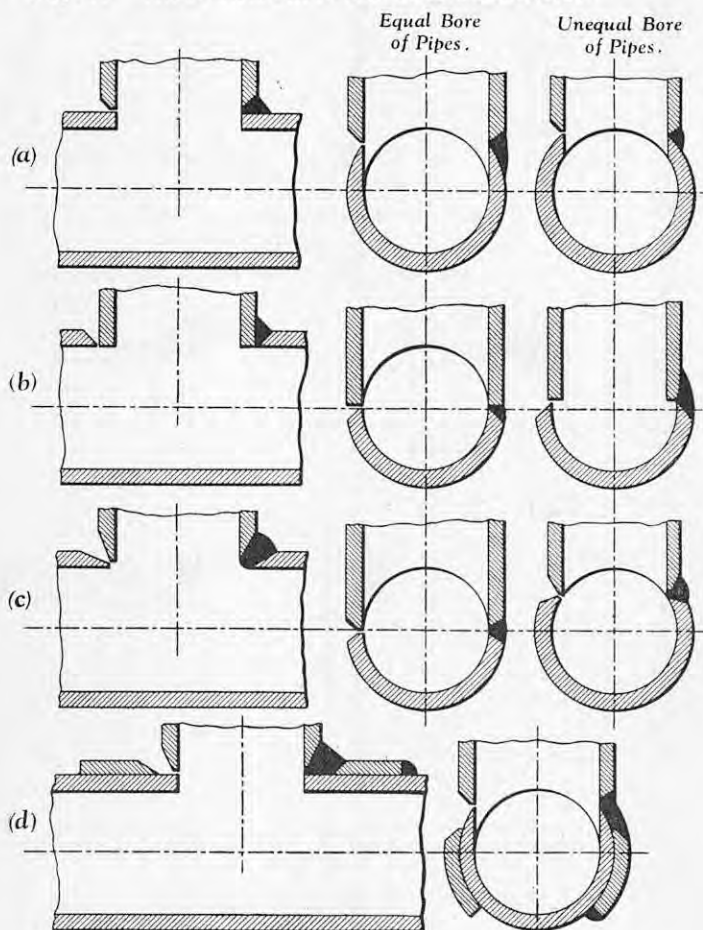


Fig. 10. FITTINGS FOR WELDING IN PIPE ARRANGEMENTS.

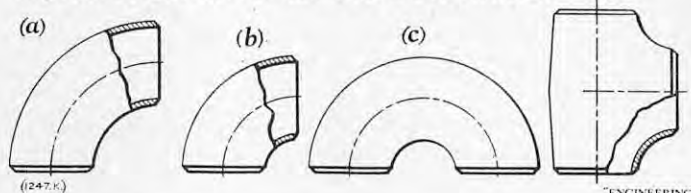


Fig. 11. WELDING FITTINGS INCORPORATED IN A PIPE ARRANGEMENT.

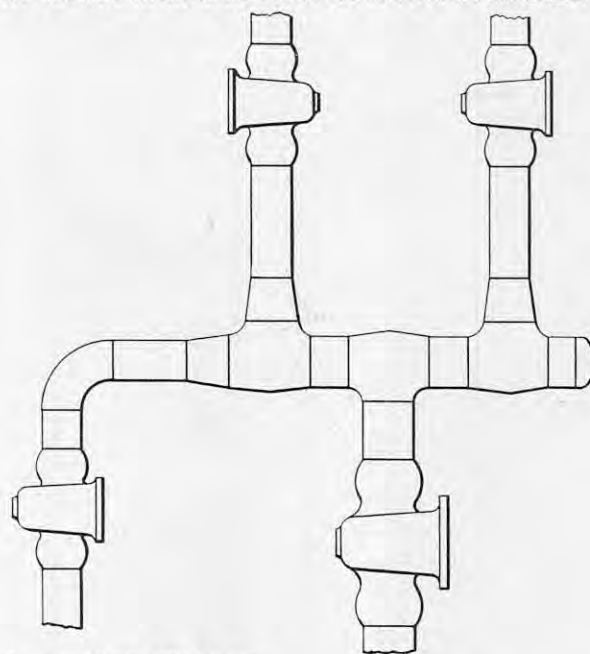
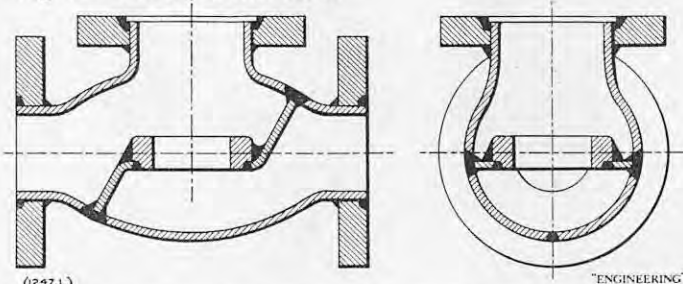


Fig. 12. FABRICATED STOP VALVE.



bedplates and entablatures, these are: freedom in design; and saving in weight. By the use of welded structures the designer can dispose his material to the best advantage for strength, accessibility, and functional purposes. Larger and more conveniently arranged crankcases can be obtained, which facilitate overhaul. Again, scavenge and exhaust belts, camshaft brackets, and cross-head guides can readily be incorporated in the fabricated design. A feature of the welded engine entablature is that the upward vertical loads may be transmitted to the bedplate, through the steel structure, instead of by long "through bolts" which are necessary in cast-iron engines.

A welded engine bedplate offers no special difficulty in either design or construction. In essence it requires two fore-and-aft girders with a number of transverse beams slung between them. These transverse beams house the main bearings in which the crankshaft is bedded. The loads on the girders and transverse beams are readily calculable. Working stresses, however, are negligible, since rigidity is the essential feature of the design, and deflection of the bedplate components must therefore be restricted to a minimum. Rigidity is obtained by using plates of suitable thicknesses in the construction of fore-and-aft and transverse members, and

by welding stiffeners to the vertical panels of the transverse beams.

In adopting reduced scantlings for fabricated bedplates, care must be taken to ensure that provision is made for an adequate length of holding-down bolts. A common feature in welded engine bedplates for marine engines is the use of steel castings for the main-bearing housings. These housings necessarily must be heavy, and, in consequence, require either forgings, folded slabs or castings. The latter are usually adopted and provide a simple solution. There is no difficulty in welding a mild-steel casting to a mild steel plate.

Despite the fact that a bedplate must be designed for minimum deflection, a considerable saving in weight is obtained by the use of mild-steel instead of cast iron since, not only is cast iron less rigid than mild steel and therefore more metal is required for the same deflection, but more metal is also required for casting purposes. Further, it should be appreciated that, even with the lighter scantlings resulting from the substitution of mild steel for cast iron, a more rigid engine structure is obtained. This use of plates of mild steel instead of cast iron results in a saving in weight of between 20 and 30 per cent.

In a particular case, that of a large marine oil-engine of the "Gotaverken" type, designed to develop 750 brake horse-power per cylinder, in comparison with a similar design in cast iron, the welded type effects a saving in weight of 37½ lb. per brake horse-power. The extreme simplicity in the design of bedplate and entablature for this type of engine can be seen in Figs. 13, 14 and 15, on page 80. It will be observed that the bedplate is made in sections which can be joined together

to give the desired length. The entablature is made in separate units (Fig. 14), again giving "freedom in design," to enable any number of units to be built into an engine, depending on the number of cylinders required. These box-like units are welded together at the column flanges. A model of a bedplate and entablature unit is shown in Fig. 15.

Different engine builders adopt different types of fabrication to suit particular designs of oil engine, but the main principles are the same. The type of fabrication illustrated here is of Continental practice; it is as good an example of "freedom in design" as will be found.

A notable example of British practice in engine fabricated structures is that of the Doxford type of heavy-oil engine, the constructional details of which can be appreciated from Fig. 17, on page 80, which shows a half-section entablature. Indicative of the "freedom in design," it will be noted that, whereas in the case of the Gotaverken engine in which the construction consists essentially of individual cylinder units—the column and entablature being integral—in the Doxford construction the bedplate and entablature are generally made in two portions, connected by individual column units. Fig. 16, on page 80, shows a completed engine on test-bed trials, it is the largest all-welded Doxford engine yet constructed in Britain. The engine has six cylinders each of 750 mm. bore by 2,500 mm. combined stroke, developing 8,000 brake horse-power at 104 r.p.m. It was built recently in Glasgow for the motor ship Polarbriss.

Welded engine bedplates, columns and entablatures have been in marine service for a considerable time, some for upward of 20 years, and it can be stated that this type of construction has proved to be completely reliable. Where trouble has been experienced, it has been due to faulty design, which has been quickly rectified. A further example of "freedom in design" is that these mild-steel engine structures can be readily modified by cutting out, or welding on, pieces without serious difficulty.

(To be continued.)

ANTI-VIBRATION NUT.

LESTER LOCK NUT AND WASHER CO., LTD., WORDSLEY.

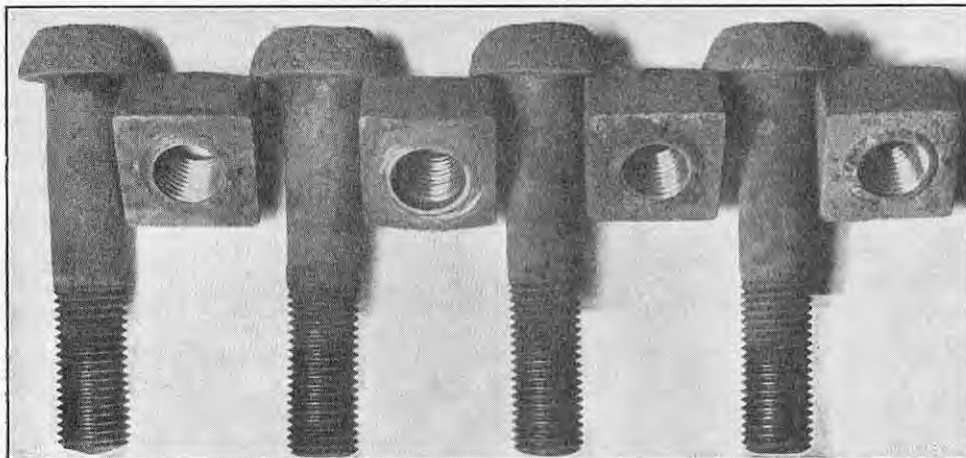
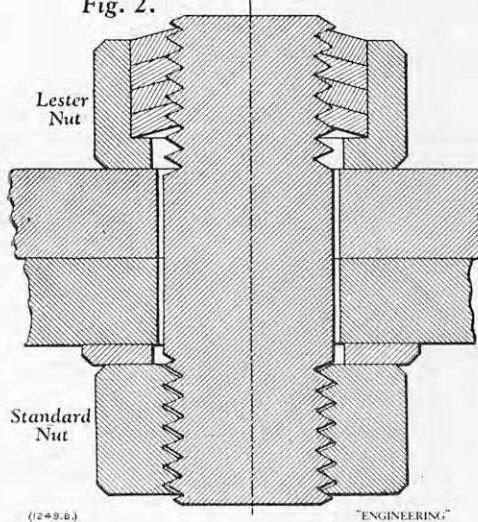


FIG. 1. FISH-BOLTS AND NUTS, SHOWING UNCORRODED THREADS AFTER SERVICE.

Fig. 2.



ANTI-VIBRATION NUT.

A NEW design of nut intended to resist loosening and to obviate deformation of the bolt threads has been introduced by the Lester Lock Nut and Washer Company, Limited, Camp Hill Works, Wordsley, Staffordshire. It has been subjected to prolonged tests in service, as well as to tests on the vibrator machine described on page 54 of last week's issue of *ENGINEERING*, and the makers report its marked superiority over conventional nuts.

Fig. 2, herewith, shows, at the top, a Lester nut, and at the bottom an ordinary nut. The Lester nut consists of a group of conical discs, made of a resilient steel and contained in a hexagonal body; the discs are drilled and tapped after they have been inserted in the body. When the nut is tightened up the coned discs are pulled down and partly flattened. This action has the effect of enforcing closer contact between the threads in the discs and the threads on the bolt, and—what is more significant—there is full contact over both flanks of the threads, and the nut thus conforms exactly to the thread, obviating all disadvantages due to irregularities in dimensions and pitch. This feature may be compared with the condition in a normal nut, where there is contact on the loaded flank only, as shown at the bottom of Fig. 2. A number of advantages arise from this improvement. Thus, the Lester nut dampens vibration, and reduces thread fatigue and deformation. Fig. 3 shows the ends of two bolts which had been used for the same length of time, and under similar service conditions, in a railway-track crossing. Deformation of the thread of the upper bolt, which had been fitted with an ordinary nut, is apparent, whereas the thread of the lower bolt, fitted with a Lester nut, is still in good condition. It is, of

course, the deformation of the thread which allows the nut to loosen under vibration; if the thread is not able to deform, the nut will not readily loosen.

The advantage of the Lester nut in preventing corrosion is illustrated in Fig. 1, which shows four nuts and fish-bolts which had been in service for two years and five months in a main line next to a crossing. The traffic there was heavy and the atmospheric conditions were conducive to corrosion, but, as Fig. 1 shows, the threads were not affected and were, in fact, as bright as when they were first assembled. One of the nuts in the illustration has been placed the opposite way to the other three to show the absence of corrosion on both flanks of the threads. Such absence of corrosion also has the advantage that it prevents thread seizure and therefore facilitates unscrewing of the nut whenever necessary. Among the other advantages claimed for the nut by the makers are: it is equally efficient on an uneven seating, since it can deflect slightly; it is better than a nut welded on to the bolt, and better than a rivet subjected to vibration; once tightened it will always unscrew with a nut/bolt friction exceeding that required by aircraft specifications; it obviates the need for washers; it can be used repeatedly; it can be supplied for a free-spinning fit on a standard bolt or not free-spinning, as required; and it has a life greater than the combined lives of two heat-treated high-tensile bolts.

To tighten a Lester nut, the torque required is about 25 or 30 per cent. greater than for a conventional nut, since the thread friction to be overcome is greater. The nut is fully tightened when it is

felt to "give" or the coned element is observed to recede inside the body of the nut. Tightening slightly beyond this point will not overload the bolt. Tests carried out on the machine described in the previous article have shown that the anti-rotational grip or friction actually increases as a result of vibration. Various types of nuts tested on the machine have given the following results, in terms of total number of reversals to failure: standard nut, 617; standard nut and lock nut, 2,492; standard stiff nut, 2,136; standard nut with a split pin 0.075 in. in diameter, 2,848; standard nut with a split pin 0.100 in. in diameter, 22,784; Lester nut, 28,302 (bolt life). Moreover, after failure the Lester nut still showed a friction on the bolt of 360 lb.-in., whereas the standard stiff nut had only 24 lb.-in. and all other types had retained no friction.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

THE *Report on Research* of the Royal Technical College, Glasgow, published recently, shows that among the departments of the College having research programmes are those of Mathematics, Chemistry, Technical Chemistry and Metallurgy—the last three are independent departments and have separate programmes—the three departments of Engineering (Civil and Mechanical, Electrical and Mining), as well as the allied departments of Textile Technology and Industrial Administration.

Although the Mathematics Department had an independent programme of research in problems of both pure and applied mathematics—two topics that were studied were those of sea-wave formations and geomagnetism—a principal aim of the department was that of advising others on the theoretical issues that necessarily arose during the investigations being pursued elsewhere in the College. These investigations were of three types: sponsored industrial research for trade associations and other authorities; short-term testing such as the proving of materials for particular contracts; and, thirdly, academic research. Because of the great amount of work mentioned in the Report, it is only possible to draw attention to a few isolated items.

The department of Technical Chemistry, with the co-operation of the departments of Mining Engineering and Natural Philosophy together with that of Pathology in the University of Glasgow, made a most intensive study of the surface phenomena of airborne dusts and of dust reduction by aqueous sprays. The absorption of gases by aqueous sprays was also examined by the same group. The work of the North of Scotland Hydro-electric Board was reflected by model studies on spillways for dams and on outfalls. On the subjects of soil mechanics and of concrete and cement technology, the work undertaken seems to have been of a more academic character. In contrast to this, however, was the general research undertaken for the Scottish Peat Committee on the utilisation of peat as a fuel in gas turbines. A particular problem studied was the mechanical removal of water from the raw peat; considerable success has been achieved by the simple application of pressure when absorbent hessian was placed between the layers of peat. The research activity of the department of Textile Technology included several short-term investigations on problems met in local mills, although the report indicates that work of a more fundamental character has also been considered, with the object of providing new knowledge for future developments and application in the industry.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The 1953 Faraday Lecture of the Institution of Electrical Engineers will be delivered by Mr. A. R. Cooper, M.I.E.E., M.Inst.F., at the Central Hall, Westminster, London, S.W.1, on Wednesday, February 18, commencing at 6.30 p.m. Mr. Cooper, who is the Controller of the North-Western Division of the British Electricity Authority, will speak on "Light from the Dark Ages, or the Evolution of Electricity Supply." Admission will be by tickets only, and these may be obtained from the secretary of the Institution, Savoy-place, Victoria-embankment, London, W.C.2.

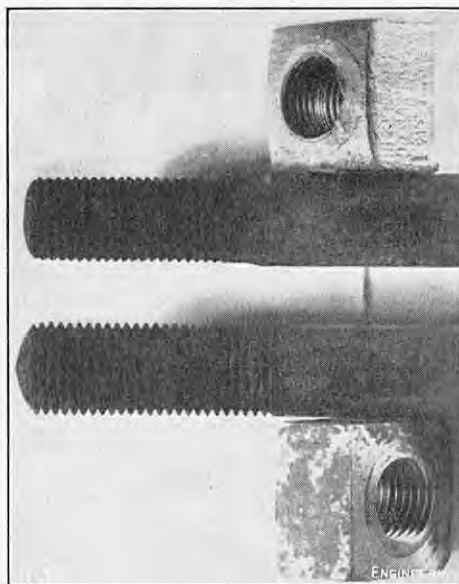


FIG. 3. TWO BOLTS AND NUTS REMOVED AFTER SERVICE.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

IRON AND STEEL PRODUCTION OF COLVILLES LTD.—The Colville group of companies, which is responsible for about 80 per cent. of Scottish steel production, had an output of 1,678,200 tons in 1952, which compares with 1,665,000 tons in 1951. The largest contribution was made by Dalzell Works, namely, 451,600 tons, followed by 439,000 tons at Clydebridge. The Clyde Alloy Steel Co., Ltd., increased their output to 35,400 tons, from 28,900 tons in 1951. The three blast furnaces operated by the group at Clyde Iron Works turned out 606,500 tons, a record for the firm. The output in 1951 amounted to 546,300 tons.

POST-HOLIDAY CONDITIONS AT COLLIERIES.—A good resumption of work was effected at collieries in the Scottish division of the National Coal Board on January 5, after the New Year holiday. Only one small mine failed to re-start. The absenteeism percentage, of about 12, compared with a normal figure of about 10 per cent., was officially described as "very good." Full production was delayed at the start by time lost in dealing with falls of roof in roadways and at the coal face.

RESERVES OF FUEL AT POWER STATIONS AND GASWORKS.—Cold weather in the early days of the new year put a heavy strain on electricity and gas-making plants; in each case, an additional output of 10 per cent., compared with 1952, was needed to cope with the loads. Coal stocks, however, met the situation fairly satisfactorily. A good proportion of the first of the fresh-mined tonnages after the resumption of work at the pits was delivered to the power stations, which also had reserves some 10 per cent. greater than was the case in 1952.

CLEVELAND AND THE NORTHERN COUNTIES.

EXTENSION AT SUNDERLAND WORKS.—Sunderland Corporation Highways Committee have approved plans for a works extension at Southwick, Sunderland, for Aiton & Co., Ltd., makers of plain and corrugated steel pipes. The extension will cover 1,000 sq. yards. Work will be provided for an additional 50 men, bringing the number of employees up to 200.

TRADE ON RIVER WEAR.—Figures issued by the River Wear Commissioners show that, during last November, coal and coke shipments from the Wear amounted to 280,085 tons, making a total of 2,924,378 tons for the 11 months of the year, compared with 2,795,517 tons for the corresponding period of 1951. Exports of general merchandise for the 11 months aggregated 81,884 tons, compared with 95,498 tons in 1951, and 70,915 tons in 1938. The largest item of export was petroleum (60,620 tons). Imports totalled 502,503 tons against 467,186 tons last year and 305,410 tons in 1938. The heaviest single import was iron ore, namely, 194,808 tons.

LAI-D-UP SHIPPING IN THE TYNE.—It was reported at the recent monthly meeting of the Tyne Improvement Commission that, at the end of December, there were four vessels, totalling 5,667 net tons, laid up in the river. A year ago, there were only two vessels, aggregating 2,685 tons; but, obviously, though the laid-up tonnage has more than doubled, the increase is not a matter of moment.

OUTPUT OF PARSONS TURBINES AND ELECTRICAL MACHINERY.—Sir Claude Gibb, chairman of Messrs. C. A. Parsons & Co., Ltd., Heaton, Newcastle-on-Tyne, writing in the current issue of the *Heaton Works Journal*, states that 1952 was characterised not so much by a general shortage of materials as by irregular deliveries of them. Many times during the year, particular types or sizes of steel or other material were not delivered as scheduled, thus adversely affecting output. Nevertheless, at home and overseas during the years 1951 and 1952, Messrs. Parsons completed the erection of turbine plant totalling more than 2,000,000 kW and delivered transformers aggregating upwards of 3,000,000 kVA. During 1952, Messrs. Parsons received orders for turbo-alternators varying in output from 5,000 kW to 60,000 kW for power stations in Britain, Canada, Australia, South Africa and Venezuela. Work was proceeding on the erection of a 15,000-kW gas-turbine alternator at Dunston-on-Tyne power station and on a 10,000-kW set for the National Gas Turbine

Establishment at Farnborough. Smaller machines under construction included a 2,000-kW plant for the municipality of Singapore. During 1952, the firm received an order for a very large double-wound transformer. This was for a 120-MVA unit which would be used to step up the generator voltage of a 100,000-kW turbo-alternator, being made for the Ferrybridge power station, to the transmission voltage of 132 kV.

LANCASHIRE AND SOUTH YORKSHIRE.

SHEFFIELD STEEL PRODUCTION.—Sheffield steel firms, in some instances, are experiencing an easing of demand. Some have very full order books, but others report gaps in orders for finished and semi-finished products. At the same time, some record outputs have already been achieved in 1953. At the works of Samuel Fox & Co., Ltd., Stocksbridge, the billet mill has beaten two previous production records. A 16-shift week has yielded a tonnage of 5,111 against the previous best of 4,661 tons, set up in the week ended April 7, 1951. A single-shift record of 406 tons, exceeding the previous best of April 23, 1950, by three tons, has also been achieved.

PLEA FOR AMERICAN CONSULATE IN SHEFFIELD.—The Sheffield Chamber of Commerce has asked for the re-opening of the United States Consulate in Sheffield. This was closed in 1940 when it was considered that the amount of business then being done did not justify its continuance. Since then, trade with the United States has expanded, but Sheffield and district exporters have had to deal through the United States Consulate in Manchester. The application has been forwarded to the United States Embassy in London.

EXTENDED TELEPHONE FACILITIES IN SHEFFIELD.—A new telephone exchange which will eventually replace the trunk exchange, at present at Sheffield head post office, is to be built in Button-lane, Sheffield. It will contain equipment for handling all telephone calls from exchanges in a 20-mile radius. Plans have also been made for building, in Wordsworth-avenue, an exchange to deal with trunk calls from exchanges in the northern part of Sheffield. The Button-lane exchange is scheduled for completion in about three or four years' time.

THE LATE MR. C. LAYCOCK.—Mr. Colin Laycock, chairman and managing director of J. Beardshaw & Son, Ltd., tool-steel and file manufacturers, Baltic Steel Works, Sheffield, died on January 7, aged 73. He had been with his firm for 58 years and became secretary in 1908. In 1911 he was appointed a director, and joint managing director in 1916. He had been chairman and managing director since 1936. He was a Freeman of the Cutlers' Company, a member of the Iron and Steel Institute, and treasurer of Sheffield and District Rollers, Tilters and Forgers Employers' Association. From 1940 to 1944 he was President of the Sheffield Chamber of Commerce. Other positions formerly held by Mr. Laycock were those of vice-president of the Saw Manufacturers' Association, and Finnish vice-consul in Sheffield.

THE MIDLANDS.

SIDBURY ROAD BRIDGE, WORCESTER.—The condition of Sidbury bridge at Worcester is causing concern. The chairman of the Worcester City Streets Committee, Alderman W. H. Norton, has reported that the bridge, which was built in 1822, is showing signs of general deterioration as a result of age, overloading, and excessive vibration. Several approaches have been made to the Minister of Transport, but these have met with the reply that the present financial position makes it impossible for the desired reconstruction work to be approved. The report states that it may soon be necessary to prohibit the passage of heavy traffic over the bridge. An alternative route, involving a detour of about two miles, would then have to be brought into use. Another application to the Minister is to be made.

REJECTION OF PROPOSAL FOR BIENNIAL B.I.F.—A suggestion from several quarters for a biennial British Industries Fair in place of the present annual event has been considered by the Midland Council of the National Union of Manufacturers. The Council have rejected the suggestion, it being considered that, as foreign trade fairs competing with the B.I.F. are held annually, a change of practice would be to the disadvantage of British trade. The Council also hold the view that a biennial fair would be uneconomic, and that it would be unsuitable for firms who wished to introduce new designs as quickly as possible.

THE BLACKSMITH IN RURAL AREAS.—A report presented to the Warwickshire Rural Community Council shows that there has been a marked revival in the work of blacksmiths in the rural areas of the county. The report shows that the small smithy of the traditional type has practically disappeared, but that, in its place, workshops of a new type have been built, with a much wider scope than the old forges, and equipped with modern machinery, enabling them to undertake a considerable variety of agricultural engineering work. One of the new repair shops, at Binley, near Coventry, employs ten men on full time.

AUSTIN MOTOR-CAR FACTORY IN SOUTH AFRICA.—The new Austin factory at Blackheath, near Cape Town, South Africa, is expected to be completed in June, and the assembly of cars will begin as soon as possible after completion. The new factory, which is built on a site of 110 acres, will employ about 500 persons at the commencement. Technicians from the main Austin works at Longbridge, Birmingham, will superintend the start of production, and will train local labour. At first, the factory will only assemble cars and lorries from imported parts, but the company's long-term plans include the use of an increasingly large proportion of South African components.

THE B.R.M. CAR.—Mr. A. G. B. Owen, chairman of Rubery Owen & Co. Ltd., Darlaston, who recently bought the assets of British Racing Motors Ltd., announced in a broadcast on January 6 that the car will race on both British and Continental tracks this year. The company are designing a new 2½-litre unsupercharged engine, to be sold to the trade.

EXPORT PROSPECTS FOR SMALL ENGINEERING FIRMS.—Mr. Duncan Sandys, M.P., Minister of Supply, at the conclusion of a three-day tour of engineering works in the Midlands, made a speech in Wolverhampton on January 7, in which he appealed to small firms to explore the possibilities of direct exporting. Small manufacturing concerns are in the majority in the Midlands, and many of them are already carrying on a considerable trade in indirect exports, as sub-contractors to larger firms, but the Minister considered that, if prices and deliveries were right, there were good prospects of many of these small firms developing a direct export trade. The Government would give every possible assistance to firms endeavouring to build up an export trade.

FOUNDRY SERVICES, LTD.—The firm of Foundry Services, Ltd. of Long Acre, Nechells, Birmingham, 7, celebrated on January 13 the 21st anniversary of their foundation. The company was formed in 1932 and began with a staff of five persons. There are now five associated companies overseas, in addition to local agents and representatives, and the staff has increased to nearly 500.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SEVERN ROAD BRIDGE.—Another attempt is to be made to secure the building of a road bridge across the Severn, a scheme which was postponed some years ago. The East Wales District Committee of the Welsh Board for Industry have decided to ask the Board to press for immediate reconsideration by the Government of the project. It was stressed that the bridge was the central feature of all attendant road improvement schemes and that it was in the interests of South Wales that the scheme be proceeded with as soon as possible. The original estimate for the scheme was 15,000,000£, for the bridge alone. The demand for the reconsideration of the plans has been supported by the Development Association of the Royal Forest of Dean.

MINERS PRESS FOR NEW WAGES STRUCTURE.—By a four to one majority, namely, 16,600 in favour and 65,850 against, South Wales miners rejected the recommendation of a national delegate conference on the wages question. The national conference resolution urged all miners to vote against the acceptance of the National Coal Board's qualified offer of 6s. a week increase in the minimum pay of day-wage men, and to instruct the union's national executive council to negotiate with the Board for a new wages structure. South Wales miners are in agreement with both these points, but they opposed the resolution because it did not propose that a new claim should be made for an immediate increase for day-wage men.

RECORD OUTPUT FIGURES AT EBBW VALE WORKS.—The Ebbw Vale works of Richard Thomas and Baldwins Ltd., achieved a record with an output of 11,490 tons of steel ingots in the normal working week ending mid-day on January 10. This exceeded by 260 tons the previous record achieved in October last.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, January 19, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Parallel Running of Private Generating Plant with the Grid System," opened by Mr. E. R. Wilkinson. *Mersey and North Wales Centre*: Monday, January 19, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Voltage Transformers and Current Transformers Associated with Switchgear," by Mr. W. Gray and Mr. A. Wright. *Measurements Section*: Tuesday, January 20, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Measurements of Magnetic Permeability," opened by Dr. A. J. King. *London Students' Section*: Tuesday, January 20, 7 p.m., Public Library, Chelmsford. "Stage Lighting and Electrical Equipment," by Mr. J. P. Crawley. *Education Discussion Circle*: Wednesday, January 21, 6 p.m., Victoria-embankment, W.C.2. Discussion on "Difficulties in the Teaching of Electrical and Mechanical Resonance," opened by Mr. C. T. Baldwin and Mr. J. C. Oakden. *Southern Centre*: Wednesday, January 21, 6.30 p.m., The University, Southampton. "Post-Graduate Activities in Electrical Engineering," by Mr. W. J. Gibbs and others. *Utilization Section*: Thursday, January 22, 5.30 p.m., Victoria-embankment, W.C.2. (i) "Hydrogen-Cooled Alternators," by Mr. T. O. Jones; (ii) "Evolution of Electromagnetic Machines," by Mr. G. Campbell; and (iii) "Electronic Control of Electrical Machines," by Mr. N. G. Meadows.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Eastern Branch*: Monday, January 19, 6.30 p.m., Cleveland Scientific and Technical Institute, Corporation-road, Middlesbrough. "Control and Recovery of Dust and Fume in Industry," by Mr. R. Ashman. *North-Western Branch*: Thursday, January 22, 6.45 p.m., Engineers' Club, Manchester. Annual Meeting. "The Synthesis of Two Marine Water-Tube Boilers," by Cmdr. (E) L. Baker. *Western Branch*: Thursday, January 22, 7 p.m., Grand Hotel, Broad-street, Bristol. Annual Meeting. Chairman's Address, by Professor J. L. M. Morrison. *Scottish Branch*: Thursday, January 22, 7.30 p.m., Royal Technical College, Glasgow. Thomas Lowe Gray Lecture on "Welding in Marine Engineering," by Mr. H. N. Pemberton. *Institution*: Friday, January 23, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting with *Industrial Administration and Engineering Production Group*. "Design of Precision Grinding Machines," by Mr. G. H. Asbridge. **AUTOMOBILE DIVISION.**—*Scottish Centre*: Monday, January 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Wider Use of Small Diesel Engines," by Mr. J. H. Pitchford. *North-Western Centre*: Wednesday, January 21, 7.15 p.m., The University, Liverpool. "Research and the Engineering Process, Especially in the Automobile Industry," by Dr. H. E. Merritt.

INSTITUTION OF THE RUBBER INDUSTRY.—*Merseyside Section*: Monday, January 19, 7 p.m., Electricity Showrooms, Whitechapel, Liverpool. "Selling in the Rubber Industry," by Mr. G. Carr.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section*: Monday, January 19, 7 p.m., College of Art, Green-lane, Derby. "Mechanical Handling," by Mr. J. Carruthers and Mr. R. M. Williams. *North-Eastern Section*: Monday, January 19, 7 p.m., Neville Hall, Newcastle-upon-Tyne. "Drop Stamping," by Mr. A. Chilton. *Southern Section*: Tuesday, January 20, 7 p.m., Municipal College, Portsmouth. "The Twin Centaurus Power Plant for the Brabazon," by Mr. J. L. Norton. *Coventry Section*: Tuesday, January 20, 7 p.m., Geisha Café, Coventry. "Application of Hydraulics to Profile Milling Machines," by Mr. S. C. Fenton. *Birmingham Section*: Wednesday, January 21, 7 p.m., James Watt Memorial Institute, Birmingham. "The Human Factor in Industry," by Mr. J. Munro-Fraser. *Western Section*: Wednesday, January 21, 7.15 p.m., Grand Hotel, Broad-street, Bristol. "Training of Supervisors," by Mr. J. R. Armstrong. *London Section*: Thursday, January 22, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "Developments in Metal Finishing," by Mr. K. J. B. Wolfe.

INCORPORATED PLANT ENGINEERS.—*Liverpool and North Wales Branch*: Monday, January 19, 7.15 p.m., Radiant House, Bold-street, Liverpool. Open Discussion. *Glasgow Branch*: Tuesday, January 20, 7 p.m., 351, Sauchiehall-street, Glasgow. "Insulation of Buildings," by Mr. A. G. Sutton. *Kent Branch*: Wednesday, January 21, 7 p.m., Bull Hotel, Rochester. "Free-Piston Engines," by Mr. P. R. Watson. *Western Branch*: Wednesday, January 21, 7.15 p.m., Grand Hotel, Broad-street, Bristol. "The Approach to Maintenance," by Mr. Colin Troup. *West and East Yorkshire Branch*: Thursday, January 22, 7.30 p.m., The University, Leeds. "Can There be a National Fuel Policy," by Mr. Oliver Lyle.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Monday, January 19, 7.30 p.m., The University, Sheffield. "Application of the Diesel Engine and the Gas Turbine to Traction," by Mr. G. H. Fletcher.

CHEMICAL ENGINEERING GROUP.—Tuesday, January 20, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "New Treatment Plant of the Colne Valley Sewerage Board," by Mr. J. Griffiths.

INSTITUTE OF REFRIGERATION.—Tuesday, January 20, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Freezing, Chilling and Cold Storage of Meat," by Dr. E. C. Bate-Smith and Mr. Putnam Eaton.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 20, 5.30 p.m., Great George-street, S.W.1. "The Claerwen Dam," by Mr. H. D. Morgan, Mr. P. A. Scott, Mr. J. C. Walton and Mr. R. H. Falkiner. *Midlands Association*: Friday, January 23, 6 p.m., James Watt Memorial Institute, Birmingham. Joint Meeting with **INSTITUTION OF STRUCTURAL ENGINEERS (Midland Counties Branch)**. "Shell Concrete Construction in England and Wales," by Dr. K. Hajnal-Konyi. *Yorkshire Association*: Friday, January 23, 7 p.m., Great Northern Hotel, Leeds. "The Acorn-Naburn Sewerage Scheme, York," by Mr. C. J. Minter.

INSTITUTE OF FUEL.—*Midland Section*: Tuesday, January 20, 6 p.m., James Watt Memorial Institute, Birmingham. "Economies in Furnace Operation," by Mr. A. H. Pinder. *North-Western Section*: Wednesday, January 21, 6 p.m., 9, The Temple, Dale-street, Liverpool. Joint Meeting with **LIVERPOOL ENGINEERING SOCIETY**. "Combined Heat and Power Supplies," by Mr. E. J. Evans.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group*: Tuesday, January 20, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, W.1. "The Electrochemical Behaviour of Metals and Corrosion," by Dr. M. Pourbaix.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*North-East Coast Branch*: Tuesday, January 20, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne. "Corrosion in Boilers," by Mr. J. C. Stainton.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, January 20, 6.30 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Role of Electricity in a Large Modern Steelworks," by Sir Henry Clay.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, January 20, 7 p.m., Grand Hotel, Sheffield. Annual Meeting. Presidential Address, by Mr. H. Hicks.

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Anglian Section*: Tuesday, January 20, 7 p.m., Public Library, Ipswich. Film Evening. *East Midlands Branch*: Wednesday, January 21, 6 p.m., College of Arts, Derby. "Study of Casting Defects," by Mr. G. W. Nicholls and Mr. D. T. Kershaw. *Bristol Branch*: Saturday, January 24, 3 p.m., Grand Hotel, Broad-street, Bristol. "Mechanical Aids in the Foundry," by Mr. J. Blakiston.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS.—Wednesday, January 21, 2.15 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. "Milking Machines," by Mr. H. S. Hall.

ROYAL STATISTICAL SOCIETY.—*Research Section*: Wednesday, January 21, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Statistical Inference," by Mr. D. V. Lindley.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch*: Wednesday, January 21, 6.30 p.m., Mackworth Hotel, Swansea. Junior Members' Evening. *Yorkshire Branch*: Wednesday, January 21, 6.30 p.m., The University, Leeds. "Design of Prestressed Concrete," by Mr. D. H. Lee. *Institution*: Thursday, January 22, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Electricity Generating Stations," by Mr. B. A. E. Hiley.

INSTITUTE OF MARINE ENGINEERS.—Wednesday, January 21, 7 p.m., Swansea Technical College, Swansea. "Construction of Marine Boilers," by Lieut.-Comdr. (E) A. P. Monk. Thursday, January 22, 2.30 p.m., Kingston Technical College, Kingston. "Construction of Steam Turbines," by Mr. J. Brown.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-West Centre*: Wednesday, January 21, 7.30 p.m., Victoria Hotel, Wigan. "Rear Axles," by Mr. R. H. Wilson. *Institution*: Thursday, January 22, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Maintenance of a Large Fleet," by Mr. J. W. Tayler.

INSTITUTE OF WELDING.—*North London Branch*: Thursday, January 22, 7.30 p.m., Polytechnic, Regent-street, W.1. "Joining of Aluminium and Its Alloys," by Mr. W. V. Binstead.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, January 23, 6.45 p.m., Engineers' Club, Manchester. "Production of Modern Design Cars," by Mr. E. W. Hancock.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 23, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Cathodic Protection," by Mr. W. G. Waite.

PERSONAL.

SIR EDWARD APPLETON, G.B.E., F.R.S., D.Sc., Hon.M.I.C.E., Principal and Vice-Chancellor of the University of Edinburgh, was inducted as the 114th President of the British Association for the Advancement of Science at Burlington House, London, W.1, on January 2.

SIR ERNEST CANNING has relinquished the position of joint managing director of W. Canning & Co. Ltd., Great Hampton-street, Birmingham, 18, but retains the chairmanship of the board.

MR. H. H. BURTON, C.B.E., F.I.M., chief metallurgist and a director of the English Steel Corporation Ltd., is to have the honorary degree of Doctor of Metallurgy conferred upon him at a special degree congregation to be held at the University of Sheffield on June 26.

The Power-Gas Corporation Ltd., and Ashmore, Benson, Pease & Co., Parkfield Works, Stockton-on-Tees, announce that **MR. C. E. WRANGHAM, C.B.E., B.A. (Cantab.),** has been appointed a director of the main board of the Power-Gas Corporation; **MR. CHARLES INGMAN** has been made a director of the technical and contracting division of the companies; **MR. T. K. HARGREAVES, D.S.O., M.A., A.M.I.Mech.E.,** the works manager, has been appointed a director of the works division of the companies; **MR. C. ROBSON,** a director and secretary of both companies, has been appointed commercial director, and that **MR. LAURENCE DAVIS, F.C.I.S.,** is succeeding Mr. Robson as secretary.

MR. W. J. MURRAY has retired from the position of chairman of Sharples Centrifuges Ltd., Tower House, Woodchester, Stroud, Gloucestershire, but retains his seat on the board. **MR. A. H. KEABLE, M.I.Mech.E., M.I.Chem.E.,** managing director, is to be chairman. **MR. G. P. BALFOUR, B.Sc., A.C.G.I., A.M.I.Chem.E.,** is to succeed Mr. Keable, and **MR. G. J. KEADY,** President of the Sharples Corporation, Philadelphia, U.S.A., has also joined the board of the British company.

MR. G. W. BONE, M.A. (Cantab.), works director of Davey, Paxman & Co., Ltd., Colchester, was appointed assistant managing director of the company on January 1.

MR. C. A. PACKER, M.B.E., who has been responsible for the training of apprentices at the works of G. and J. Weir Ltd., Cathcart, Glasgow, S.4, for more than 30 years, retired on December 31, 1952.

MR. R. B. SIMS, B.Sc., A.M.I.Mech.E., A.Inst.P., head of the Rolling Laboratory of the British Iron and Steel Research Association since 1948, has relinquished that appointment to take up the new post of research manager of the Davy and United Engineering Co. Ltd., Sheffield. He will, however, also act, for an agreed period, as consultant to the Rolling Laboratory.

MR. HUGH O. BOURNE has retired from the position of managing director of Maiden & Co. Ltd., Hyde, Cheshire, after 42 years of service with the company, but remains a director and will continue in an advisory capacity. **MR. G. BARRIE TINKER** has been appointed general manager.

MR. GEOFFREY WOODS has been appointed honorary secretary-treasurer of the Fan Manufacturers' Association, Copthall House, Copthall-avenue, London, E.C.2.

MR. J. H. HUTCHINSON, A.M.I.Mech.E., A.M.C.T., A.C.T. (Birm.) has been appointed project engineer to the Hymatic Engineering Co. Ltd., Redditch, Worcestershire, in succession to **MR. A. H. A. BASTABLE,** who has left the company.

MR. J. STEWART ROBERTSON has been appointed assistant general manager of Babcock and Wilcox Ltd., who also announce that, following the integration of the trading activities of the Stirling Boiler Co. Ltd., **MR. S. J. WHYBROW** has been appointed manager, Commonwealth sales department, of Babcock and Wilcox, Ltd.

MR. HOWARD BARON, secretary of Kayser, Ellison & Co. Ltd., Carlisle Steel Works, Sheffield, has been elected a director.

MR. J. D. LLOYD, general sales manager, Mavor and Coulson, Ltd., Bridgeton, Glasgow, S.E., has been elected to the board of directors.

MR. ANDREW BLUTH, general manager, William Mills Ltd., aluminium-alloy foundries, Friar Park-road, Wednesbury, Staffordshire, has been appointed a director as from January 1.

MR. W. E. S. TOOMEY joined the staff of the Howard Pneumatic Engineering Co. Ltd., Fort-road, Eastbourne, Sussex, on January 1. His successor in his previous post with Cannon (Holdings) Ltd., is **MR. B. H. MOORE.**

MR. A. M. HUTCHESON, A.M.I.Mech.E., has been appointed a director of Thompson Brothers (Bilston) Ltd.

THE NEEPSSEND STEEL AND TOOL CORPORATION LTD., Neepsend, Sheffield, 3, have acquired the firm of **DENTON AND BEST AND SAMUEL SWIFT LTD.,** Birley Meadows, Sheffield, 6.

WELDING IN MARINE ENGINEERING.

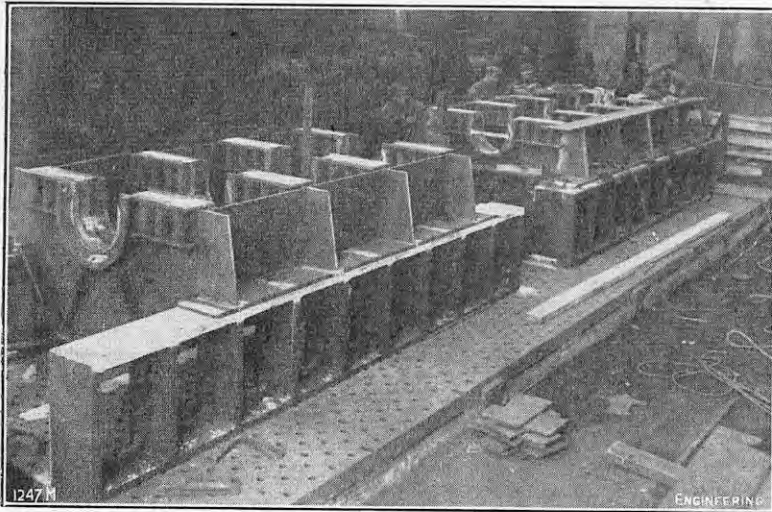
(For Description, see Page 73.)

FIG. 13. SECTIONS OF FABRICATED BEDPLATE.

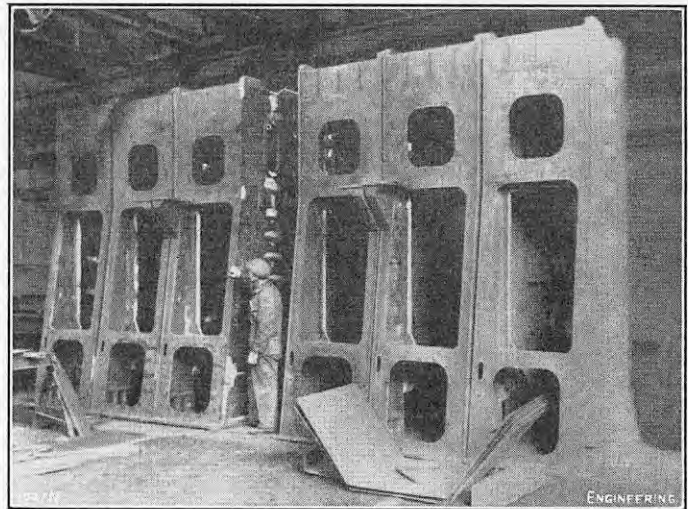


FIG. 14. COLUMN AND ENTABLATURE SECTIONS.

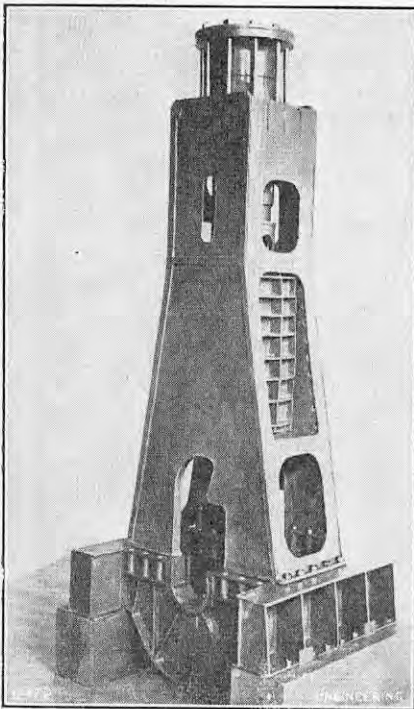


FIG. 15. MODEL OF CYLINDER UNIT.

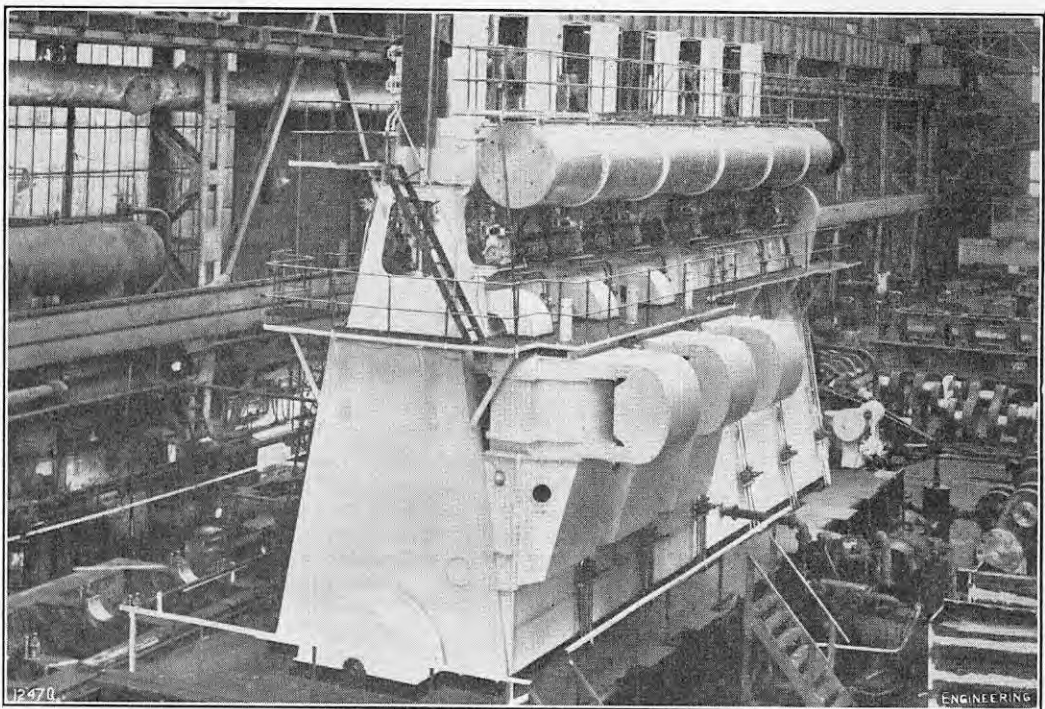


FIG. 16. WELDED DOXFORD ENGINE ON TEST-BED.

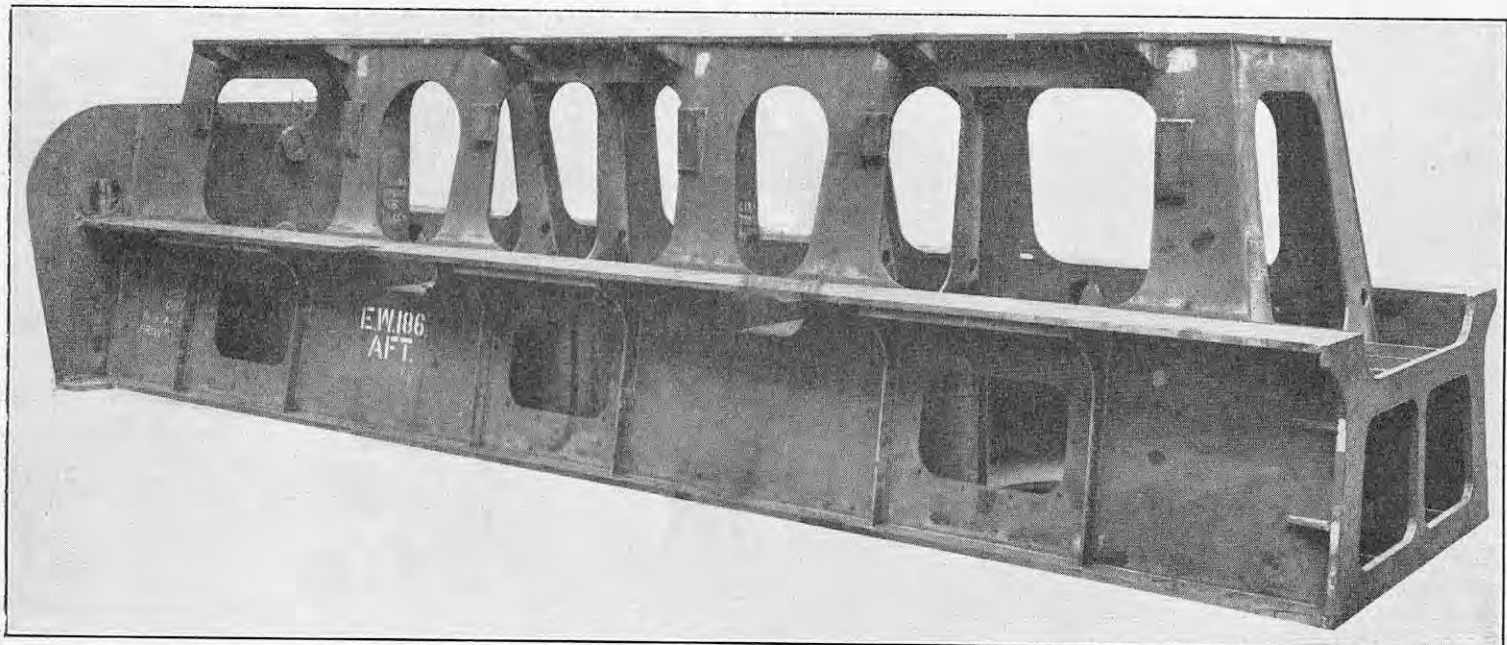


FIG. 17. HALF-SECTION OF ENTABLATURE FOR DOXFORD ENGINE.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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

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ENGINEERING, LESQUARE, LONDON.

Telephone Numbers :

TEMPLE BAR 3663 and 3664.

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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 can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns $2\frac{1}{2}$ 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 ; $12\frac{1}{2}$ per cent. for thirteen ; 25 per cent. for twenty-six ; and $33\frac{1}{3}$ 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 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

CONTENTS.

	PAGE
The Propagation of Fractures in Mild-Steel Plates (Illus.)	65
The Engineering Outlook.—I (Illus.)	70
Surface-Finish Projector (Illus.)	72
Welding in Marine Engineering (Illus.)	73
Anti-Vibration Nut (Illus.)	77
The Royal Technical College, Glasgow	77
Notes from the Industrial Centres	78
Notices of Meetings	79
Personal	79
American Engineering Literature	81
British Electrical Equipment and Canadian Standards	82
Notes	83
Obituary.—Sir James Weir French	83
Letters to the Editor.—Extended Surfaces for Heat Exchangers. Vector Method of Solving Vibration Problems	84
Nuclear Reactors and their Applications	84
Maintenance of Locomotives on British Railways	85
Aluminium Silo for Grain (Illus.)	86
Printed and "Potted" Electronic Circuits	86
Diesel-Mechanical Locomotives for Denmark (Illus.)	87
British Standard Specifications	88
Labour Notes	88
Aircraft Maintenance Dock of Unit Construction (Illus.)	89
5-MVA High Rupturing-Capacity Miniature Circuit-Breakers	89
Ultrasonic Equipment for Locating Whales (Illus.)	90
Early Development of the Centrifugal Pump	91
Portable Load-Measuring Set (Illus.)	93
Chalk Crushing and Screening Plant (Illus.)	94
Launches and Trial Trips	95
Books Received	96
275-kV Transmission Tower (Illus.)	96
Trade Publications	96
Contracts	96

ENGINEERING

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AMERICAN ENGINEERING LITERATURE.

It was in 1866 that Johann Gregor Mendel propounded his theory of heredity which constituted a fundamental advance in biological science and has proved of great economic importance in plant and animal breeding. Mendel's conclusions, which were based on what would now be described as an extensive and careful research, were ignored in his lifetime and it was not until 1902 that they were brought to the notice of the scientific world by the late Professor William Bateson. This example from a sphere alien to engineering shows that it is possible for knowledge of an important scientific advance to be lost for many years and raises the question whether or not a basic step in the physical sciences might be overlooked in the same way. In these days, when the mass of scientific publications has grown to its present dimensions, such an event seems unlikely, but it is none the less possible that the mere bulk of material available is such that parts of it may be ignored ; the mass has become almost unmanageable.

Dr. Sanford Larkey, of Johns Hopkins University, has said that "each year approximately one million articles of interest in the field of medicine appear in some 50,000 journals. Of these, only about half find their way into the conventional abstracting and indexing services and the remainder are, in effect, lost." This remark was quoted by Dr. Vernon D. Tate, Director of Libraries of the Massachusetts Institute of Technology, in a paper read at the 1952 annual meeting of the American Society for Engineering Education. The Engineering School Libraries Committee of the Society arranged for four papers dealing with "The Present State of Engineering Literature" to be read at the meeting ; Dr. Tate's contribution was one of these. His conclusions about "the present state" were gloomy. After dealing with some of the difficulties of publishers and librarians, he summed up by saying that, "unless the full efforts of those who

create, publish, store and make available and finally use the documentation of the field are concentrated on the control of the many problems . . . the entire mechanism of research and progress in the field will gradually grind to a shattering stop, or proceed at the dead slow level of mediocrity."

It may be assumed that Dr. Tate, in common with most other librarians, is faced with material difficulties in connection with storage space, but he does not dwell on this matter. His remarks about engineering literature, however, bear on the subject. He states that there is an over-abundance of library material and a good deal of it is "froth and repetition." The engineering profession is seriously embarrassed by its mass, and "we have as yet devised no successful way to separate the froth from the substance." This is presumably one of the reasons he would assign for progress grinding to a "shattering stop." Others appear to be economic. In connection with periodicals which, particularly in the engineering field, constitute the main agency for the publication of new material, he avers that the majority are "not in good shape" because of increasing printing costs and the decrease in the number of subscribers consequent from the increase in subscription rates.

Apparently, Dr. Tate's concern was not with the finances of publishing houses, but with the fact that present economic difficulties prevent periodicals from keeping abreast of the mass of contributions which they wish to publish. He stated that the arrears of articles approved for publication "ranged from three months to three years"; and that, while difficulties in obtaining publication in recognised journals had led to the issue of independent monographs, that course only added to the mass of material with which researchers had to deal. Furthermore, if a communication does not appear in accepted sources it may be overlooked. The only praise which Dr. Tate bestowed in his highly-critical paper was given to *Chemical Abstracts*, prepared by the American Chemical Society. The implication presumably was that they should be copied in the engineering sphere ; but there are plenty of engineering abstracts. The type of abstract journal dealing only with a selected sphere is the most useful ; there are some excellent British examples.

The economic difficulties with which publishers of periodicals are faced bear equally on book publishers, as was pointed out in each of the three other papers read at the meeting. Dr. James K. Finch, Dean Emeritus of the School of Engineering, Columbia University, however, raised the matter in a somewhat different form from that of other speakers. His complaint about "the present state of engineering literature" was that it ignored the human element. There were three major types of engineering book—the handbook, the theory book and the descriptive book. The latter, which was, in effect, a case history, had disappeared from modern publishing. In saying this, he had in mind such notable treatises as Smeaton's *Narrative of the Construction of the Edystone Lighthouse*, and Smile's *Lives of the Engineers*. His point was that the "cold-blooded theory book" ignored an essential factor in life and tended to encourage the production in the engineering schools of "half-baked pseudo-scientists," who failed to comprehend the basic requirements of their profession. Apart from the matter of costs, publishers were not to be blamed for not producing expensive works of this type as "there is no market for them to-day." It appears that the criticism implicit throughout Dr. Finch's paper should be directed to those who control American engineering and general education.

The other two papers were read by Mr. Samuel A. Miles, technical editor of the Hagstrom Company, New York, and Mr. Edward P. Hamilton, president of John Wiley and Sons. Both authors referred to the quality of technical writing. Mr. Miles said

that, as far as he knew, "no engineering school in the country offers any courses in training engineering literature specialists." He explained that his business was the preparation and editing of technical instruction manuals, but that he found, when approaching a specialist in some scientific field to write a treatise, that "he can't spell, and in constructing sentences and paragraphs he makes his own grammar rules." The final result is satisfactory, as the illiterate specialist is supervised and assisted by a skilled writer. It would clearly be more satisfactory if the technical specialist could express himself properly, but the extra expense and difficulty caused by this necessity for detailed supervision is not to be charged against engineering literature as such; again it is due to defects in the educational system.

Mr. Hamilton was not so severe, although he stated that the insistent problem was to "find the author with technical competence who is also a good expositor." He thought that "many of the older writers possessed a fluent and facile style of writing which is sometimes wanting in present-day books." It is not impossible, but is hardly likely, that the scientific treatise which will endure and become a classic will be produced by the supervised type of authorship described by Mr. Miles; something of the quality of Mr. Hamilton's "older writers" is necessary. By far the greater number of engineering books which are produced make no pretension to fall within the class of enduring treatises. Most, probably, are text-books. It is in every way desirable that these should be well written, but in general they do not contain new material.

On the whole, the papers were not complimentary to modern American engineering literature, but there are many valuable and important engineering books published in the United States, as frequent reviews in these columns testify. No doubt, only selected works reach this country and American engineers and students may be embarrassed by a flood of publications of which only the upper waters reach Great Britain. Those who produce and use American engineering literature appear to be faced by two main problems—the cost of printing and the superabundant mass. Both Mr. Hamilton and Mr. Curtis G. Benjamin, President of the McGraw-Hill Book Company, who spoke in the discussion, had something to say about costs. Mr. Hamilton said that a survey made by the American Textbook Publishers Institute showed that between 1939 and 1950 college text-books had increased in price by 62 per cent. and school books by 82 per cent. These figures should possibly now be increased by another rise of 10 per cent. Everything possible was being done to keep prices down but he could not promise any immediate decrease as a result of new production processes. Paper covers, which are familiar in France, would result in a saving of only ten or fifteen cents a copy. Mr. Benjamin also referred to alternative methods of production, but stated that publishers who had experimented with them found them more costly than monotype. He did not favour any arbitrary methods of limiting the number of books published or attempting to "separate the froth from the substance." Quality would suffer if the quantity was arbitrarily, rather than naturally, restricted. Although limitation of the number of books was not given as one of the specific duties of the "Technical Information Laboratories" suggested by Mr. Miles, they would apparently have much influence in the publication field. They would be under the direction of full-time staffs of scientists and engineers and among other duties would "develop on a systematic basis new methods of creating, producing . . . and distributing technical information." These bodies would apparently not contribute to the mass of technical information, but in handling it they would have much influence on what was used and what was ignored.

BRITISH ELECTRICAL EQUIPMENT AND CANADIAN STANDARDS.

Just over three years ago, the British Government altered the sterling-dollar exchange rate from 4·03 to 2·8 dols. to the pound, thus taking a step which, at the time, was accurately described as both a challenge to, and an opportunity for, the trading community of this country. This challenge was promptly accepted by the engineering industry, and plans were rapidly prepared for increasing the export of goods of all kinds, particularly to the Canadian market, where the openings for profitable business appeared most favourable. It was realised, however, that this would be no easy task in the face of both Dominion and American competition. In the case of the electrical engineering branch, it was clear that an additional and formidable obstacle would have to be overcome, for, to secure an opening in Canada, it was not only necessary that the price should be right; it was also essential that the equipment should satisfy the rigid testing and approval regulations of the Canadian Standards Association. In principle, of course, there can be no objection to rules designed to secure the greatest possible degree of safety in operation; they are a safeguard both to the manufacturer and to the user. The Canadian stipulation that, in addition, the necessary approval could only be obtained after samples and prototypes had been sent to Toronto for testing was, however, a cause of serious delay and expense, not to mention the consequent irritation, which it was obviously desirable to avoid.

Fortunately, this state of things is largely a thing of the past. As the result of a mission to Canada, the British Standards Institution agreed, some time ago, to act as agent of the Approvals Laboratories Division of the Canadian Standards Association, and to set up an organisation in this country through which British manufacturers could obtain approval without having to send their equipment to Canada. Since its establishment, this organisation, known as the B.S.I./C.S.A. Approvals Agency, has successfully performed the useful task of interpreting the procedure and technical requirements of the Canadian Standards Association to more than 2,000 manufacturers. The range of products covered has been very wide and has extended from heavy equipment, such as generators, motors and switchgear, to domestic appliances. Electrically-driven industrial plant, such as machine tools, textile machinery and printing presses, as well as specialised equipment for dental and other medical purposes, have also been dealt with. The Agency have now added to their services by issuing a booklet* dealing with the approvals system, which should receive the close attention of all those desirous of engaging in the Canadian electrical trade.

The approval of the Canadian Standards Association is required for "any equipment, machinery, apparatus, appliance, or material designed for use in or intended to be used in the generation, transformation, distribution, supply or utilisation of electrical energy," which may be installed in buildings, on structures, or in premises. Although the plant of supply concerns as well as railway, mining, aeronautical and marine equipment and certain other categories of apparatus, are specifically excluded, it will be clear that a wide field is covered, and that there is room for plenty of legitimate difference of opinion in deciding upon the design of the products which will reduce fire hazard and the risk of electric shock to reasonable levels. Moreover, the procedure which must be

adopted before approval can be obtained for each individual piece or class of apparatus is not without its obscurities; so much so, in fact, that considerable specialised experience is necessary before the "drill" can be understood.

The first and essential task of the BSI/CSA Approvals Agency was therefore to acquire the necessary knowledge of the Code's ramifications and then to apply that knowledge so that a speedy and efficient service would be available to manufacturers. In addition to its advisory functions, and, of course, testing the actual equipment, the Agency has also undertaken the duty of re-inspecting factories as is required under the protocol of the Canadian Standards Association to ensure continuity of approval. As might be expected, these visits of re-inspection have frequently had the useful result of enabling some manufacturers to extend their ranges of approved products and to secure authorisation for minor changes in types of goods, which had already been approved. Since its establishment, the Agency has dealt with some 450 formal applications and, after the necessary inspection and tests had been made, 300 approvals have been granted. Work on 40 other applications has been completed and these now only await clearance in Canada. It is of some significance, from the point of view of British trade, that, while some of these applications have only covered single appliances, the majority have included complete ranges of equipment, and that much of it has been in the heavier categories.

Progress has also been made in another important direction. In its early days, the Agency was unable to carry out all the work required owing to the large number of applications received, and so many of the smaller items were still sent to the Canadian Standards Association's Approval Laboratories in Toronto. As the experience of the British staff has risen, the amount of equipment dealt with in this way has progressively fallen. This means that both time and money have been saved and that the difficult path from the manufacturer to the user has been smoothed. The present position is, in fact, that direct help from Canada is sought in only a negligible proportion of the cases and before long, it is expected, all test work will be carried out in this country. That such success has been achieved in such a comparatively short time is a tribute to the work of both the British and Canadian officials concerned, and to the close personal contacts that have been maintained continuously between them. Co-operation of this kind is one of the best ways of removing causes of friction, both actual and potential.

Having said so much by way of approval of the remedies that have been adopted to relieve what might easily have been a real obstacle to increased trade with an important Dominion we may, perhaps, comment on a correlated situation which offers opportunities for improvement. Even now electrical manufacture is confined to comparatively few countries in the world, and of the few those with large outputs can probably be numbered on the fingers of one hand. In each of these countries a series of regulations, either compulsory or voluntary, has been prepared to ensure that, to paraphrase the Canadian Code, both fire hazard and the risk of shock in the use of electrical equipment shall be reduced to a reasonable level. A striking feature of these documents is their uniformity; in broad outline, they all employ the same means to attain the desired end. Where they differ is in detail, and sometimes unimportant detail, the amendment of which might well form a subject for international discussion and co-operation. The success that has been achieved in other directions (for example, the unification of British and American screw threads) shows what can be done to smooth out such difficulties when there is the inspiration of a common purpose.

* *The Canadian Standards Association Approvals System.* The British Standards Institution, 24, Gillingham-street, London, S.W.1. [Price 3s. 6d. net]

NOTES.

FIVE YEARS OF "BRITISH RAILWAYS."

BRITISH Railways, in the January issue of their staff magazine, quote some "successful results of the efforts made to achieve increased efficiency and economy" in the first five years since nationalisation. They state that in 1951 the locomotives (1,500 fewer than at the end of 1947), though they ran 10 million more miles than in 1947, consumed 2.58 lb. of coal per mile less, and the total coal consumption decreased by 285,000 tons. The new standard locomotives, carriages and wagons have been designed to permit the maximum availability throughout Great Britain—"a result often dreamed of but never tackled in the old days." The all-steel standard coaches give twice the end-shock resistance of any design previous to unification, and the number of types of wagons has been reduced from 480 to 90 during the five years. New 24½-ton wagons have been produced for coal and iron ore and the number of wagons out of service for repairs has been reduced by half since 1947. In building locomotives, carriages and wagons, it has been possible to use all British Railways workshops on a unified national basis, allocating work for all Regions to the shops best equipped to carry it out; "this has lowered costs by millions of pounds." The new standard track with flat-bottom rails has 16,900 fewer components to the mile than pre-war track and is cheaper in maintenance. There has been a rapid growth in the use of mechanised appliances for permanent-way work and in the last three years 1,000 miles of track have been laid in pre-assembled lengths. Thirty-six motive-power depots and sub-depots have been closed. The article also refers to a number of improvements that have been effected in the operating, stores and other departments.

CONSTRUCTION OF PRESTRESSED CONCRETE TANKS.

The difficulties experienced and the expedients adopted by the contractors were the subject of a paper on "The Construction of Eight Prestressed Concrete Tanks," presented to a joint meeting of the Institution of Structural Engineers and the Reinforced Concrete Association, at the Institution, on Thursday, January 8. In introducing their paper, Colonel A. Raymond Mais, O.B.E., and Mr. A. C. Little, who are associated with Messrs. Trollope and Colls, Limited, showed that it was feasible for a general civil-engineering contractor to undertake the construction of large prestressed concrete structures. The authors, however, stressed the importance of close supervision of labour throughout the duration of the work and of the value of having a higher proportion of leading hands than was usually found on general civil-engineering work. The value of the paper lay in the detail in which the contractor's difficulties were stated and in the completeness with which the expedients adopted, unsuccessful as well as successful, were discussed. The tanks each had a capacity of 430,000 gallons with a liquor height of 33 ft. and an internal diameter of 50 ft.; the floor as well as the walls were prestressed and the Magnel-Blaton system was used. To achieve the designed location of the vertical cables in the centre of the 9-in. thick walls, the scaffolding was erected to the full height of the tanks and all the cables hung in position before any of the concrete was placed. This proved inconvenient, however, and for constructing future tanks the authors advocate building the walls with suitable chases, afterwards placing the cables and grouting the chases. No water-seals were used for either the vertical construction joints or between successive lifts, but the joints were successfully made by scarifying the hardened concrete with a water jet and "buttering" with a rich mortar before placing the new concrete. Immersion vibrators were used throughout the contract to compact the concrete. During the discussion that followed the paper, Professor G. Magnel referred to the difficulty of overcoming the friction when loading the hoop cables encircling the tanks; he advised that less

friction would be encountered if the face of the concrete were left rough rather than if it were smooth. Professor Magnel accounted for this by suggesting that the cables strained more uniformly when they were supported on relatively infrequent high spots than when they were bedded continuously throughout their length.

EUROPEAN IRON AND STEEL PRODUCTION.

The production of steel ingots in European countries outside the U.S.S.R. reached the record total of 73,870,000 metric tons in 1952, exceeding by about 9 per cent. the output for 1951, which stood at 67,639,000 tons. According to the *Quarterly Bulletin of Steel Statistics for Europe*, published by the United Nations Economic Commission for Europe (E.C.E.) in Geneva and obtainable, price 3s. 9d., from H.M. Stationery Office, Kingsway, London, W.C.2, the estimated 1952 total steel production of European countries outside the "iron curtain" was 62,970,000 metric tons, and that of Czechoslovakia, Poland, Eastern Germany, Hungary and Roumania combined, 10,900,000 tons. Last year's production in the United States is given as 84,750,000 tons and that of the U.S.S.R. as 35,000,000 tons. The United Kingdom was the largest producer of the "free" European countries, the estimated total for 1952 being 16,400,000 metric tons; Western Germany was second with 15,800,000 tons, and France third with 10,900,000 tons. A healthy sign for the future of the industry is that pig-iron, iron-ore and coke-oven coke production in industrial European countries outside the Soviet Union have all increased in 1952, as compared with 1951. Thus, the pig-iron output totalled 53 million tons during the first three-quarters of 1952, compared with 49.1 million tons in the corresponding period of 1951, an increase of 8 per cent. Similarly, 76.3 million tons of iron ore were extracted during the first three-quarters of 1952, against 65.8 million tons in the corresponding period of 1951, an increase of 16 per cent. The production of metallurgical coke in ten European countries, for the two corresponding periods, was, respectively, 61 million tons and 55.6 million tons, an increase of 10 per cent. In so far as the United Kingdom is concerned, the increase in the output of pig-iron is given as 9 per cent., in that of iron ore 8 per cent., and in that of coke-oven coke 6 per cent.

METALS ECONOMY ADVISORY COMMITTEE.

The critical shortage of alloying and non-ferrous metals which appeared imminent in the United Kingdom in the middle of 1951 has been averted, although supplies of most metals are still short. Only in the cases of lead and zinc has the shortage entirely disappeared; nickel, cobalt and copper, in particular, still give cause for concern, and supplies of other metals are adequate to meet the present essential needs only on account of the restrictions which are being maintained on their use. Such, in brief, are the conclusions arrived at and published in a report issued by the Metals Economy Advisory Committee. The committee, under the chairmanship of Mr. D. A. Oliver, were appointed in August, 1951, by the Minister of Supply, acting in conjunction with the Lord Privy Seal in his capacity as Minister of Materials. The committee's terms of reference were: "To bring under review . . . ways of economising in the use of scarce metals in the design, specification and the manufacturing process of metal goods for both rearmament and civil purposes, and to advise the Government how it can best assist in promoting such developments." As a result of their deliberations the committee recommend, in the first place, that the Government should emphasise, through its many contacts with industry, the continuing need for making the most economical use of metal supplies by the adoption of the latest and best techniques. The second recommendation is that research establishments and associations should continue to be encouraged to undertake work aimed at the better and more economical use of metals. In the third recommen-

dation, it is pointed out that the Defence Departments should ensure that all concerned with the design and specification of defence material are fully aware of the need for metals economy. The fourth recommendation is that the Government should provide as much information as is practicable to industry, at regular intervals, regarding future supplies of the main metals and possible shortages. Finally, it is urged that the work of the Metals Economy Advisory Committee should continue, and that, in the light of the changing supply and demand position, they should review developments at home and abroad; focus attention on the continuing need for metal economy and make recommendations from time to time.

THE KUWAIT OIL COMPANY.

An exhibition of photographs showing recent developments in the Arab State of Kuwait, and its phenomenally rapid rise since the war to a high place among the oil-producing countries of the world, is now open from 10 a.m. to 4 p.m. daily at the Royal Society of Arts, 6, John Adam-street, London, W.C.2. It should be of particular interest to those who have seen the excellent film, "Desert Harvest," made for the Kuwait Oil Company, and who may wish to study at leisure the scenes that it portrayed. The numerous photographs and illuminated coloured transparencies illustrate not only the local inhabitants and their crafts, but how the oil has been won from this stretch of more or less barren desert, about the size of Wales, lying at the head of the Persian Gulf some 120 miles south of Basra. During the past few years well over half a million tons of equipment, machinery, and materials has been brought into the State; and in 1951 (the most recent year, apparently, for which figures are available) over 28 million tons of crude oil were exported from the Burgan field, one of the largest single fields in the world, where oil was located under high pressure at a depth of approximately 5,000 ft. The photographs show the schools, hospitals and clinics which have been built with the great wealth that has come to Kuwait under its enlightened ruler, His Excellency Sheikh Abdullah as-Salim as-Sabah, K.C.M.G., C.I.E.; and the drilling rigs and ditching machines, pipe lines and jetty, etc. It may be mentioned that the jetty incorporates principles developed during the building of the "Mulberry" harbour, and can accommodate nine of the largest tankers afloat. Nearly 100 million tons of oil have been obtained from the Kuwait field since regular production began in 1947.

OBITUARY.

SIR JAMES WEIR FRENCH.

It is with much regret that we have learned of the death, on January 14, of Sir James Weir French, formerly chairman of Barr and Stroud, Limited, and a prominent figure for many years in Scottish scientific, industrial and educational circles. Sir James, who was in his 77th year, was the son of Andrew Gordon French, well known in his day as a metallurgist, and was educated at Bearsden Academy and at Glasgow University (of which he was a D.Sc.), Glasgow Technical College, and in Berlin, where he made a close study of German instrument-making. On his return, he joined the firm of Barr and Stroud, and, on the death in 1931 of Professor Archibald Barr, and the succession of Professor William Stroud to the chairmanship of the company, became vice-chairman. Seven years later, when Dr. Stroud died, French became chairman, holding that office throughout the recent war. His contributions to the design and production of range-finders, etc., were recognised by the award of a knighthood in 1941. Sir James was a Fellow of the Institute of Physics, of the Physical Society, and of the Society of Glass Technologists, and a member of the Institution of Engineers and Ship-builders in Scotland. He was also a past-president of the Royal Philosophical Society of Glasgow, and, for five years, chairman of the Governors of the Royal Technical College, Glasgow.

LETTERS TO THE EDITOR.

EXTENDED SURFACES FOR HEAT EXCHANGERS.

TO THE EDITOR OF ENGINEERING.

SIR,—We have read with considerable interest the article "Extended Surfaces for Heat Exchangers," on page 745 of the issue of ENGINEERING for December 12, 1952. We were rather surprised, however, to read the remarks on stud welding in the last paragraph and its reference to Fig. 12. Stud welding has been applied to heat-exchange purposes in this country for some years for the same reasons as expressed in the article in question. We feel that Fig. 12 is not entirely accurate in describing a typical stud weld, as it does not show the weld fillet surrounding the fusion zone. The ferrule used in the normal stud-welding process is designed to restrict the dimensions of the weld fillet, but could equally well be designed to form a fillet nearer to the ideal, from the heat-transfer viewpoint.

Typical stud welds were exhibited by the Copper Development Association on their stand at the 1951 British Industries Fair.

Yours faithfully,

Crompton Parkinson, Limited,
Cyc-Arc Stud Welding Division,
A. R. AINSWORTH,
Research and Development.

1-3, Brixton Road,
London, S.W.9.
January 7, 1953.

VECTOR METHOD OF SOLVING VIBRATION PROBLEMS.

TO THE EDITOR OF ENGINEERING.

SIR,—I am pleased to see by Mr. R. E. D. Bishop's letter on page 795 of your issue of December 19, 1952, that my article on vector methods for the solution of vibration problems has evoked some interest in the subject. I fear, however, that readers who may have turned to the two books mentioned by him will have been a little disappointed, if they wished to pursue the subject further, as these books do not contain as much on the subject as there is in my article, e.g., there is no vector treatment of natural damped motion in either of them nor, indeed, is there in any other text-book known to me. Further, to remove any possible misapprehension, I may add that my article owes nothing whatever to these and other comparatively recent books on vibrations which make some limited use of vectors. As stated in the opening paragraph, diagrams of the type described have been in use for a considerable time. To my personal knowledge they were in established use in 1934 by Professor B. P. Haigh at the Royal Naval College, Greenwich, to whom, I believe, their particular form was in no small part due.

My article was not intended to be an exhaustive treatment of vibration problems by vector methods but rather to draw attention to the power and scope of such methods. As I hinted therein, it can be used effectively on a wide variety of problems. I am accordingly interested, though not surprised, that Mr. Bishop and his colleague, Mr. Welbourn, have applied vector methods to the steady state of motion of the dynamic vibration absorber, as shown in their article. I have in my possession a vector solution of this problem, generally similar to the one given, written by a former colleague in 1946. Nevertheless, I look forward with interest to their promised article on crankshaft vibration.

Yours faithfully,

CHAS. H. HELMER.

Engineering Laboratory,
The University,
Southampton.
January 7, 1953.

CONFÉRENCE INTERNATIONALE DES GRANDS RÉSEAUX ÉLECTRIQUES À HAUTE TENSION.—The fifteenth session of the Conférence Internationale des Grands Réseaux Électriques à Haute Tension (C.I.G.R.E.), will be held in Paris from Wednesday, May 12, to Saturday, May 22, 1954.

NUCLEAR REACTORS AND THEIR APPLICATIONS.

A LECTURE on "Nuclear Reactors and their Applications" was delivered by Sir John Cockcroft, C.B.E., F.R.S., at a meeting of the Institution of Electrical Engineers on Thursday, January 8, the President (Colonel B. H. Leeson) being in the chair.

Nuclear reactors, said the lecturer, could be divided into two main classes: thermal reactors, in which the chain reaction was carried on by neutrons from fission; and fast reactors, in which the fission neutrons were slowed down as little as possible before producing further fissions. Intermediate reactors, having characteristics between these two classes, had also been built. In thermal reactors, which were typified by the Harwell B.E.P.O., 40 tons of uranium metal rods, sheathed in aluminium "cans," were distributed in a regular lattice of 8 in. spacing in 800 tons of graphite bricks. The chain reaction started when the critical quantity—about 25 tons—of uranium bars were loaded. In this amount of uranium metal about 100,000 fissions of U 238 were occurring spontaneously every second; and in each fission process about 2.5 neutrons were given out. These neutrons had energies of about 1,000,000 volts, corresponding to speeds of about 10^9 cm. per second. These fast neutrons lost energy by successive collision with the carbon nuclei in the graphite and, after about 200 collisions, reached the energy of the carbon atoms—about $1/40$ electron volts. They were then said to have "thermal energies." As the neutrons were slowed down the chance of producing fission in U 238 decreased to zero, but the chance of producing fission in the light uranium U 235 fluctuated and finally rose very substantially. The critical size of a graphite reactor occurred when each fission releasing 2.56 neutrons was succeeded by at least one more fission. This required that of the 2.56 neutrons released in the first fission at least one survived all the processes leading to neutron waste and produced a further fission.

In the second, or fast, type of reactor no moderator was used and the neutrons from the fission process produced further fissions while they were still moving rapidly. This type of reactor could only develop where the proportion of U 238 in the uranium had been greatly reduced. It consisted of a reacting core of U 235 together with only a few parts of U 238. The fuel rods must be contained in suitable sheaths and a coolant must circulate through the core to remove the heat. Intermediate reactors, in which the neutrons from fission were partially slowed down and produced further fission at energies between the fast and thermal types, could also be built. They were likely to be important for mobile nuclear power plants. Within each class of reactor many variants were possible. For instance, the thermal reactor might use uranium in which the proportion of U 235 was increased. It was then known as an "enriched thermal reactor" in which it was not essential for the uranium to be concentrated in a lattice structure. It might, on the contrary, be distributed fairly uniformly through the moderator and was then known as a homogeneous enriched reactor. Similarly, there were fast reactors with fluid or fluidised fuel elements.

NUCLEAR CHARACTERISTICS.

The most important characteristic of a reactor was its neutron balance. Of the 2.56 neutrons which on the average were emitted in the fission of a U 235 nucleus, one was required to carry on the chain reaction. Of the remainder, a total of 1.45 were either absorbed in U 238 to produce plutonium, in U 235 to produce U 236, in the moderator or in the structural materials. Some 0.09 neutrons escaped from the core and there was a small excess for control and for changes in neutron losses. Reactors tended to change from primary to secondary fuel and the burning time of a charge of fuel would ultimately be limited by the excess reactivity vanishing. For each megawatt-day of thermal energy released by fission about one gram of U 235 was destroyed. If the reaction proceeded until 1,000 megawatt-days had been released for each ton of uranium, about 1 kg. of

U 235 would have been destroyed out of the initial 7 kg., and would have been replaced by about 900 grams of plutonium, some of which would have been "burnt" and in turn partially replaced. Since the fuel cost of reactors would depend increasingly on the burning time of the charge it was important to increase the fuel regeneration as much as possible by reducing or avoiding sources of loss—such as those due to graphite impurities. Canning materials with a low neutron absorption must also be chosen and the amount used must be kept to a minimum consistent with engineering requirements. An ideal reactor would produce more secondary fuel than the primary fuel burnt, thus achieving what had been described as a "breeder reactor." A great part of the U 238 would then be burnt up.

The technical problems of reactors could be divided into four main groups: physical, metallurgical, chemical and engineering. The physicists had to determine the principal parameters of the reacting core from nuclear considerations. The effect of the reactor radiations on the stability of the moderator must be studied by both chemists and physicists. The metallurgist had to provide uranium fuel elements sheathed in a material which would resist corrosion by the coolant and would not absorb too many neutrons. The fuel elements must not distort too much under the influence of thermal cycling and reactor radiation. The engineers had to deal with problems of heat transfer to the coolant, the heating of all the components by radiation, and the problems of safety and construction, taking account of the fact that all materials in the core of the reactors became highly radio-active.

The control of a thermal reactor was effected by the insertion and withdrawal of rods containing boron. It was made possible by the fact that about 1 per cent. of the fission neutrons were emitted at times up to one minute after fission. Provided that the excess of neutrons in the balance sheet was less than 0.01, the time-constant of the control mechanism was adequately long for safe control. Fast reactors could be controlled by altering the geometry of the reflector, and thus changing the proportion of neutrons which escaped. Fast neutron fission produced about the same proportion of delayed neutrons as thermal reactors, so that the time-constants of control were not effectively different. The primary control instruments measured the neutron flux inside the reactor, while measurements were also made of the temperatures of the uranium metal, moderator and coolant. Safety instruments recorded any escape of radio-activity from the fuel elements, due to incipient failures of the uranium sheathing, so that early remedial action could be taken. The permissible operating temperature of reactors depended primarily on the stability of the fuel elements. Secondary factors were the reaction of the moderator with the coolant and, in the heavy water reactor, the effect of temperature on the corrosion rate of the materials in contact with the moderator and coolant.

THE HARWELL AND CHALK RIVER REACTORS.

The graphite-moderated reactor (B.E.P.O.) at Harwell, and the Chalk River heavy-water reactor, were designed to provide facilities for testing components for future units, for research in the fields of atomic energy and nuclear physics and for the production of radio-active isotopes. A high neutron flux in the reacting core was important for all these purposes as it reduced the time required to carry out a particular component test and was advantageous in radio-active isotope production. The neutron flux was proportional to the energy generated per unit mass of uranium. The Harwell reactor developed 150 kW per ton and had a critical thermal neutron flux of 2×10^{12} neutrons per square centimetre per second. The Chalk River pile was water-cooled and had a specific energy generation and neutron flux 20 times higher. Since heavy-water reactors had a much smaller critical size than graphite reactors, they contained less uranium metal. The total power of the pile did not, therefore, have to be increased in proportion to the flux, compared with graphite reactors—an important advantage in research work. This production of radio-active isotopes required not only a high neutron flux, but a surplus of neutrons available for

absorption by the elements which were to be transmuted into radioisotopes. The neutrons available were proportional to the total power of the pile and the excess reactivity allocated for this purpose. The Harwell reactor operated at 6 MW and 0.001 of reactivity was allocated for isotope production. This provided about 6×10^{14} neutrons per second, or about 1/40 gramme of neutrons per annum for isotopes. This was inadequate to meet growing demands and the construction of a new high-intensity heavy-water reactor to meet the future research, development and isotopic requirements of the Harwell project was being considered.

REACTORS FOR POWER PRODUCTION.

The development of reactors for the production of power was now proceeding, with the two-fold objects of providing an additional source at an economic price and of sufficient magnitude to add substantially to the world's fuel reservoir; and of constructing power units for specialised purposes, such as ship propulsion, where low fuel consumption and long endurance were advantageous. The first and easiest step towards the production of useful power would probably be to use improved piles of the same general type as those at Harwell and Chalk River. The heat from the reactor would be used to raise steam by transferring gas under pressure in the case of the graphite reactor and water under pressure in the case of the heavy-water reactor. In both cases a pressure envelope would be required. To obtain reasonable thermodynamic efficiencies the fuel elements in a graphite power reactor ought to operate at a temperature of about 350 to 450 deg. C. This would allow the use of aluminium or magnesium cans and neutron economy would be preserved. With such temperatures, thermodynamic efficiencies of 20 to 25 per cent. would be possible. The power output of a first reactor would be determined largely by the critical size, which set a lower limit to the amount of uranium fuel loaded. Since this was an expensive item, it would pay to have as high a specific rating—megawatts per ton—as could be obtained from heat-transfer considerations. The size of the first experimental power unit was therefore likely to be comparable to that of a British Electricity Authority set. The total volume of plant would not be very different from that of a coal-burning station.

The economics of natural-uranium power reactors would depend largely on the "burning time" of the uranium charge and on the cost per ton of the uranium metal. The heat generated in a nuclear power station developing 50 MW would be equivalent to about 200 MW and, if heat were withdrawn at an average rate of 2 MW per ton, the reactor would require an initial charge of 100 tons, costing 1,500,000£. Assuming that there was about 7 kg. of U235 in each ton of uranium, operation at 2 MW per ton would consume 2 grammes of U235 per ton of metal per day, so that 7 kg. would last 3,500 days. In this case, the initial load of 100 tons, costing 1,500,000£, would lead to a fuel charge of 150,000£. per annum, compared with a coal cost of 750,000£. per annum for a 50-MW steam station. If only one quarter of the U235 was burnt, the burning time would be correspondingly reduced, and the annual fuel costs would be 600,000£. per annum. The burning time might also be limited by the deterioration of the fuel elements, owing to temperature cycling and the intense bombardment of fast neutrons in the reactor. This emphasised the importance of metallurgical development.

As regards capital costs, while the cost of the turbo-generators and transformers would be the same as in a steam station, the boilers and coal-handling equipment would be replaced by the more expensive reactor. As a result, the cost of a first nuclear power station would be double that of a conventional plant. This difference was not, however, important enough to prevent embarkation on its development, especially as no credit had been taken for the value of the residual plutonium, of which from 1.5 to 2 kg. per ton would have been produced by burning one-third of the U235, or 2.3 kg. per ton. A total consumption of 1 ton of uranium per day would, however, burn 2.3 kg. of U235 per day, thus enabling not more than about 5,000 million kilowatt-hours per annum to be

produced, or only 9 per cent. of our present output. As 1 ton of uranium per day was a considerable proportion of the world supplies it was very desirable to increase the efficiency of its utilisation and to aim at burning not one part in 400 of the total, but something much greater than 10 per cent.

In order to burn a greater part of the uranium, the aim must be to increase the number of secondary fuel units produced for each primary fuel atom burnt. To do this, more than one neutron must be used to produce plutonium, and the first step in this direction had been to develop fast-fission reactors for the purpose. The first experimental power-producing fast reactor had in fact been operating for some time in the United States. It consisted of a core, "about the size of a regulation football," made of uranium with a very high proportion of U235 canned in some suitable metal. The heat developed by burning the U235 was removed by circulating liquid sodium-potassium alloy, which left the reactor at a temperature of 350 deg. C. This liquid metal then passed through a heat exchanger and steam was developed to drive a 250-kW power unit.

Reactors of this type for generating large amounts of power would be characterised by a core consisting of fuel elements of plutonium or U235 mixed with U238. Plutonium would be preferable since three neutrons were produced in each fission compared with 2.5 in U235. Surrounding the core would be a blanket of natural uranium or thorium to absorb the escaped neutrons and so to produce more fuel atoms. Heat would be transferred from the core to a heat exchanger by a liquid metal and power generation would follow on conventional lines. The burning time of the fuel would again depend on changes in reactivity and the aim would be to make this as long as possible by breeding new fuel in the core as well as in the blanket. When the excess reactivity was dissipated, the core would be withdrawn for the removal of the fission products and the adjustment of the primary fuel content. The blanket would require chemical processing at different intervals. The development of reactors of this type would depend on the discovery of fuel elements which would withstand high temperatures, intense neutron bombardment and corrosion by the liquid-metal coolant. Another major problem was the preparation of a safe design, since the high power rating per unit mass of core, together with the intense heating due to the fission products after shut down, would mean that a complete failure of coolant would lead to melting.

The application of reactors to ship propulsion was severely limited by questions of weight and space. It was obvious, for instance, that a graphite-moderated reactor to develop 10,000 h.p. would be impossibly large and heavy, as the B.E.P.O. shield weighed about 5,000 tons. Heavy-water reactors were more compact, but it seemed unlikely that natural-uranium reactors developing such power could weigh less than 1,000 tons. It would, therefore, appear essential to use enriched uranium for fuelling such reactors and thus to reduce the size of the core to values determined mainly by heat-transfer considerations.

NUCLEAR POWER AND WORLD RESOURCES.

A recent American survey of the world's fuel reserves indicated that these amounted in the case of coal to 33 Q, and in the case of oil to 5.6 Q, where Q was 10^{18} B.Th.U. The present annual output of energy was equal to 0.2 Q, an ever-increasing proportion of which was provided by oil. If the figures for oil were proportionately correct, by the end of the century a good deal of liquid fuel would have to be obtained from coal, with a 50-per cent. loss in thermal value. The same report estimated that about 25 million tons of uranium were available at a price of 100 dols. per pound in the ore. If breeding and 100 per cent. utilisation of uranium were achieved, this would add 1,700 Q to the world reserves. If users were prepared to pay only 50 dols. per pound the available reserves would be 250 Q. Even at the higher figures, the primary fuel cost would be negligible if breeding were successful, since the needs of the United Kingdom could be met by 10 to 50 tons of uranium per annum at a primary fuel cost of less than 10 million dols.

In conclusion, Sir John said that it now seemed

fairly certain that large-scale nuclear power stations of the natural-uranium type could be built, and that they would produce power at a cost not much greater than existing stations. It had also been demonstrated that low-power fast-fission reactors could be built to generate power. The development of the full-scale breeder was more difficult to predict until more experience was available.

MAINTENANCE OF LOCOMOTIVES ON BRITISH RAILWAYS.

As a result of some adverse comment, by a Ministry of Transport inspecting officer of railways, on the standard of locomotive maintenance on British Railways, the Railway Executive have issued a statement which "sets out the facts which will enable an accurate judgment to be formed on the matter." The inspecting officer's report was summarised in *ENGINEERING*, on page 9 of the issue of January 2, and the Executive's statement, slightly abridged, is given below.

The maintenance of locomotives on British Railways is carried out by periodical overhaul in the main workshops and day-to-day service at the motive-power depots. In each Region there is a locomotive shopping bureau which decides the locomotives to be brought into the main workshops for periodical repairs, a decision which is made entirely on the physical condition of each locomotive as revealed by regular reports from the motive-power depots. When a locomotive is received at the workshops it is examined to ensure that all parts requiring attention are restored to sound mechanical condition. All work done is subject to careful inspection, both during progress and before the locomotive is returned to traffic. There are 18 main locomotive workshops on British Railways, in which about 10,000 "classified" repairs are carried out each year. Approximately 80 per cent. of the total man-hours expended in these works are devoted to locomotive maintenance, the remaining 20 per cent. being spent on building new locomotives and on the maintenance of plant and equipment. (Owing to a severe limitation of steel allocation the number of new locomotives that it has been possible to build has been severely curtailed.) During the last five years 2,407 locomotives have been put into stock and 3,375 have been withdrawn from traffic.

The day-to-day maintenance at regional motive-power depots is undertaken by an examination and repair system on a period or mileage basis. This system ensures that all moving parts are subjected to examination according to the mileage worked, and that non-moving parts, such as boilers, steam fittings, etc., which are subject to deterioration whether the locomotive is in motion or not, are subjected to examination on a period basis. In addition, all locomotives working main-line passenger or fast freight trains are submitted to a thorough examination by a qualified examining fitter, or other fitter so detailed, once each day. A similar examination is carried out weekly on all other locomotives. In addition, every driver of a locomotive submits, at the termination of his turn of duty, a card indicating whether or not any defects have become apparent while the locomotive has been in his charge. Mechanical failures are reported immediately they occur. A mechanical failure is defined as any incident which causes five minutes delay to a passenger train or 10 minutes to a freight train, attributable to the locomotive. In addition, any incident in which parts of the locomotive are concerned, whether causing delay or not, is reported, e.g., hot bearings.

The number of locomotives has been reduced by 1,776 since British Railways took over in 1948, as shown in Table I. This has been secured by the

TABLE I.—Number of Locomotives.

At End of :	Number.	At End of :	Number.
1938	18,931	1950	19,053
1947	20,445	1951	18,849
1948	19,757	1952	18,669
1949	19,386	(Nov. 22)	

improved availability and power of modern locomotives, which up-to-date design and maintenance methods make possible, and from the progressive improvement in the utilisation of the locomotive stock.

A proportion of the locomotives must always be undergoing repair if the stock is to be kept efficient. The target of availability of the stock for service is 85 per cent., and it will be seen from Table II that the figure is now nearing this target, which could

TABLE II.—Percentage of Locomotives available for Traffic.

At End of :	Per cent.	At End of :	Per cent.
1938	81.7	1950	83.8
1947	80.2	1951	84.1
1948	82.9	1952	Not yet known.
1949	83.1		

not be the case unless there were a thoroughly sound maintenance organisation.

A test of maintenance efficiency is the frequency or otherwise of locomotive casualties. A systemised method of reporting and recording has been introduced under unification and has enabled comparisons between all Regions to be made. It will be seen from the all-line figures given in Table III that the mileage run between locomotive casualties has been nearly doubled in recent years. In fact,

TABLE III.—Locomotive Mileage per Mechanical Casualty.

Year.	Miles.	Miles.	Miles.
1949 (April) ..	15,845	1952 (April)	29,441
1950 (April) ..	19,667	1952 (Nov.)	30,722
1951 (April) ..	27,730		

the figures indicate that, on average, each locomotive in service is subject to rather less than one mechanical failure a year.

The number of staff available for cleaning locomotives to-day is 2,762, which is barely half the number required, and notwithstanding the most constant and strenuous effort to secure the cleaning complement required, the Labour Exchanges have been unable to meet the railway requirements. Before the war, with large numbers of men unemployed, a full complement of cleaners was obtained without difficulty.

CHANNEL FORMED BY EXPLOSIVE CHARGE.—The construction of the new refinery at Coryton for the Vacuum Oil Co., Ltd., has provided an unusual example of the use of explosives. In order to provide an outfall to the sea at low tide and across the intervening foreshore, for the cooling water from the power plant, it was decided that it was necessary to excavate a channel some 6 ft. deep and 200 yards long, as measured from the sea wall bounding the refinery site. The foreshore, however, would have bogged down any normal type of earth-moving equipment, and this presented a problem which was solved by the somewhat unusual expedient of laying charges in groups along the chosen alignment, and detonating them at approximately 10-minute intervals. Tons of mud and slush were thrown into the air and a channel sufficient for the purpose, was formed. It is anticipated that as soon as the discharged cooling water begins to flow (of the order of 15 million gallons daily), the channel will keep itself open and clear.

JET-ENGINE TEST-BEDS FOR BRITISH OVERSEAS AIRWAYS CORPORATION.—Work has commenced at the engine-test site of British Overseas Airways Corporation at Nantgarw, near Cardiff, on the conversion of two piston-engine test cells for testing jet engines with a static thrust of up to 15,000 lb. without reheat. The design and installation of the test equipment, which will incorporate a silencing system, are to be carried out by Heenan and Froude, Ltd., Worcester Engineering Works, Worcester. The building has been redesigned by the Corporation's civil engineering branch. The constructional work is sub-contracted to T. F. Howells, Ltd., Caerphilly. A fire-protection system, manufactured by the Walter Kidde Co., Ltd., Lux Works, Belvue-road, Northolt, Middlesex, is to be installed. As a further precaution against fire, a fan ventilation system is interlocked with the test equipment so that the latter cannot be operated until the fans have been working for a predetermined time, to ensure that any accumulated gases will be extracted. Three 12,000-gallon fuel tanks will be installed.

ALUMINIUM SILO FOR GRAIN.

THE storing of grain presents no difficulties to the farmer who uses a binder, because he can keep his crop "in the rick" and thresh it just before disposal. To the user of a combine-harvester, however, the problem is not so easy, as the large quantities of corn produced at harvest time make storage a necessity until such time as there is a demand for the product. The Ministry of Agriculture and Fisheries, aware of the difficulties of storing corn in sacks, have initiated the development of a small silo which will be relatively inexpensive and yet provide bulk storage for up to 20 tons of grain. Prototype silos have been erected at the National Institute of Agricultural Engineering, at Silsoe, Bedfordshire, where they are undergoing trials under service conditions. A particularly interesting type of silo is one constructed entirely of aluminium by the Northern Aluminium Company, Limited,



Banbury, Oxfordshire. To hold 20 tons, the silo is 10 ft. in diameter and 16 ft. in height, yet it weighs only 3 cwt., which, it is pointed out, makes it easy for three men to erect it without scaffolding or lifting tackle of any kind. The completed silo is seen in the accompanying illustration. The wall is of a special form of corrugated sheet (known as "Mansard" sheet) curved in such a manner that four sheets can be bolted together to form a complete ring. For a 20-ton silo, five such rings are required, but more or fewer can be used.

The roof is composed of 16 triangular panels having overlapping flanges to make them watertight. It is assembled on the ground and then mounted on the first tier or ring, with which it is then raised on four temporary leg supports to enable the segments of the next ring to be attached to it. The process is repeated for each tier; all joints are bolted for ease of assembly, and a standard size of bolt is employed throughout. A door is provided in the roof and an aluminium ladder is fitted inside the silo to permit of the inspection of the structure and its contents. The silo is mounted on a 3-ft. high plinth of brick and concrete and is provided with an outlet chute at the base so that the grain can be discharged into sacks as required.

Among other advantages, it is emphasised that the aluminium silo, in addition to being light, is strong and durable, impervious to vermin and does not require painting, as it will not corrode. Moreover, it does not harbour insect pests or bacteria, or promote mould growths which would damage or contaminate the contents.

PRINTED AND "POTTED" ELECTRONIC CIRCUITS.*

By G. W. A. DUMMER AND D. L. JOHNSTON.

FOUR methods of depositing wiring are being used in Britain to-day: printing and firing on glass plates, using silk-screen stencils; off-set printing processes using colloidal silver pastes; acid-etched copper foil bonded to plastics; and die-stamping. In any printed wiring scheme it is essential that a circuit can be altered easily and, in order to do this, an experimental method of heated die-pressing on plastics has been worked out. In this system, a metal block with a raised pattern is used as the die. Silver powder is spread over a laminated plastic panel and the heated die brought into contact on the surface under pressure. The silver powder that is compressed is bonded to the panel and becomes a dense conducting layer, the surplus powder being brushed off and used again. Strips of steel $\frac{3}{8}$ in. wide and $\frac{1}{16}$ in. deep and in various lengths are used to make up any type of normal circuit and their position can be readily changed. To hold the strips in place on the die, either a magnetic block or semi-cured resin on rayon may be used. To overcome weaknesses at the joints, a bevel of about 0.005 in. is made at the edges of the strips, under which the silver powder is forced. The resulting joint is stronger than the single printed wiring lines. Lines 0.003 in. thick and $\frac{3}{8}$ in. wide, printed on phenolic-resin plastic, can carry currents up to 12 amperes before the base material blisters and lines on ceramic bases currents up to 70 amperes before breakdown. In no case has failure occurred at the bevel joint. After one side of the plastic plate has been hot die-pressed with the wiring lines, holes are punched through it. The plate is then turned over and the components inserted by hand in the correct positions. The base of the plate is next dipped in a solder bath and the component wire ends cropped off.

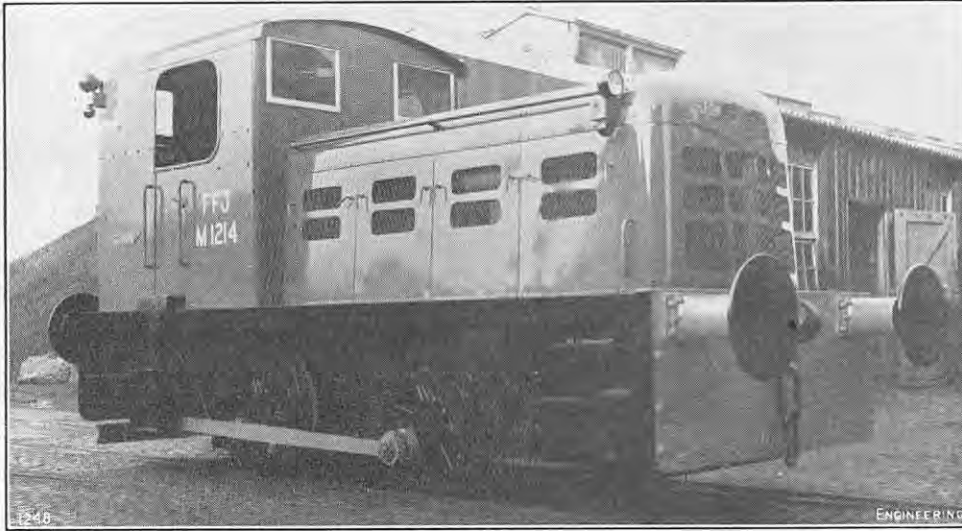
An interesting process is that in which silver wiring, fired on glass plates, is used in the arithmetic circuits of electronic digital computing machines. The plug-in glass panels employed for this purpose are 5 in. long and 3 in. wide and, together with the components, are protected with varnish or sealed in metal covers. The glass plates are jig-drilled with diamond drills in a standard pattern of 72 holes, which are taken as reference points for registering the printing. The initial stage of the wiring process is to coat the inside of the holes through the glass plate with a paste comprising a suspension of finely-divided silver and a lead borosilicate adhesion-promoting agent in a nitro-cellulose solution. After the faces and edges of the plate have been thoroughly cleaned to remove all traces of silver which might produce a stain detrimental to the performance of the finished unit, the circuit design is screen-printed in silver paste. Three separate operations are necessary for this purpose: first, the contacts are printed on the edge of the glass and dried by infra-red radiation; secondly, the design is printed on one of the glass faces and dried; thirdly, the other face is printed and dried. During the subsequent firing operation, which consists in raising the plate slowly to a temperature of 575 deg. C. in an electric muffle furnace, allowing it to remain at that temperature for 20 minutes and then cooling it very slowly to ensure perfect annealing, the organic constituents of the paste are burnt away and the silver is caused to adhere firmly to the glass. Finally, the deposit is burnished with silver sand to improve its soldering qualities and to enhance its appearance.

The resistance of the lines on the plate does not exceed 0.1 ohm, but zig-zag engraving is used to multiply it by a ratio of up to about 100 to 1. The power rating is about 0.5 watt. The engraving is carried out automatically, the head of the machine being switched off directly the correct resistance has been reached. The resistors are protected by a coating of ethoxyline resin. The change in resistance due to varnishing is about ± 2 per cent. and the overall long-term stability is ± 5 per cent., the

* Paper read before the Radio Section of the Institution of Electrical Engineers on Wednesday, January 14, 1953. Abridged.

100 - H.P. DIESEL LOCOMOTIVE.

JOHN FOWLER & CO. (LEEDS), LTD.



power rating being about 1 watt per square centimetre. The capacities used in these units are of ceramic and values up to 0.01 microfarads can be obtained in a high-permittivity titanate tablet 10 mm. by 7.5 mm. by 0.01 in. thick.

Experimental work has also been carried out on a system of deposited resistors using "aspect ratio" techniques. Instead of attempting to place resistors of different values in the correct circuit position on the plate, it may be easier to cover it with an evenly-deposited resistor material, select the correct amount and remove the remainder. In the early stages, considerable difficulty was experienced in making sound electrical connections to the carbon film, but this has been overcome by die-pressing fine silver particles to which a layer of thermosetting varnish has been added under heat and pressure. Further considerable experimental work has been carried out on the preparation of very stable resistors by using thin platinum and gold films fired on to glass plates. Printed circuits have been made employing such resistances and fired on silver lines. It is possible that photographic methods of producing resistors will lend themselves to automatic printing of the resistors in the correct position relative to the printed conductors, the initial resistance being made slightly low and brought up to the correct value by mild acid etching. Such high-stability circuits, using metal-film resistors with printed wiring and high-quality components will be of value where maximum reliability and circuit stability are required. It is also possible by this method to produce potentiometers with no oxide film, so that very slight brush pressure is required. Low-resistance stepless potentiometers are readily made, while stepped potentiometers of values up to 100 kilohms have been produced and can also be printed as part of the circuit.

"POTTED" CIRCUITS.

Circuits "potted" in wax have been known for some time, but the use of plastics for this purpose is comparatively recent. Resins now exist which have most of the required electrical characteristics, for use as casting resins for potting complete circuits. A cast unit has the advantage that each component is protected from mechanical shock, vibration and the effects of humidity and also that no mounting brackets or tag strips are necessary other than two single strips of plastics to hold the components together. The design of a sub-miniature potted unit is considerably simplified when it can be made as a "throw-away" device and the designer can concentrate on the best layout for mass production. The best form of construction is to cast the components in blocks with the valves mounted externally. This has the advantage that the heat from the valve is dissipated directly and does not raise the temperature of the components inside the resin. The division of a

circuit into functional units requires careful consideration if simplicity of construction and maintenance is to be attained. The aim is a number of units designed to require the minimum of inter-connection with valves, and with their coupling components grouped in bricks of similar size. Complex shapes should be avoided and the tubular-insert method of fixing has proved to be the simplest and most convenient.

In radio telemetering equipment where space is at a premium, the utmost "miniaturisation" must be achieved. The components are therefore mounted in a jig assembly with a minimum spacing of $\frac{3}{16}$ in. between the components. Top and bottom mounting plates (usually of Perspex) are drilled to the required pattern and the brass tubular inserts are placed in position to form a rigid box assembly. The components are then degreased and the leads cut to the correct lengths and inserted between the mounting plates. Inter-component connections are next made, bare wires being used for this purpose wherever possible. Where insulated sleeving is necessary, varnished cotton has been found to be compatible with the resin. The jigged components are placed in the mould and the polyester resin is poured over them in the form of syrup, care being taken to avoid trapping air under the plates. Polymerisation should be complete within 3 to 4 hours, after which the block may be withdrawn from the mould. It is proposed to use the pressed silver-dust technique to print the top and bottom plate wiring connections for the jig assembly, extending the top plate to include the wiring for the sub-miniature valves. It is also hoped to use solder dipping to make all the connections before the unit is finally potted.

An experimental radar equipment using potted circuits has been constructed. Its main advantage is that it runs cooler and needs no fans or blower motors, while all the components, except the valve holders, are protected by sealing in potted units. Much use is made of sealed components, such as transformers, chokes, relays and capacitors, which are mounted directly on the flat chassis. The remaining resistors and capacitors are subdivided into circuit functions, potted and connected to the appropriate valves. Casting rubber is used to seal the backs of the multi-way sockets. A unit constructed in this manner, using eleven potted units, has successfully passed pan-climatic tests to the Inter-Service specification.

The stray field associated with flat or printed coils usually limits their diameter to about 1 in. Since it is difficult to etch very large numbers of lines to the inch, the minimum diameter is generally from $\frac{3}{8}$ to $\frac{1}{2}$ in. If the lines are printed 0.03 in. wide with a line/space ratio of unity and an allowance of $\frac{1}{8}$ in. at the centre for connecting the coil to the circuit, the resulting coils will have seven turns. This will limit such coils to the 30 to 100

megacycles wave band. The stacking of a number of coils would extend this range downwards, but dielectric losses in the usual base materials limit employment at very high frequencies. The Q-factor compares unfavourably with that of a normal coil, probably due to "edge effect." This is not necessarily deleterious, as in television receivers and some pulse systems a large band width is required.

Experimental methods of automatic soldering are being explored, since as the units become smaller greater skill is required and the possibility of dry joints is increased. These methods are of two types: those using direct dip soldering and those using masks. Some of the printed circuit schemes are approaching the position where automatic methods can be used to produce some 50 to 70 per cent. of the complete equipment. In any such process it is essential that there should be no possibility of errors in the assembly processes. This means that components produced by the process must be inherently reliable and added components must be tested before assembly.

DIESEL-MECHANICAL LOCOMOTIVES FOR DENMARK.

Two Diesel-mechanical locomotives of 100 brake horse-power have recently been built by Messrs. John Fowler and Company (Leeds), Limited, Hunslet, Leeds, 10, for the Aalborg Private Railway in Denmark. Though the maker's locomotives of this type are usually fitted with McLaren engines, these two have Leyland engines, as specified by the Aalborg Railway because Leyland-engined 'buses are used, and have given satisfactory service, in Denmark. The locomotives, one of which is illustrated above, are of the 0-4-0 type, for the standard (4 ft. 8½ in.) gauge, and have 3-ft. wheels with a 5-ft. 6-in. wheelbase. They each weigh, in full working order, 19½ tons.

The Diesel engine is a Leyland A.U. 600 of the vertical six-cylinder water-cooled type, with compression ignition and direct injection. The bore is 4.8 in. (122 mm.) and the stroke 5.5 in. (139.7 mm.). The power developed at 1,700 r.p.m., intermittent rating, is 110 brake horse-power. Electric starting and wet-sump lubrication by means of a gear pump are employed. At the rear end of the engine is a Leyland friction clutch, servo-operated from the cab by a lightly-loaded pedal. From the clutch the torque is transmitted through a transfer gearbox and flexible coupling to a Fowler four-speed gearbox. Thence it is through reversing bevel gears, spur reduction gears, a jackshaft, fly-cranks and side rods to the wheels. At normal engine revolutions, the travelling speeds are 3, 5, 7.5 and 11 miles an hour, and the corresponding maximum tractive efforts are 10,715, 6,550, 4,100 and 2,720 lb. The speeds are changed manually, and smooth and positive control is ensured by a Fowler synchromesh mechanism for each gear ratio. All other controls—for the Diesel engine, speed, air brake, clutch and sanding—are duplicated so that the driver can work on either side of the cab. A "dead-man" control is arranged so that it also applies the air brake if the maximum permitted rail speed is exceeded.

The plate frames are 1½-in. thick, tied together by substantial cross-stretchers. Westinghouse air-brake and air-operated sanding gear are fitted to both locomotives. The remaining mechanical parts follow the builders' normal practice. The overall length, including buffers, is 21 ft., the height is 10 ft. 9½ in., and the width is 7 ft. 11½ in. The fuel-tank capacity is 70 gallons.

CONFERENCE ON THE DEEP DRAWING OF METALS AND THE CONTINUOUS CASTING OF INGOTS.—The Department of Industrial Metallurgy of the University of Birmingham have arranged to hold their annual two-day conference this year on Monday and Tuesday, March 16 and 17. The subjects to be discussed will be the "Deep Drawing of Metals" on March 16, and the "Continuous Casting of Ingots" on March 17. No fees are payable, but persons attending are required to register. Applications should be addressed to the secretary of the Department, The University, Edgbaston, Birmingham, 15.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Reamers, Countersinks and Counterbores.—A revised edition of Part 2 of B.S. No. 122, which covers reamers, countersinks and counterbores, has been issued. Part 1 of the specification relates to milling cutters, and work on its revision has now been completed. It is hoped, therefore, to publish this shortly. The two parts of the specification were first issued as two sections of one publication in 1920, and subsequent revisions appeared in 1931 and 1938. In the present edition, for the first time, the two sections have been issued as two separate publications. In the newly-issued Part 2, the principle of indicating preferred sizes has been adopted in a number of tables and the compilers hope that this will materially assist in concentrating usage on more restricted ranges of sizes. A section giving the nomenclature of the various component parts and features of reamers is also included, and more specific requirements and recommendations are given throughout the tables on matters of detail, such as back taper and bevel head. [Price of Part 2, 15s., postage included.]

Glossary of Terms relating to the Welding and Cutting of Metals.—A revision of B.S. No. 499, which is a "Glossary of Terms (with Symbols) relating to the Welding and Cutting of Metals," has now been issued. The glossary was first published in 1933 and a first revision was issued in June, 1939. The considerable increase in the application of welding, resulting from the recent war, and the many new techniques developed since 1939 have made the present edition necessary. In view of the magnitude of the subject, it has been decided to divide the glossary into eight main sections, dealing respectively with terms common to most types of welding, to welding with pressure, to fusion welding (welding without pressure), to brazing and bronze welding, to testing, to weld imperfections, and to cutting; a further main section deals with a scheme of symbols for welding. The latter, which is also published separately, represents a considerable advance on that given in an appendix to the 1939 edition. It differs radically from former practice in order to comply with a general move towards achieving greater co-ordination between British, Canadian and American practice, a policy originating at the Ottawa Conference of 1945. The glossary is fully illustrated with sketches and line drawings and many reproductions of radiographs are given in the section on terms relating to weld imperfections. Incidentally, this section has been published separately hitherto as B.S. 499: Part 2. The glossary ends with a fully cross-referenced index of all the terms dealt with. [Price 21s., postage included.]

Code of Practice on Water Supply.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have issued, in final form, Code No. 310 dealing with water supply. It is concerned with water supplies to all types of buildings, either directly from wells, boreholes, rivers and similar natural sources or through the agency of a public water undertaking. The section of the Code relating to design considerations is divided into four parts, dealing, in turn, with the supply, treatment, conveyance and storage of water. Other sections are concerned with work off and on the site, inspection and testing, and maintenance considerations. [Price 6s., postage included.]

Protective Spectacles and Screens for Steelworks Operatives.—A new specification, B.S. No. 1729, covers green protective spectacles and screens for steelworks operatives. An important purpose of the green lenses or screens is to protect the eyes of the wearer against injury from the infra-red and ultra-violet radiation emitted. The spectacles commonly used by persons engaged in steel melting and working have been made of cobalt-blue glass which aids the visual assessment of the temperature. Little protection against infra-red radiation is afforded, however, and, moreover, a melter whose protective spectacles are broken finds it difficult to match them. The three main advantages of the green glass now specified are, firstly, that it protects wearers against harmful infra-red radiation; secondly, the green glasses are more comfortable to wear than the blue glasses on account of the lack of chromatic aberration; and, thirdly, the green glasses can be replaced by a pair from stock without affecting the wearer's judgment of furnace conditions. [Price 2s. 6d., postage included.]

THE INSTITUTION OF METALLURGISTS.—The next examinations for the associateship and licentiate of the Institution of Metallurgists, 4, Grosvenor-gardens, London, S.W.1, will be held from August 24 to September 1.

LABOUR NOTES.

A POOR response has been forthcoming to the voluntary release scheme introduced by the National Dock Labour Board on December 4, 1952, to enable surplus dock employees to find alternative work of a temporary nature. As announced on page 768 of our issue of December 12 last, the scheme provides that dockers leaving the industry may have their names transferred to a "dormant section" of the dock employment register. If their services are required by a local dock Board during the present year, they will have the opportunity of returning to the active section immediately. Those who prefer to remain in other employment, however, will have their names retained on the dormant list. The scheme, which the National Dock Labour Board emphasises is an entirely voluntary one, was brought out in the hope of reducing the excessive labour force available at Britain's docks. It is a temporary measure and the Board intends that it shall end at the beginning of 1955.

The Board announces that, up till January 7, only 235 men had availed themselves of its new arrangements. Of this number, 95 transferred to the dormant section at Liverpool, 62 at London, 30 at Hull, and 20 at Manchester. The remaining 28 were distributed among other ports. The need for some effective scheme to reduce redundancy at the docks is apparent when it is noted that at times last autumn one dock employee in five was idle. During the period between early October and November 22, 1952, there was an average of 16,150 men proving attendance each day for whom no work was available. The average number of disengaged dockers during the eleven months ended November 22 last was approximately 12,000 a day. Owing to increased activity at the ports during the Christmas period and to imports of timber from the Baltic region having begun earlier than usual, the numbers of dockers proving attendance, in excess of requirements, have been as low as 8,000 on some days since the Board's scheme was announced. There have, however, been wide fluctuations, and the average redundancy during the last week or so is estimated to have been around 12,000 daily.

Registered dockers who prove attendance, but for whom there is no work, are entitled to draw "fall back" pay amounting to 4l. 8s. a week and the money required to meet this expense is raised by a levy on the weekly wage bills of dock employers. Although the suspension of recruiting since last April, combined with normal man-power wastage due to deaths and retirements, has reduced the total number of dockers in Britain from its peak level of nearly 80,000 in early 1952, the names of approximately 76,000 men still remain on the national dock register. The Board considers that this total is several thousands more than the country's trade in the near future is likely to justify.

Comments on the need for a drive to increase productivity are contained in the January issue of the official journal of the Amalgamated Engineering Union. The editor states that it is now generally agreed that the only effective way of protecting and improving the national standard of life is to raise the level of productivity and to increase the efficiency of Britain's economic enterprises. It is all to the good, he states, that it is now becoming more uniformly recognised that the problems of productivity and efficiency are not to be solved merely by exhorting operatives to work harder for longer hours without material increases in wages. There are, in fact, far more important issues involved in the planning for greater productivity than that.

Significant developments have recently taken place in this connection. The most important of these, from the trade-union standpoint, the editor states, is the establishment of a new joint council, fully representative of both sides of industry, to take over the work of the United Kingdom section of the Anglo-American Council on Productivity. He recalls that the Anglo-American Council was

formed in the autumn of 1948, on the initiative of Sir Stafford Cripps, to deal with short-term questions of industrial and economic co-operation, and pays tribute to its valuable achievements. The British Productivity Council, on the other hand, which, like its predecessor, is independent of Government control, has been formed on broad lines to deal with long-range problems.

It has been made clear, the editor continues, that the British Productivity Council will seek to develop local as well as national activities and will arrange to hold conferences and meetings for the consideration of productivity problems in all their aspects. Teams of experts will be set to work and, by means of films, publications of various kinds, conferences, and other methods, prolonged efforts will be made to awaken public interest, especially among working people, on the need for the raising of the level of industrial efficiency, and the promotion of maximum productivity at all stages. The new Council will not work in isolation, the editor affirms. Productivity problems are a common concern.

Reference to the negotiations which preceded the recent increases in wage rates for women employed in the engineering industry, is made in the January issue of the *Transport and General Workers' Record*, the official journal of the Transport and General Workers' Union. These negotiations resulted in an increase of 6s. 5d. a week for women aged 18 and over, and in proportionate advances for juveniles. All increases made under the award were applied retrospectively as from November 10 last. The *Record* comments that the unions concerned in the claim endeavoured to secure increases of the same amounts for the women as were granted to male employees in the industry, but that, although the difference between the increase given to adult men and the 6s. 5d. offered by the employers for adult women amounted to only 11d. a week, the employers declined to make any further concession. As the alternative to acceptance of the employers' offer was to embark on arbitration proceedings, with all the delays that this course entailed, and as the need for wage adjustments was urgent, the unions decided, the *Record* states, to accept the offer, which represented the limit that the employers would voluntarily concede.

In the same issue of the *Record*, it is stated that it has been necessary to report a dispute in the metal-finishing industry to the Minister of Labour and National Service. This has arisen owing to the rejection of the wage claim of the T.G.W.U. and other unions for an increase of 4d. an hour. The *Record* states that the employers would apparently be prepared to consider increasing minimum rates for the various grades in the industry, but were not prepared to discuss all-round adjustments. In view of the trouble which the unions had experienced in this connection in the past, they decided to test the whole issue before an independent authority.

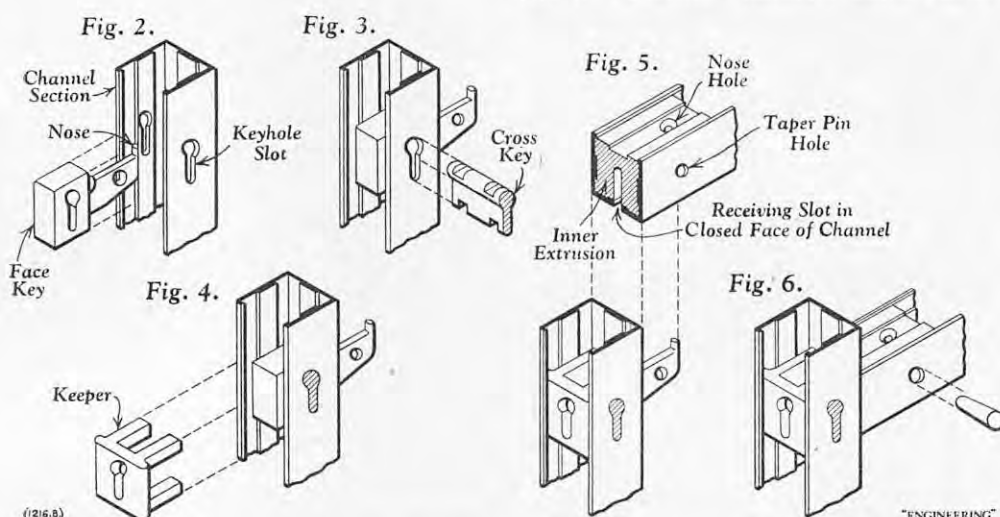
Suggestions that it would be "a good thing" for their union to be responsible for discipline in the works were made by members of the Transport and General Workers' Union at a day school held by the union a short time ago at Salisbury. Various proposals were put forward regarding the best way for the union to operate in such circumstances and it was generally agreed that some form of works committee was the best means, with opportunities to be given to aggrieved parties to appeal against its decisions.

Redundancy notices at the Courthouse Green factory of the British Motor Corporation, at Coventry, will be reduced from 1,000 to 500, as a result of discussions on January 8 between Mr. J. R. Edwards, the production director of the Austin branch of the Corporation, and trade-union officials. It was decided that work on gearboxes should be transferred from Birmingham to Coventry and that the re-conditioning of engines and manufacture of spare parts should continue to be undertaken at Coventry and not transferred to Birmingham, as was at one time suggested.

AIRCRAFT MAINTENANCE DOCK OF UNIT CONSTRUCTION.



FIG. 1. "PIONEER" AIRCRAFT BEING SERVICED.



AIRCRAFT MAINTENANCE DOCK OF UNIT CONSTRUCTION.

To provide convenient working platforms giving easy access for servicing their Pioneer air-liner fleet (converted Douglas Dakota aircraft), British European Airways have recently installed a new maintenance dock at Renfrew airport, in Scotland. The dock, which is shown in Fig. 1, above, was designed by Tiltman Langley Laboratories, Limited, Redhill Aerodrome, Surrey, and consists of eight mobile rostrums, in aluminium-alloy construction, each of which can be wheeled into position by one man. After the rostrum has been so placed, the castoring wheels can be retracted so that the staging rests securely on the ground on its column bases. The eight units comprise one nose rostrum, port and starboard engine rostrums, two wing "fly-overs" which bridge over the wing to form a continuous working platform with the nose rostrum, two under-wing rostrums, and one tail-unit rostrum which can be used on either side of the aircraft.

The engine rostrums are provided with hinged platforms to allow clearance for turning and removing the propeller. Light-alloy grid floors with removable drip trays are fitted immediately below the engines. Access to the undercarriage wheel bays is provided by two light grid-floored stands, with telescopic light-alloy wheel drip covers, spanning the main wheels. These stands can be drawn forward, clear of the wheels, when retraction tests are to be carried out.

The nose rostrum comprises an upper platform fitting around the aircraft nose and a flight of shallow steps leading down below the fuselage nose, giving access to the batteries and radio aeri-als. The wing fly-overs comprise a 14-ft. static platform on which a 14-ft. sliding platform runs on rollers. After the fly-over has been wheeled into position,

the sliding platform is extended to meet the rear edge of the engine rostrum, to which it is connected by short removable flaps. Vertical supports are provided below the extended sliding platform. The under-wing rostrums each consist of four sloping stepped platforms mounted on a rigid structure, giving access to the underside of the wings and the leading and trailing edges. The tail-unit rostrum provides an upper and lower platform, 6 ft. apart, to span the tailplane for access to the rudder hinges and trailing edge, de-icing boot and aerial connections. Apart from the wing fly-overs, which have vertical ladders, all the rostrums are fitted with access stairways.

An adaptable and easily-assembled form of construction is used, which permits the structure to be readily dismantled and re-assembled in a different layout, should it be desired. Each rostrum is constructed from standard members, prefabricated by the Keylock system developed by Robert Building Inventions, Limited, Stover, near Newton Abbot, South Devonshire. The basic elements of the Keylock construction are 1-in. by 1-in. extruded aluminium-alloy beaded and grooved channels, in which key slots are punched at regular centres on all three faces. The channels can be assembled together, in any required configuration, with specially-shaped pressure die-cast keys and locking elements. Figs. 2 to 6 show how a typical joint, in this case the attachment of a horizontal member to a continuous vertical column, is made up. A face key is inserted through the slot in the back face of the vertical channel, and is secured by a cross key, driven through the slots in the channel side faces and the face key, and a "keeper" is sprung past the beads. An inner extrusion, slotted and drilled to receive a taper pin, is inserted in the horizontal member and is located on the protruding tongue of the face key. The joint is then fixed by driving a $\frac{5}{16}$ -in. diameter taper pin through the horizontal channel, the key, and the inner extrusion. The joint can be dismantled

by a simple extractor tool after the taper pin has been driven out by a nail punch.

In the prefabricated units from which the rostrums are built up, four of the standard channels are braced to form open girders, as can be seen in Fig. 1. The cross-section dimension of the vertical columns is 4 in. by 4 in., that of the horizontals either 4 in. wide by 7 in. deep or 4 in. wide by 10 in. deep, and that of the diagonals 4 in. by 4 in. Diagonal bracing has, in fact, been reduced to the minimum to allow personnel to move freely below the staging. The floors of the rostrum are made from aluminium dovetail decking with hardwood-strip inserts, which has good wearing and non-slip properties.

5-MVA HIGH RUPTURING-CAPACITY MINIATURE CIRCUIT-BREAKERS.

THE Atlas high-rupturing capacity miniature circuit-breakers, manufactured by Chilton Electric Products, Limited, Hungerford, Berkshire, have been produced to meet the growing demand for such equipment as a means of protecting sub-circuits. The employment of circuit-breakers for this purpose instead of fuses has, of course, the advantages that the time spent in replacement is saved, that there is no risk that larger-size wire than is safe will be used and that single-phasing will not occur on three-phase motors, as an overload on one phase causes tripping on all. Moreover, the combination of a miniature circuit-breaker with earth-leakage protection ensures that, where it is difficult to obtain a good earth, protection can still be obtained by connecting the frame of the machine through the tripping coil of an earth-leakage trip to a separate earth.

Atlas circuit-breakers are manufactured in single-pole, double-pole and triple-pole units, the last two of which can be fitted with earth-leakage protection. A standard single-pole unit is used in all three types, two or three being interlinked to form the double-pole and triple-pole equipment, respectively. Overload protection is afforded by a thermal tripping element, which operates on sustained overloads, and by an instantaneous magnet trip which comes into action on sudden overloads and short-circuits. When the breaker is closed, contact is first made by an arcing tip on to a carbon bed, after which auxiliary and laminated main contacts come successively into operation, a wiping action being used to ensure positive contact. When the breaker is opened, the reverse sequence is followed, the arc being finally transferred from the arcing tip to the arc chute, where it is extinguished, thus minimising any risk of burning. Since the initial contact is made on carbon the danger of welding is very small. Owing to the employment of multiple contacts, the rupturing capacity of these breakers is as high as 5 MVA at 550 volts, when clearing phase-to-phase faults.

ULTRASONIC EQUIPMENT FOR LOCATING WHALES.

BEFORE describing the equipment designed and constructed by Kelvin and Hughes (Marine), Limited, 99, Fenchurch-street, London, E.C.3, to enable a whaling expedition to take the largest possible number of whales in the limited time available, it may be of interest to give a few brief particulars of the industry.

The present whaling season opened in January, and will conclude when the total number of whales permitted by international agreement has been caught. The quota for the season has been fixed at 16,000 whale units, a unit being one blue whale, or two fin or sperm whales. International inspectors are attached to each expedition to see that the permitted quota is not exceeded.

The industry is conducted principally by Norwegians, and most of the expeditions, regardless of their nationality, are largely Norwegian-manned. Eleven expeditions have now left Norway for the Antarctic whaling grounds, and of this number seven are Norwegian, three British and one South African. They will be joined in the Antarctic by five expeditions of other nationalities and between them they will operate about 250 catchers. The most important product obtained from whales is, of course, whale oil, but other typical by-products are meat, whalebone, guano, bonemeal, meatmeal, gelatin materials and blubber for leather. These are mostly extracted at sea on the factory ships which accompany the expeditions, one factory ship using as many as 12 catchers and may use other craft in addition for towing the whales back to the factory ship after the catcher has killed them. There are a few land-based factories in South Georgia, but the bulk of the whale oil is obtained from factory ships which can follow the whales wherever they may gather.

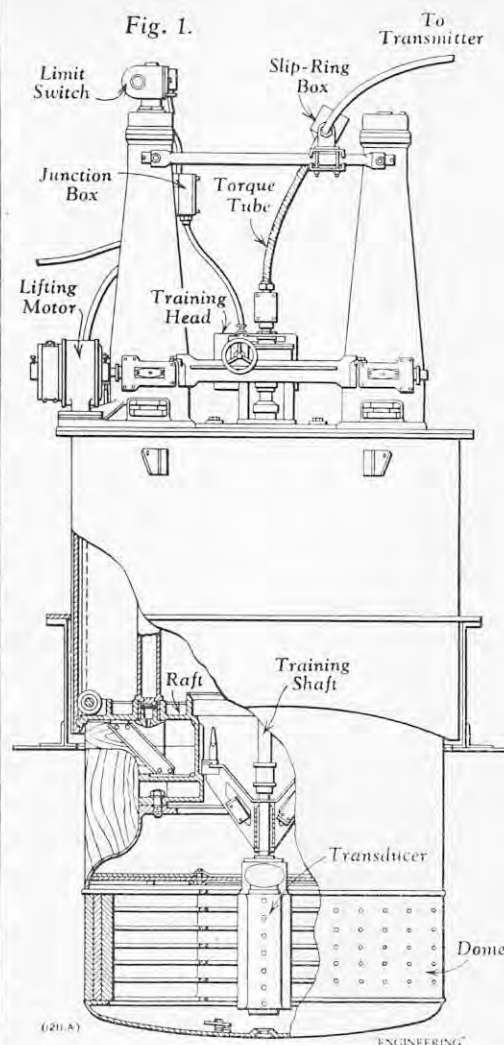
The cost of fitting out a whaling expedition is obviously high and the financial results, of course, depend upon the duration of the expedition and the selling price of whale oil. This varied last year from 80*l.* to 110*l.* per ton. A typical production of a factory ship last year was 116,800 barrels of whale oil and 8,500 barrels of sperm oil. Six barrels are equivalent to one ton, so that at an average price of 90*l.* per ton this particular expedition would show a gross return of 1,879,470*l.* In spite of this apparently satisfactory figure, the cost of fitting out and conducting an expedition is such that three Norwegian expeditions are not sailing this year on account of the low price of whale oil and the high cost of producing it. Evidently, therefore, any practicable method of accelerating the rate at which whales can be located and killed is worthy of careful consideration by the whaling industry. The Kelvin Hughes echo whale finder provides such a method, and in the present season 11 catchers attached to two factory-ship expeditions will be hunting with its aid. It will be interesting at the end of the season to compare the number of whales taken by these two expeditions with others not so equipped.

The function of the catchers is to locate, chase and harpoon the whales, a gun mounted in the bows of the vessel being used to fire the harpoon. The firing range is comparatively short, of the order of 20 yards, and as the speed of the catcher is not greatly in excess of that at which the whale can travel, considerable time may be occupied in bringing the catcher into firing range after a whale has been located. Blue or fin whales usually surface to "blow" every two or three minutes, but periodically they remain submerged for 15 to 20 minutes, when they may change their course and are frequently lost. It is for locating and keeping track of submerged whales that the echo finder is most useful.

The apparatus comprises an ultrasonic sound transmitter which protrudes through the bottom of the ship on the keel and can be turned through an angle of 360 deg. in azimuth. A narrow horizontal beam, which has a maximum range of about 2,000 yards, is transmitted in the form of a series of short pulses, and when the beam encounters a submerged object, such as a whale, part of the

energy is reflected back to the ship, where it is amplified and recorded. The angular direction of the beam can be read on a scale and the distance can be determined from the length of the time interval between the transmission of the pulse and the reception of its echo. Thus the whale is completely located and its movements can be followed by turning the beam so that the echo is received continuously.

The complete equipment comprises four main units, namely, the transmitter with the gear for lowering, raising and training it; the pulse generator and receiver; the motor-alternator and control cabinet; and the console unit. The transmitting unit is shown, partly in section, by the drawing reproduced in Fig. 1. It consists of a watertight trunk constructed of steel plating open to the sea at the bottom and is mounted on a seating built into the ship's hull. Inside the trunk is a "raft" which can be raised or lowered inside the trunk by a pair of screws driven by a 2-h.p. direct-current motor;



a limit switch is provided to control the motor when the raft is near the top and bottom stops. A hollow vertical shaft mounted centrally in the trunk carries at its lower end the transducer, which is of the magnetostriction type and produces vibrations at either 14 or 25 kilocycles per second. The shaft, which encloses the electrical connections, passes through a gland mounted on the cover plate of the trunk and, when in the working position, engages with the training-motor drive which is controlled from the console unit. The electrical circuits for lifting and training the transducer are distributed from a junction box mounted on one of the tapered pillars which enclose the two lifting screws. Secured to the lower side of the raft is a streamlined casing, or dome as it is called, in which the transducer is located. The dome consists of top and bottom castings with horizontal frames between them; a thin sound-transparent shell is attached to the frames and through this the pulses are transmitted to the water, in which the dome is completely immersed when the raft is lowered. When not in use the dome is housed inside the trunk. As shown in Fig. 1, a wooden fairing is fitted between the top of the dome and the raft in

order to reduce the risk of fouling the harpoon line when the dome is lowered.

The transducer is indicated in Fig. 1 and is shown separately in Fig. 2. It is 15 in. wide and is double-faced, one face transmitting energy at 14 kilocycles and the other at 25 kilocycles, the latter frequency being used for short-range work. The transducer is made up of horizontal strip elements in the form of packs which can be switched to give the beam three different angular widths in the vertical plane. The widths provided are 13 deg., 36 deg., and 50 deg. at the lower frequency and 14 deg., 31 deg., and 48 deg. at the higher; moreover, the axis of the deep beam at 25 kilocycles is tilted to an angle of 22½ deg. below the horizontal. The angular widths of the beam in the horizontal plane are 8 deg. and 15 deg. for the higher and lower frequencies, respectively. To facilitate replacement the wires from the individual elements of the transducer are taken separately to a junction box at the top, shown in Fig. 2. From the transducer, connections are brought out through a flexible cable passing through the hollow training shaft to a slip-ring box, the position of which is indicated in Fig. 1. This box is designed to tilt and follow the vertical movement of the transducer and from it connections are made to the transmitter panel, which is shown, with the doors open, in Fig. 3.

This panel, together with the receiver rack and the control cabinet, is mounted in the hull close to the trunk containing the transducer-control gear. On it is mounted the send-receive panel at the top. This panel includes rapid change-over switching to connect the transducer either to the transmitter or receiver, high-speed relays to determine the pulse length employed, and means for switching the various sections of the transducer. All these operations are controlled from the console unit. A master oscillator and power-amplifier combination are also mounted on the transmitter panel and means are provided on it for changing the frequency, the change being effected by remote control from the console unit.

Apparatus is provided on the receiver rack to control the amplifier gain and to rectify the high-frequency signal received so that it can mark a chemically-treated recording paper on the console unit. The signal is also heterodyned to a beat frequency of 1,000 cycles per second, so that it can be heard on headphones or a loudspeaker. The receiver rack also carries a panel which provides a steady direct-current bias to the transducer. This current is obtained, through a step-down transformer and rectifier, from a 2-kVA motor-alternator which is driven from the ship's supply and provides current at 230 volts and 50 cycles to operate the pulse generator and receiver. This part of the circuit is housed in the control cabinet, which includes an automatic starter and carbon-pile regulator for the alternator. The control cabinet also contains the circuits controlling the training of the transducer, the housing of the dome, and the bias supply, together with the necessary switches, meters and fuses.

The whale finder is designed to be operated by one man, all the essential controls being grouped in the console unit, which is housed in a hut on the bridge, from which a clear view of the whole area of operations can be obtained. The unit is illustrated in Fig. 4. On the right is a knob and circular scale which the operator uses to train the transducer through the agency of a servo system. This enables the transducer to be turned through a complete circle in 15 seconds. A gyro repeater is incorporated which automatically stabilises the transducer in azimuth to the last bearing set by the operator. On the left-hand side of the unit is the range recorder, incorporating a moving paper band treated with potassium iodide on which the outgoing pulses and the echoes are recorded by means of three revolving pens. A speed-governed direct-current motor provides the time-base for the range scales and also drives the paper roller. Contacts on the pen-driving shaft are used to control the send-receive change-over switching and the bias for the receiver; other contacts are used to initiate the transmission. The pen traverse across the width of the paper can be made to represent alternative ranges of 250, 500, 1,000, 1,500, or 2,000 yards,

ULTRASONIC EQUIPMENT FOR LOCATING WHALES.

KELVIN AND HUGHES (MARINE), LTD., LONDON.

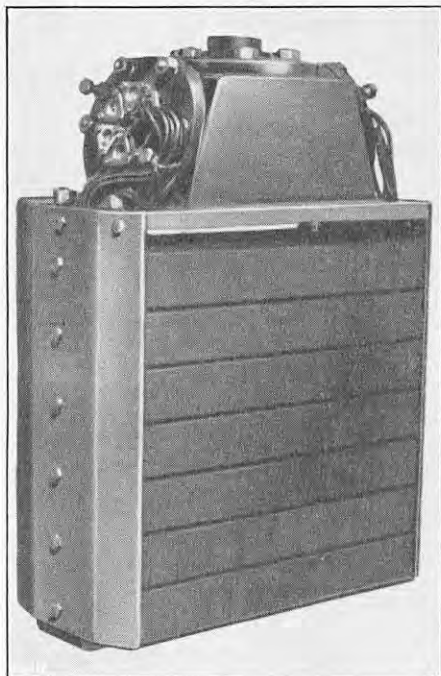


Fig. 2. TRANSDUCER, SHOWING 14-KC FACE.

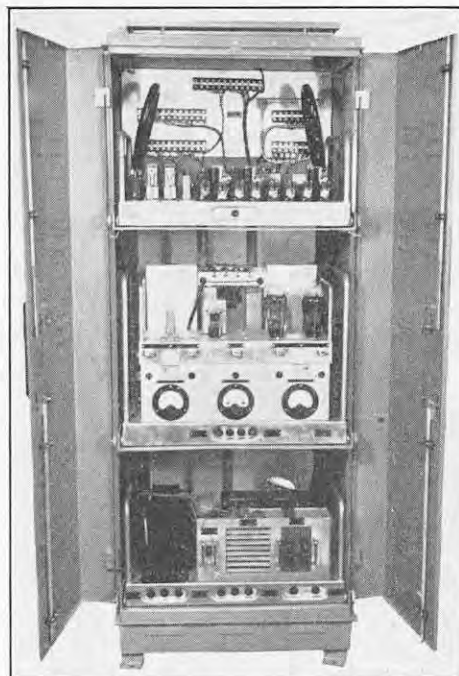


FIG. 3. TRANSMITTER PANEL.



FIG. 4. CONSOLE UNIT.

the change being effected by means of a five-speed gearbox in the driving mechanism. A pair of headphones is provided to enable the echoes to be examined aurally and there is also a hand key for transmitting signals when required.

It will be obvious that the effective use of the echo whale finder requires some skill and experience of the behaviour of sound beams in water on the part of the operator, who also needs aural acuity for detecting echoes against background noises, as well as pitch discrimination for detecting frequency changes due to the movements of the whale, which naturally produce a Doppler effect. To provide the necessary training in a convenient manner, Messrs. Kelvin and Hughes have set up at Barking-side a set of electronic equipment by means of which the signals received at sea can be simulated on an actual console unit and the responsive actions

required of the operator can be carried out. In addition to this shore trainer, a simpler unit can be supplied for use on board ship in conjunction with the standard equipment. This enables an instructor to introduce artificial whale echoes with the main equipment for training purposes while the vessel is on passage and suitable targets are not available.

AERONAUTICAL INFORMATION CONFERENCE.—The Aslib Aeronautical Group of technical librarians and information officers serving the aircraft industry will hold their second annual conference at the College of Aeronautics, Cranfield, from Friday, March 27, to Monday, March 30, 1953. Technicians and librarians from Europe, America and the Dominions are to contribute papers. Further particulars will be available in the near future from Mr. C. W. Cleverdon, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire.

EARLY DEVELOPMENT OF THE CENTRIFUGAL PUMP.*

By L. E. HARRIS, A.M.I.Mech.E.

(Concluded from page 42.)

THE year 1818 can be termed, with justice, a landmark in the history of the centrifugal pump, because in that year began its really practical development. The country to which the credit for this must be given is America. The year 1818 saw the introduction in America of what is now known as the "Massachusetts Pump," from the name of its place of employment, the name of the designer having been lost. In spite of its semi-anonymity, the Massachusetts pump is of considerably more importance than is usually appreciated, because it showed a return to the original conception of Denis Papin with the creation of a forced vortex within a circular, or spiral, casing by means of blades, as opposed to all the other devices which had been tried in the intervening century. This principle of the forced vortex is fundamental to the general principle of all modern centrifugal pumps, and it will be appreciated that the design of the Massachusetts pump had much in common with present-day design. From 1818 onwards, though there may have been minor departures from this fundamental design, the development of the centrifugal pump has proceeded along a well-defined line.†

In 1830, an improved version of the Massachusetts pump was at work in New York, and in 1831 Messrs. Blake, of the New Steam Mills, Connecticut, brought out a design of a vertical pump. This pump is noteworthy because it is the first example of what was then known as a "centrifugal disc pump," the impeller consisting of a horizontal disc with a series of radial vanes attached to the underside, working just clear of the bottom of the circular casing. In other words, the pump was provided with a semi-shrouded impeller, as opposed to the open impeller, or simple radial blades, of both the Papin and Massachusetts pumps. This was clearly an advance in design of some importance, but there was a retrogression to the circular casing. There is also the defective feature of the position of the discharge branch at right-angles to the plane of rotation of the impeller, involving a complete change of direction of motion of the fluid on discharge.

In 1838, Robert McCarty installed a centrifugal pump in the Navy Yard, New York; it is believed that this pump was of the Massachusetts type. In 1839, W. D. Andrews took out the first United States patent for a centrifugal pump, of a design very similar to that of the Massachusetts pump, which was employed in 1844-45 in New York Harbour. McCarty was subsequently a member of the jury which adjudicated on the centrifugal pumps in the Great Exhibition of 1851. Some time prior to 1836, the Russian mining engineer, General Lieutenant Sablukow, had built and demonstrated a centrifugal pump in St. Petersburg, and later employed it on mining work in the Urals. The first description of this is said to have appeared in the *Annuaire du Journal des Mines de Russie*, in 1836.

In July, 1838, M. Combes, a member of the Institut de France, read a paper before the Académie des Sciences entitled "Sur les Roues de Réaction."‡ While, as the title implies, his considerations were based primarily on the behaviour of water turbines, or reaction water-wheels, Combes discussed both the centrifugal ventilator and the centrifugal pump, and their analogy to the water turbine. Furthermore, he investigated the effect of the curved form of blades, which, as events were to prove, was to be such a potent factor in the development of the centrifugal pump. In August, 1838, he took out a *brevet d'invention* for "Une Machine universelle, à force centrale, propre à déplacer les liquides et les fluides aëriiformes," which was undoubtedly a form

* Paper read before the Newcomen Society, in London, on Wednesday, January 7, 1953. Abridged.

† For the developments in America, see "The Centrifugal Pump, An Historical Review," *Practical Mechanics Journal*, Sept. 1, 1851.

‡ *Comptes Rendus, Acad. des Sciences*, vol. vii, 2me Semestre, 1838.

of centrifugal pump*; and in 1843 he published a work entitled "Recherches théoriques et expérimentales sur les Roues à réaction ou à tuyaux," in which he established principles and formulæ applicable to the centrifugal pump. Meanwhile, in 1840, he had published the results of his experiments on blade curvature in a paper entitled "Recherches expérimentales sur les roues à réaction."† All these investigations have a special interest, if only because Combes paid tribute to, and developed his ideas from, the work of Segner and Euler in the preceding century, and thus showed some continuity of development. It must not be overlooked that, during the first half of the Nineteenth Century, there was, in France, considerable advance in the design of water turbines. For example, in 1827, Fourneyron introduced his outward-flow reaction turbine, to be followed later by Jonval, Girard, and others. In 1838, Poncelet presented a paper to the Académie des Sciences entitled "Sur la théorie des effets mécanique de la turbine Fourneyron."‡ The significance of all this theoretical and mathematical research lies, of course, in the direct relationship between the reaction turbine and the centrifugal pump, the latter, theoretically at least, being a reversed turbine; but these theoretical advances do not appear to have influenced practical design until some time after 1851.

In 1844, James Stuart Gwynne began in America his experiments on the centrifugal pump, destined eventually to have a more lasting influence on progress in England than any others. Gwynne was an Englishman, one of the three sons, John, James and George, of William Gwynne, a Londoner. John went to Ireland as a young man, George and James to America; John and James were subsequently to be associated in the manufacture of centrifugal pumps in England.§ Gwynne's experiments were carried out in Pittsburgh, and eventually resulted in what he termed his "Direct Acting Balanced Pressure Centrifugal Pump," first publicly demonstrated at the Passaic copper mine in January, 1849, where a pump 12 ft. in diameter was in operation. The United States patent for the invention was granted on January 14, 1851. In March, 1846, W. D. Andrews had been granted a further patent in the United States for a so-called improvement of his pump of 1839. In this later specification, Andrews stated that the novelty of his invention lay in the fact that, as he said, "I use vanes, and I enclose them within, and connect them to an additional case, which revolves with them, within the exterior or stationary case." If the Blake pump of 1831 was the first example of the "centrifugal disc pump" with a semi-shrouded impeller, Andrews's pump of 1846 provided the first double-shrouded impeller, though, in common with Blake's design, it suffered from the defect of the abrupt change of direction of discharge.

Andrews's improved design of 1846 has particular significance because the patent rights were acquired by James Stuart Gwynne. In Gwynne's description of his pump, he stated that "the general features of the machine are a hollow revolving piston, within which the water is received at the centre, and from the periphery of which it is thrown by centrifugal force into an outer and stationary case, whence it passes into the outlet pipe, through which it is discharged." The design of the "revolving piston," more usually, at that time, termed the "disc" and to-day the "impeller," was somewhat unusual. Outwardly the pump was of conventional appearance but the "revolving piston" was formed of two hollow discs similar in shape to the two discs forming the outer casting, and, to quote the subsequent British Patent Specification,|| the former were "held at a short distance asunder by slight transverse connections and a long central boss, by which the whole, forming a duplex disc, is keyed upon the driving shaft." The unusual and weak feature was that, initially, Gwynne employed only one blade, or "impeller," as he termed it, between the inner surfaces of the rotating discs, though he did envisage other designs with several water passages cast in the inner surfaces of these

discs. It is of interest that in his United States specification he specifically stated that he did "not claim to be the inventor of the centrifugal pump,"* a statement later to be of particular interest.

In 1839, James Whitelaw, of Johnstone, Scotland, obtained a patent† for a "Rotary machine to be worked by the pressure and reaction of a column of water . . . and a machine for raising water or other liquids by its centrifugal force." The main feature of this latter machine was the employment of a "hollow conical case," something after the style of Euler's "hollow funnel," and having some resemblance to a modern centrifugal separator. It was intended for drainage purposes.

While the developments recorded were being made in America, Appold and Bessemer were making their contributions on the British side of the Atlantic. John George Appold was the son of Christian Appold, a fur-skin dyer, and was born on April 14, 1800, at his father's factory in Wilson-street, Finsbury. Wilson-street still exists and there is also an Appold-street in the neighbourhood. It has been said that "his centrifugal pump stands boldly forth as an invaluable instrument for raising large quantities of water to a moderate height. The construction of this pump was a special instance of an invention arrived at by thoughtful investigation."‡ How much Appold knew of what Gwynne and others were doing in America, whether he knew of Combes's investigations in France, particularly relating to blade curvature, or was aware of Papin's achievements of 1689, can only be conjectured, but some time prior to 1848 he started his careful series of empirical investigations into the fundamental practical principles of the operation of the centrifugal pump. That word "empirical" must be emphasised, because at no time was Appold concerned with investigating a theory of the centrifugal pump.

The first public demonstration of the Appold pump was made at the meeting of the British Association at Birmingham in September, 1849, when he exhibited a "model of a centrifugal pump . . . capable of discharging 10 gallons of water a minute, and only 1 inch diameter." Appold on this occasion gave the results of various experiments which he had carried out and stated that he had found it possible to obtain efficiencies of 75 per cent. His experiments led to the production of the fully practical and efficient centrifugal pump, manufactured with such success by Easton and Amos. There are still a few examples to be seen working in the Somerset marshes. Incidentally, the designer took out no patent.

Bessemer, between 1838 and 1883, took out 117 patents. Only two related to centrifugal pumps, but the ideas embodied in these two patents might have had a potent influence on the development of the centrifugal pump, had they been pursued. They were not, however, and Bessemer's connection with the centrifugal pump is a phase in his career overshadowed by his more lasting fame in other fields. On September 5, 1845, he was granted British Patent No. 10981, covering "Certain Improvements in Atmospheric Propulsion and its Apparatus connected therewith, Part or Parts of which Improvements are applicable to the Manufacture of Columns, Pipes and Tubes, and other Parts are applicable to the Exhausting and Impelling of Air and other Fluids generally." The important part of this specification lies in the "Exhausting and Impelling of Air and other Fluids generally," which Bessemer intended to effect by means of a rotary radial-vaned fan coupled to, and directly driven by, a simple reaction steam-turbine, designed to run at 2,000 to 3,000 r.p.m. Admittedly, the primary function of this apparatus, as concerned with atmospheric propulsion, was the exhausting of air, but the "impelling of air or other fluids" is a natural corollary of exhausting. In the specification Bessemer clearly stated that pressure is produced in the fan through centrifugal force and that "the partial vacuum which has been formed in the centre of the fan by the expulsion of the air is again supplied with more air through the central opening."

To what extent this machine was used in practice

is uncertain, but clearly Bessemer did not allow the subject of pumping water by centrifugal force to leave his mind, because, on June 23, 1849, he was granted British Patent No. 12669 for his invention of "Improvements in the Methods, Means, and Machinery or Apparatus employed for raising and forcing Water and other Fluids." The specification contained 21 claims, 13 of which referred particularly to the design and operation of centrifugal pumps. The specification is accompanied by 51 drawings, most of these illustrating forms of centrifugal pumps, and designs of impellers, far in advance of anything of that day, and even almost modern by present-day standards.

Bessemer, in his autobiography,* wrote that, when he was at the Great Exhibition prior to its opening in May, 1851, in company with his "esteemed friend the late Bryan Donkin, F.R.S.," the latter, seeing the centrifugal machine which Bessemer was exhibiting—a centrifugal separator for molasses and sugar, driven by a reaction steam-turbine—said to him, "Why do you not show that old scheme of yours for raising water by centrifugal force?" Bessemer goes on to say that, next day, he sat down at his drawing board and schemed a combined engine and centrifugal pump, which he afterwards exhibited. It is clear that, when Bessemer wrote this story in his autobiography, he had forgotten the true facts of the matter. Bryan Donkin may have induced him to exhibit a centrifugal pump, but there was no need for him to design a combined unit for this purpose; he had already done that some years previously, as evidence his patents of 1845 and 1849. In the event, Bessemer's exhibit, far from being confined to one combined unit, consisted, as the official Exhibition catalogue shows, of no fewer than four different types of centrifugal pumping sets, namely, a combined steam engine and "centrifugal disc pump for land and sewer drainage . . . said to be capable of discharging 20 tons of water per minute"; a "Model of a pump for steamships, being a precise copy of the exhibitor's original patent for the centrifugal disc, dated 5th December, 1845"; "A centrifugal disc pump for locomotive engines" (to be used as a boiler feed pump); and "A small model worked by hand to illustrate the principles of the centrifugal disc." Bessemer's exhibit, therefore, was much more comprehensive than that of either of his competitors, Appold and Gwynne, each of whom exhibited only one pump; and though, in later years, their pumps found wide application, there is some justification for saying that, in 1851, Bessemer was in some respects far more advanced in his ideas.

By the time that the Exhibition opened in May, 1851, James Stuart Gwynne's position had been strengthened by the fact that he had returned from America and had joined his brother John, who had set up as a mechanic and hydraulic engineer in Essex-street, Strand, where the "direct acting balanced pressure centrifugal pump" was being made. John was granted British Patent No. 13,577 for this pump on March 31, 1851, the same patent covering the design of the first multi-stage centrifugal pump. This design is important because it shows that J. S. Gwynne was realising that the centrifugal pump would, and could, be made for much higher heads than had been considered up to that time, when it was looked upon as necessarily a low-head machine.

Controversy raged at the time of the Exhibition between Bessemer, Appold and Gwynne as to the merits of their respective pumps and the priority of their inventions. None of them was the inventor of the centrifugal pump, but, a few weeks before the opening of the Exhibition, *The Times* stated that ". . . our friends across the Atlantic have brought forward at least one invention—a centrifugal pump—the idea of which was caught, it appears, from the *Mining Journal* [of England] The original inventor [Bessemer] is upon the ground, and has, it is said, been at some pains to explain to his plagiarist wherein the machine produced by him was defective." This statement justifiably aroused the ire of J. S. Gwynne, who was further incensed by the notice, appearing on Bessemer's exhibit No. 2, to the effect that "This model

* Report of Juries, Great Exhibition, 1851.

† *Comptes Rendus*, vol. x, 1840.

‡ *Ibid.*, vol. iii, 1838.

§ 100 Years of Gwynnes Pumps, Gwynnes Pumps, Ltd.

|| British Patent No. 13,577, Sept. 30, 1851.

* *Journal of the Franklin Inst.*, 3rd Series, vol. 21.

† British Patent No. 8061, May 7, 1839.

‡ *Proc. Royal Soc.*, vol. XV, pp. 523-525 (1866-7).

* *Sir Henry Bessemer, F.R.S.: An Autobiography* published by ENGINEERING, 1905.

PORTABLE LOAD-MEASURING SET.

BOULTON PAUL AIRCRAFT, LIMITED, WOLVERHAMPTON.



of a Centrifugal Pump for forcing liquids is constructed in rigid accordance with the specification of Bessemer's original patent, dated Dec. 4, 1845, being the first recorded invention for impelling fluids by centrifugal force generated in a revolving disc." Gwynne objected not only to Bessemer's claim to priority of invention, but also maintained that Bessemer had no right to exhibit his machine "as a water pump" since there was no mention in the patent specification "of employing it for the purpose of raising water."

The relative efficiencies of the three makes of centrifugal pump in the Exhibition were conclusively settled by the tests conducted by the Jury of the Exhibition, which may be summarised as follows:—

Make.	Quantity.	Height.	Speed.	Efficiency.
	G.p.m.	Ft.	R.p.m.	Per cent.
Appold ..	1,236	19.4	788	68
Gwynne ..	290	13.8	670	19
Bessemer ..	846	3.28	60	22.5

The superiority of the Appold pump is apparent from these figures, and the great disparity between the efficiency of this pump and those of its competitors calls for some comment. The high figure attained by Appold was largely due to his employment of curved instead of radial blades. At a later date, Appold produced figures to show that, during his experiments, while with curved blades he could attain an efficiency of 68 per cent., with straight blades inclined at 45 deg., this figure was only 43 per cent., and with radial blades it dropped to 24 per cent.* The low figure of the Gwynne pump may have been due primarily to the employment of one blade only in the rotating disc—a feature which Gwynne soon abandoned—and to the comparatively small size of the pump. Bessemer's pump suffered from two disabilities, namely, the use of radial blades and its slow speed. This latter point is somewhat difficult to explain because, from what Bessemer had said in his specification of 1845, he was fully alive to the need for high rotational speeds. It is important to note that Appold's was a horizontal-spindle pump, while the pump for which he is, perhaps, best remembered is the vertical-spindle pump, widely used in Fen drainage, with the "wheel" or "impeller" situated at the bottom of a suction well, lined with cast-iron segments. It is true that the first Appold pump for Fen drainage, at Whittlesey Mere, put into operation in November, 1851, and ordered as a direct result of the Exhibition, had a horizontal spindle. While the vertical-spindle pump in later years was generally superseded in the Fens by the horizontal-

spindle pump, to-day the tendency is for the vertical pump to supersede the horizontal pump; but that is for reasons which were not appreciated in 1851.

The Great Exhibition of 1851 undoubtedly placed the centrifugal pump on firm ground, but it would be wrong to say that, before 1851, there was a conscious development; each phase was, to a large extent, made independently, and in ignorance of what had gone before. Le Demour, Fahrenheit, and even Euler, owed little or nothing to Papin, and if Combes, in the Nineteenth Century, did owe something to Euler, Appold, Bessemer and Gwynne owed nothing to Papin, Le Demour, Euler or Combes. Up to 1851, the designers of such pumps relied little, or not at all, on theory, but almost entirely on experiment and trial and error. Even to-day, the centrifugal-pump designer relies on experiment for the development of his design, though such design is primarily based on theory. It would not be too much to say that, if Bessemer, Appold and Gwynne, and others, ignored theory in design, the modern designer owes more to Euler than is sometimes recognised, even if 200 years have elapsed since he first investigated the operation of Segner's crude reaction turbine, and thus founded the theory of the centrifugal pump. So much for theory. In 1818, the Massachusetts pump returned to the fundamental practical design evolved by Denis Papin between 1689 and 1705, from which it has never since departed.

THE AUSTRALIAN ROAD FEDERATION.—The Australian Road Federation has been incorporated recently with its offices at 443, Bourke-street, Melbourne, C.I. The chairman is the Hon. Sir Herbert Olney and the secretary, Mr. D. B. Leahey, B.Com., A.C.I.S. The Federation, which is the Australian member of the International Road Federation, will serve the interests of the industrial, commercial and mining communities as well as the tourist and road transport industries, and its members are from all these groups. Broadly, its objects are to encourage, promote and protect the interests of all who are concerned in the planning, construction, use and maintenance of roads.

LONDON COUNTY COUNCIL BUILDING BY-LAWS.—The London County Council have published the London Building (Constructional) By-Laws, 1952 (price 3s. 6d.), together with a separate explanatory memorandum (price 1s. 0d.), which deals particularly with points raised by certain objectors when the by-laws were being redrafted. A memorandum (price 1s. 3d.) has also been issued on matters to be examined when applications are made to construct buildings of excess height and/or additional cubical extent that require approval under section 20 of the London Building Acts (Amendments) Act, 1939. These three publications may be obtained from the Record Keeper, County Hall, Westminster Bridge, S.E.1, at the price indicated above; postage is extra in each instance.

PORTABLE LOAD-MEASURING SET.

DESIGNED originally for measuring the forces acting on the brake-control linkages of heavy road-transport vehicles during road trials, but equally suitable for remote load measurements in many other mechanisms or engineering structures, the portable four-channel load-measuring set (type L 4000) shown in the accompanying illustration, has been developed by Messrs. Boulton Paul Aircraft, Limited, Wolverhampton. The indicating instrument is a robust micro-ammeter, resiliently mounted in the instrument case to avoid shock damage, that can be calibrated to give a direct indication of load. It has an accuracy of ± 0.5 per cent. and a linearity of ± 0.5 per cent. The outer casing, which is supplied with shock-absorbing mountings, houses four strain-gauge bridge circuits, with balance potentiometers. Any one of the bridges may be connected with the indicating instrument by a selector switch. A calibrating unit is also provided. Four load-measuring rings each having a high-resistance strain gauge, protected from the effects of weather and temperature, and insensitive to bending forces, are connected to the measuring set through a screened or armoured cable and a plug-and-socket connection. The component in which the load is to be measured is replaced by a coupling rod incorporating the load-measuring ring, the coupling rod being constructed in two sections of suitable length which screw into the threaded ends of the ring.

The instrument can also be used with any bonded resistance strain gauge within the range 2,000 to 2,500 ohms; it is then necessary to carry out a calibration test. For this purpose, each bridge circuit is provided with an adjustable sensitivity control, a known load is applied to the strain gauge, and the sensitivity control is then adjusted to set the instrument pointer at a suitable value. It is then locked. When the instrument is supplied with the load-measuring rings, the sensitivity controls are adjusted before delivery to give full-scale deflection at maximum load. At maximum sensitivity, full-scale deflection is obtained for an equivalent strain of 0.0005 on two of the strain gauges. At minimum sensitivity, the equivalent strain for full-scale deflection is 0.0012.

The instrument requires a separate stabilised power supply to provide 0.125 amperes at between 100 and 120 volts. A suitable power unit can be supplied as additional equipment.

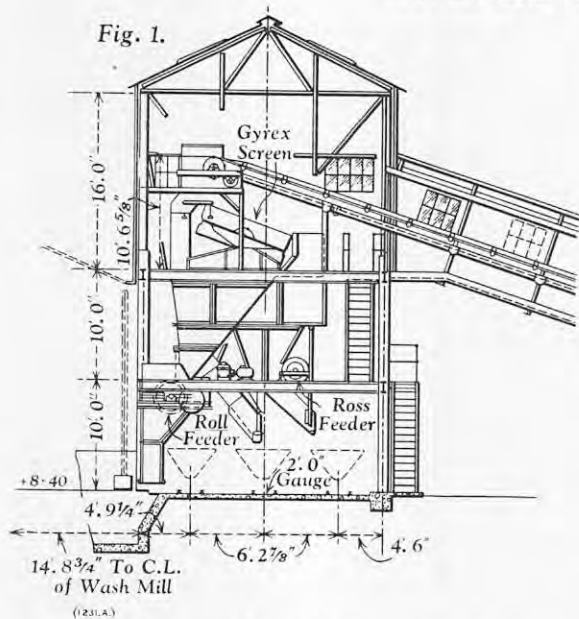
TECHNICAL DICTIONARIES.—A useful catalogue entitled "Technical, Scientific, Special and Commercial Dictionaries in Various Languages" has been issued *gratis* by Bailey Bros. and Swinfen Ltd., Minerva House, 26-27, Hatton-garden, London, E.C.1. It lists the most complete and useful works that have come to the notice of the publishers up to November, 1952, and it is stated that supplements to the catalogue will be issued from time to time. It is classified under eight main headings, one of which is "Engineering, Technical, Scientific," comprising the longest section, and covering 8½ pages. This section is subdivided under such heads as atomic physics, aviation, building, electricity and electronics, civil engineering, general and mechanical engineering, gas, glass, iron and steel, machines and tools, metallurgy, mines, oils and lubricants, paint and varnishes, petroleum, plastics, radio and television, sewage, textile, and welding. There is also a short section on mathematical tables. The catalogue includes a subject index.

METHANE FOR DOMESTIC USE IN NORTH WALES.—Negotiations between the National Coal Board and the Wales Gas Board have recently been concluded for the public utilisation of methane collected from coal seams below the estuary of the River Dee at the Point of Ayr colliery, Flintshire. The gas, which is at present being released to the surface for boiler firing, will be reduced from a pressure of 300 lb. a square inch to one of 6 lb. a square inch at the colliery. It will then be conveyed by 6-in. pipelines to gas-holders at Prestatyn, where it will be mixed with low-grade water gas to enable it to be used for household and industrial purposes. The first stage of the scheme will be to use some 600,000 cub. ft., of the colliery's present daily production of 2,250,000 cub. ft., to supply consumers in Prestatyn, Rhyl, Rhuddlan, St. Asaph, Abergele, and perhaps Holywell, Colwyn Bay, and Flint. It is hoped eventually to establish a grid system on lines similar to those used for the supply of electricity.

* *Proc. Inst. Mech. E.*, 1852, page 155 *et seq.*

CHALK CRUSHING AND SCREENING PLANT.

FRASER AND CHALMERS ENGINEERING WORKS, ERITH, KENT.



CHALK CRUSHING AND SCREENING PLANT.

THE chalk quarries of the Chinnor Cement and Lime Company, Limited, Oxfordshire, have been worked since the early part of the century, and the company's works have been extended recently by installing a crushing and screening plant designed and built by the Fraser and Chalmers Engineering Works, Erith, of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. A longitudinal section through the crushing and screening houses and the conveyor gallery is given in Fig. 1, herewith, and a general view of the buildings is given in Fig. 2. The plant has a capacity of 70 tons of dry material per hour and can handle pieces of chalk as large as 3 ft. long by 2 ft. by 2 ft.; on occasions, even larger boulders have been fed into the crusher.

The chalk is excavated at the nearby quarry face by a 1-cub. yd. mechanical shovel and loaded into 5-ton dumpers for conveyance along a concrete road leading to the crushing house. On arrival at the crushing house the chalk is tipped into the receiving hopper (Fig. 5, opposite), which is 12 ft. long by 5 ft. wide and 7 ft. deep. From the hopper it is transferred into the crusher by a moving-bar "grizzly" feeder of a type which is particularly suitable for handling large pieces of glutinous material. The feeder removes the fines before they reach the crusher and drops them directly on to the conveyor belt below. A 7½-h.p. slip-ring motor, working at speeds varying between 480 r.p.m. and 725 r.p.m. drives the feeder; a V-rope is used to transmit the drive and partly to reduce the speed, which is further reduced by a spur-gear train. The last wheel of the gear train is coupled directly to the eccentric which actuates the feeder. The crusher is a Fraser and Chalmers "Pennsylvania" single-roll crusher of their "Super Armorframe" series, fitted with a toothed roll having a diameter of 30 in. and a length of 50 in. A cross-section through the crusher is given in Fig. 3, opposite, and the crusher can also be seen in the foreground of Fig. 5. The position of the cranked breaker plate can be adjusted so that the crusher gives a product as large as minus 9 in. (i.e., a material containing pieces with a size not exceeding 9 in., as well as finer sizes), or a product as small as minus 5 in. The roll operates at a speed of 35 r.p.m. and is driven by a 65-h.p. slip-ring motor with a nominal speed of 725 r.p.m.; the speed reduction is effected in the V-rope drive to the roll countershaft and by a spur-gear reduction between the countershaft and the roll spindle. Like the "grizzly" feeder mentioned above, this type of crusher has been chosen as being particularly suitable for dealing with a glutinous material which might clog a jaw-type crusher. The breaker plate

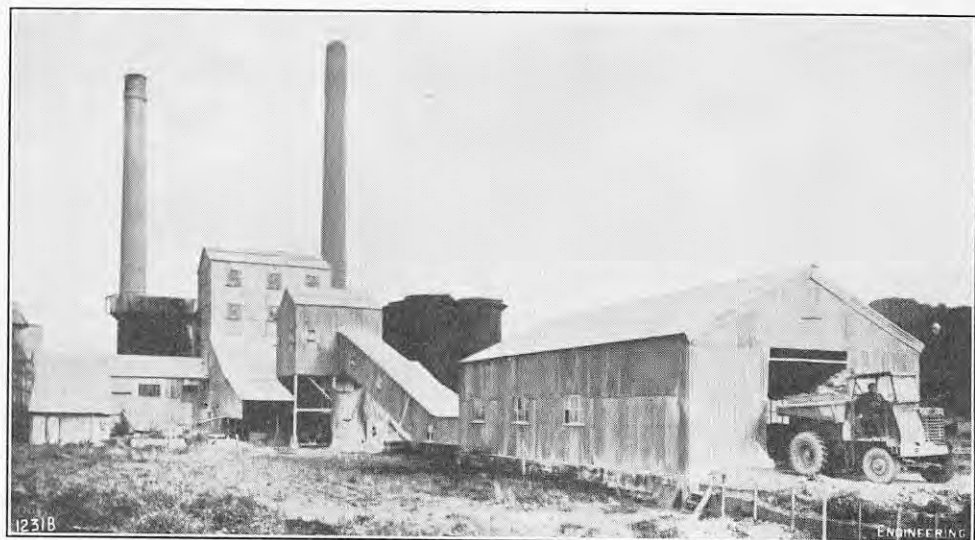
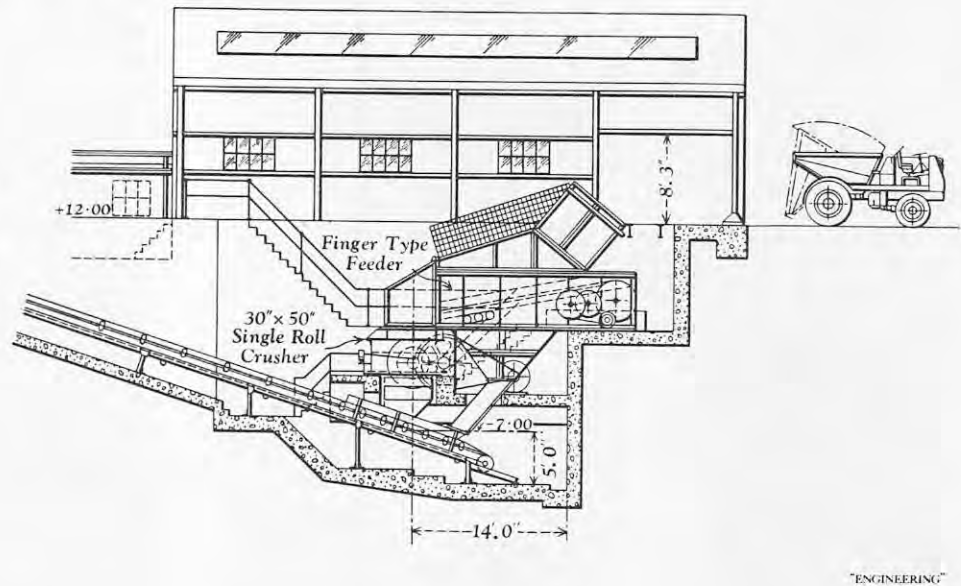


FIG. 2. GENERAL VIEW OF PLANT.

is a steel casting fitted with renewable manganese-steel wearing plates and it is also provided with bronze bushes for the hinge spindle. The housings for the bearings of the roll and its countershaft are likewise steel castings fitted with renewable bronze bushes. The mechanical grease lubricator is driven off the roll shaft.

The crushed chalk is then carried up an inclined belt conveyor, 30 in. wide and 156 ft. long between the centres of the head and tail pulleys, to the top of the screening house. The conveyor is fitted with troughing idlers of the pulley type, the outer idlers, having taper-roller bearings. The idlers are mounted on steel boards which, at the feed end below the crusher, are heavily rubber-cushioned and spaced at not more than 2-ft. centres. Taper-roller bearings have also been used on the return idlers and the head, tail and scrub pulleys are similarly mounted on roller bearings. Auxiliary equipment on the conveyor includes a weighted-type belt cleaner and a hold-back gear of the pawl and ratchet type. A high-torque squirrel-cage motor developing 10 h.p. at 720 r.p.m. is used to drive the worm-gear reduction unit coupled to the head pulley of the conveyor.

In general, all the material from the conveyor is discharged on to a "Gyrex" screen, 60 in. wide by 102 in. long. The screen has a static bar mesh of 6 in. but it can be replaced by another with a different size of mesh. Over-size material passes into one hopper while the remainder passes through the screen into a second hopper. If necessary, all the material can be fed through a valve into

the "under-size" hopper. The screen is of a heavy pattern and is vibrated by an eccentric shaft supported at its ends in heavy self-aligning roller bearings mounted in the fixed side plates of the screen base. The middle length of the shaft has been machined ½ in. eccentric with respect to the main axis of the shaft bearings and the vibrating screen frame moves in a small circular path by being mounted on saddles above the eccentric length of the shaft. Roller bearings have been used in the mountings of the saddles both on the screen frame and on the eccentric shaft. To prevent the vibrations from being transmitted to the supporting structure the shaft is both statically and dynamically balanced by counterweights that are provided with vernier adjustments. The drive for the shaft is transmitted by a V-rope from a high-torque squirrel-cage motor developing 7½ h.p. at 720 r.p.m.

From the hopper the under-sized material is conveyed to the wash mill of the adjoining cement plant and the "over-size" is discharged by a chain feed into 1-cub. yard Decauville wagons that are used to transport it to the company's lime kilns. The discharge of the under-sized material is regulated by a roll-type feeder, having a diameter and width of 30 in. and 62 in., respectively, that is driven by a 2½-h.p. slip-ring motor working at speeds varying between 480 r.p.m. and 725 r.p.m. An auxiliary chute has also been provided so that, if required, all the material can be emptied into the Decauville wagons through a radial gate which has a radius of 36 in. and a width of 30 in. A train

CHALK CRUSHING AND SCREENING PLANT.

FRASER AND CHALMERS ENGINEERING WORKS, ERITH, KENT.

Fig. 3.

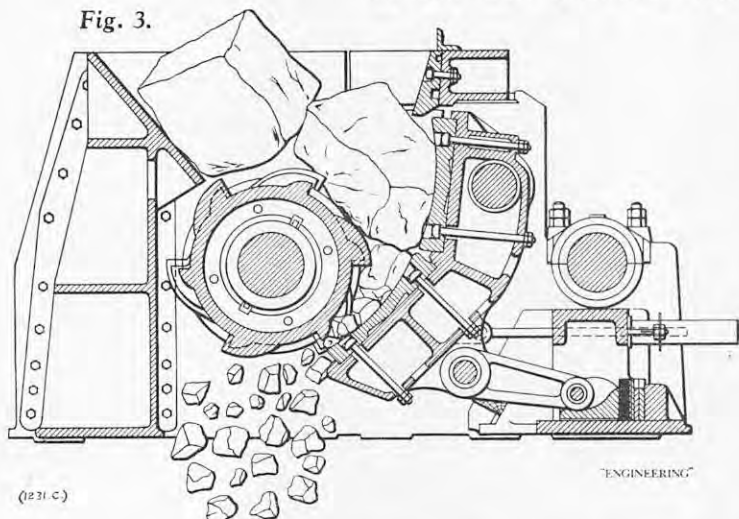


FIG. 4. LOADING CRUSHED AND SCREENED CHALK.

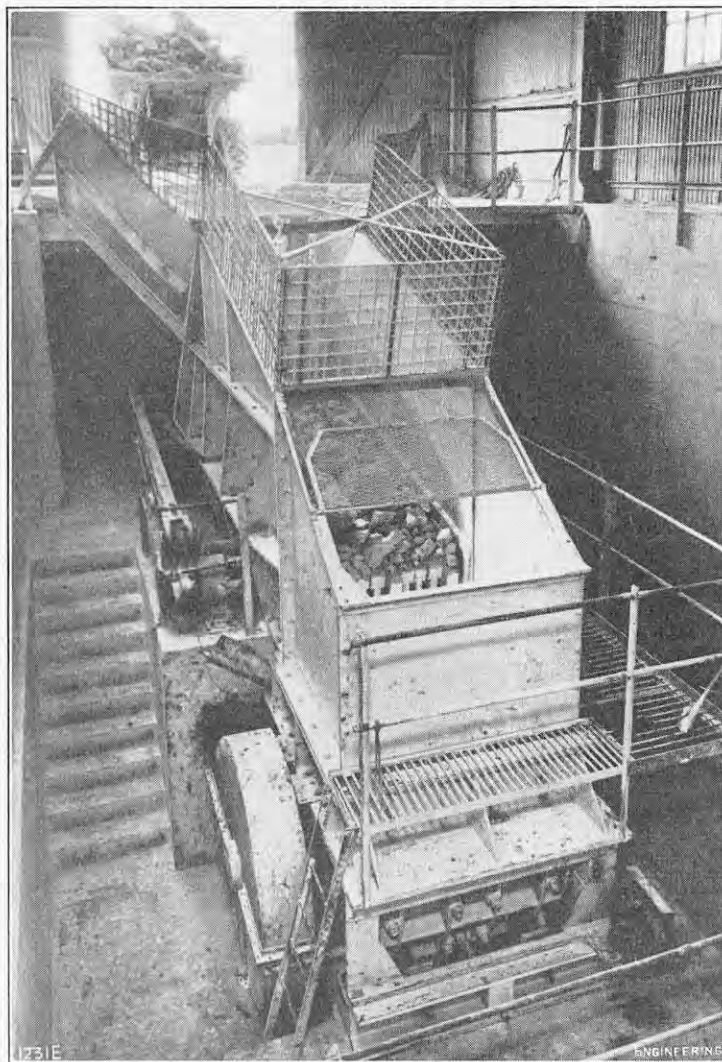


FIG. 5. RECEIVING HOPPER AND CRUSHER.

of loaded wagons in position below the chute is shown in Fig. 4, herewith.

To assist in servicing the feeder and the crusher, etc., a 5-ton travelling crane has been installed in the crusher house. The crane is hand-operated and has twin girders spanning 24 ft. between rails that are 25 ft. above the level of the crusher floor. The hoist works through worm gearing and is fitted with an automatic self-sustaining unit with the load carried on two parts of chain. Two independent hand chains have been provided to give two speeds for the lifting hook, which is mounted in ball bearings, and these two chains have been duplicated so that the crane may be conveniently operated from either the ground floor or from the crusher floor. Both the cross traverse and the longitudinal travel motions are fitted with roller bearings. A 2-ton travelling block, or crawl, built into a 4-wheeled trolley underslung from the bottom flange of a rolled steel joist, has been installed in the screen house for the purpose of servicing equipment. Both the crusher house and the screen house have been constructed with steel frameworks and galvanised-steel sheet cladding; a similar form of construction has also been adopted for the conveyor gallery.

ZINC AND ALUMINIUM DIE-CASTING PRODUCTIVITY.—Meetings to discuss the Zinc and Aluminium Die-Casting Productivity Report of the Anglo-American Council on Productivity, open to all interested in die casting, have been arranged by the Zinc Alloy Die Casters Association, Lincoln House, Turl-street, Oxford. The first will take place on Friday, January 23, at the Northampton Polytechnic, St. John-street, London, E.C.1, and the second on Wednesday, January 28, at the College of Technology, Suffolk-street, Birmingham, 1. Both meetings will begin at 6.30 p.m.

LAUNCHES AND TRIAL TRIPS.

M.S. "GUILDFORD."—Single-screw collier, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the South Eastern Gas Board, Croydon, Surrey. Third vessel for these owners. Main dimensions: 264 ft. 6 in. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, 2,875 tons on a draught of 17 ft. 1 in. Eight-cylinder marine Diesel engine, developing 1,150 b.h.p. at 225 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Launch, November 17.

M.S. "KING ARTHUR."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the King Line, Ltd., London, E.C.3. Main dimensions: 467 ft. overall by 59 ft. by 39 ft. 9 in. to shelter deck; gross tonnage, 5,770. Harland-B. and W. six-cylinder single-acting four-stroke Diesel engine. Launch, November 19.

M.S. "RIPLEY."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the Thomasson Shipping Co., Ltd. (Managers: Stephens, Sutton, Ltd., Newcastle-upon-Tyne). Main dimensions: 435 ft. between perpendiculars by 58 ft. 9 in. by 38 ft. to shelter deck; deadweight capacity, 10,200 tons on a summer draught of 25 ft. 9 in. Swan Hunter-Doxford four-cylinder combined-stroke oil engine, developing 3,300 b.h.p. at 108 r.p.m., constructed by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne. Speed, 12 knots. Launch, November 19.

S.S. "SILVERBURN."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Gray & Co., Ltd., West Hartlepool, for the Silver Line, Ltd., London, E.C.2. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 27 ft. 10½ in. to upper deck; deadweight capacity, 8,900 tons on a draught of 25 ft. 0½ in. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine, and two oil-fired boilers. Service speed, 10½ knots. Launch, November 19.

M.S. "HOPEMOUNT."—Single-screw oil tanker, built

by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Hopemount Shipping Co., Ltd. (Managers: Stott, Mann and Fleming, Ltd.), Newcastle-upon-Tyne. Main dimensions: 526 ft. between perpendiculars by 72 ft. 6 in. by 40 ft. 6 in.; deadweight capacity, 18,600 tons on a draught of about 31 ft. 5½ in.; oil-tank capacity, 833,000 cub. ft.; gross tonnage, 12,500. Wallsend-Doxford six-cylinder two-stroke opposed-piston oil engine, developing 8,000 b.h.p. at 104 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Launch, November 19.

S.S. "GRIMSBY TOWN."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for the Consolidated Fisheries, Ltd., Grimsby. Main dimensions: 178 ft. between perpendiculars by 31 ft. by 16 ft. 3 in.; gross tonnage, 700. Triple-expansion engine developing 1,200 i.h.p., and one oil-burning boiler, constructed by Amos and Smith, Ltd., Hull. Launch, November 19.

M.S. "SIBELLA."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Skibsaktieselskabet Avanti (Managers: Tschudi & Eitzen), Oslo, Norway. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in. to upper deck; deadweight capacity, 24,600 tons on a summer draught of 32 ft. 3½ in.; oil-carrying capacity, 23,530 tons. N.E.M.-Doxford six-cylinder single-acting two-stroke oil engine, developing 6,800 b.h.p. at 116 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Trial trip, November 19.

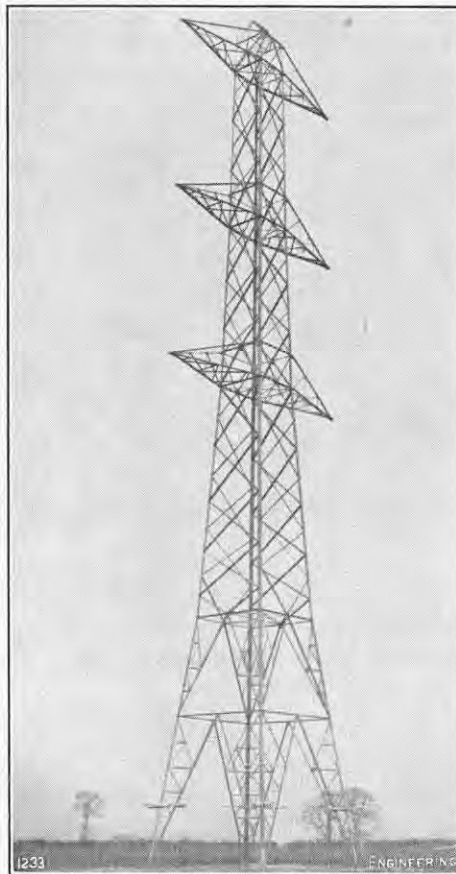
No. 865.—Single-screw steam trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the North Cape Fishing Co., Ltd., Grimsby. Name not yet decided. Main dimensions: 175 ft. by 29 ft. 6 in. by 15 ft. 6 in.; gross tonnage, about 610; fishroom capacity, 12,800 cub. ft. Triple-expansion steam engine, constructed by C. D. Holmes & Co., Ltd., Hull, and one oil-fired boiler. Launch, November 20.

BOOKS RECEIVED.

- Weight-Strength Analysis of Aircraft Structures.* By F. R. SHANLEY. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 72s. 6d.]
- The Electrical Year Book.* 1953. Emmott and Company Limited, 31, King-street West, Manchester, 3. [Price 3s. net.]
- An Introduction to Scientific Research.* By PROFESSOR E. BRIGHT WILSON, JR. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 51s.]
- Proceedings of the Eighth International Congress of Refrigeration.* London, August 29th to September 11th, 1951. Offices of the Congress, Dalmeny House, Monument-street, London, E.C.3. [Price 60s. net.]
- Annuaire pour l'An 1953.* Le Bureau des Longitudes, Gauthier-Villars, 55, Quai des Grands-Augustins, Paris (6e). [Price 750 francs.]
- A Survey of Production and Industrial Engineering Organisation and Practice in the U.S.A. and Canada.* By T. G. ELLIOTT. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]
- Current British Directories, 1953.* Compiled by G. P. HENDERSON. Staples Press Limited, Mandeville-place, London, W.1. [Price 30s. net.]
- City of Birmingham. Annual Abstract of Statistics.* No. 2, 1950-1951. Edited by DR. RICHARD PADLEY and WALLIS TAYLOR. The City of Birmingham Central Statistical Office, Council House, Birmingham, 1. [Price 10s.]
- The Wire Reference Year Book and Directory.* 1952-1953. Edited by D. J. BLASHILL and NEIL LINDSAY. Alfred Hinde Limited, Clarence-street Printing Works, Wolverhampton. [Price 25s.]
- Bautechnik-Archiv.* No. 8. *Vorträge der Baugrundtagung 1952 in Essen vom 30 Januar bis 2 Februar.* Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf. [Price 12 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 21s.]
- Der Stahlhochbau.* By C. KERSTEN. Vol. II. Fifth revised edition by DIPL.-ING. WERNER TRAMITZ. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf. [Price 24 D.M. in paper covers, 27 D.M. bound]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 42s. in paper covers, 47s. 3d. bound.]
- Theorie der Verbundkonstruktionen.* By DR.-ING. KONRAD SÄTTLER. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf. [Price 43 D.M. in paper covers, 46 D.M. bound]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 75s. 3d. in paper covers, 80s. 6d. bound.]
- Class Rates Section of Standard Charges, 6 to 750 Miles.* (Provincial.) December 1, 1952. The Railway and Shipping Publishing Company, Limited, 12, Cherry-street, Birmingham, 2. [Price 15s., post free.]
- The Directory of Shipowners, Shipbuilders and Marine Engineers, 1953.* Tothill Press, Limited, 33, Tothill-street, London, S.W.1. [Price 40s. net.]
- Television and Radar Encyclopaedia.* Edited by W. MACLANACHAN. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2. [Price 30s. net.]
- Transmission Lines and A.C. Networks.* By DR. T. F. WALL. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2. [Price 30s. net.]
- Road Research Technical Paper. No. 25. Rear Lights of Motor Vehicles and Pedal Cycles.* By R. L. MOORE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]
- Bulletin de l'Association Technique Maritime et Aéronautique.* No. 51. 1952. Association Technique Maritime et Aéronautique, 1, Boulevard Haussmann, Paris (9e). [Price 6,000 francs.]
- Theory of Elasticity and Plasticity.* By PROFESSOR H. M. WESTERGAARD. Harvard University Press, Cambridge, Massachusetts; and John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 40s. net.]
- Mechanics. Part II. Dynamics.* By PROFESSOR J. L. MERIAM. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32s. net.]
- High-Voltage A.C. Circuit-Breakers.* By PROFESSOR S. GERSZONOWICZ. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 63s. net.]
- Nigeria. Annual Report of the British West African Meteorological Services, 1950.* The C.M.S. Bookshops, Lagos and Port Harcourt; the S.I.M. Bookshop, Jos; and the Crown Agents for the Colonies, 4, Millbank, London, S.W.1. [Price 9d. net.]

275-KV TRANSMISSION TOWER.

WORK has now been started on the erection of that portion of the 275-kV grid which is to connect Tilbury, in Essex, and North Elstree, in Hertfordshire, a distance of 45 miles. The first tower, of which there will be 217, has recently been completed, the construction of the second is well advanced, while the foundations of another 45 have been placed. As will be seen from the accompanying illustration, these towers are of lattice construction, the material used for the main legs, cross-arm members and chief bracings being high-tensile steel, while the remainder is mild steel. The total weight of a straight line tower is about 11 tons, of which about 6.6 tons is high-tensile steel; and the four legs on which it is supported are carried on foundations which are sunk to a depth of 10 ft. 6 in., the base being 26 ft. by 25 ft. Each tower is 136 ft. 6 in. high, compared with the 85 ft. of a standard tower on the 132-kV system. They are being fabricated by Messrs. Painter Brothers, Limited, Hereford, to the designs of Messrs. Blaw Knox, Limited, Brompton-road, London, S.W.3.



and the main contractors for the erection work are Messrs. J. L. Eve Construction Company, Limited, 17, Hill Side, Ridgway, Wimbledon, London, S.W.19.

Normally the towers will be spaced at distances of 1,200 ft. and will carry two three-phase circuits, each consisting of two steel-cored aluminium conductors per phase. These twin, or "bundled," conductors will be suspended 12 in. apart in the horizontal plane and will be made up of 54 aluminium wires, each 0.125 in. in diameter, and seven steel wires of the same section, the aggregate cross-sectional area being equivalent to 0.4 sq. in. of copper. The spacing at the middle cross arm will be 37 ft. 6 in. The height of the towers is such that it will be possible to operate the line at 380 kV should that become desirable in future. To do so will, however, necessitate a greater number of insulators of new design.

GERMAN RADIO AND TELEVISION EXHIBITION.—We are informed by John E. Buck & Co., 47, Brewer-street, London, W.1, that this exhibition at Düsseldorf will now be held from August 29 to September 6, 1953.

TRADE PUBLICATIONS.

Lubrication of Oil Engines.—We have received from Shell-Mex & B.P. Ltd., Shell-Mex House, Strand, London, W.C.2, a book entitled *The Lubrication of Oil Engines*, a concise survey of modern practice that includes some notes on the causes and remedies of difficulties encountered in operating such engines. Copies may be obtained from any of the divisional offices of the company.

Electrical Equipment for Overseas Markets.—The General Electric Co. Ltd., Kingsway, London, W.C.2, have published a 190-page supplement to their recent handbook. This contains fully illustrated particulars of such typical examples of the company's products as switchgear, transformers, motors, control equipment, cables and telephones, and is specially designed to assist the overseas engineer in ordering.

Chimney Cows.—W. H. Colt (London) Ltd., Surbiton, Surrey, have sent us a descriptive booklet and lists of distributors of their chimney cows.

Bifurcated Fan Units.—We have received an illustrated leaflet from Keith Blackman, Ltd., Mill Mead-road, Tottenham, London, N.17, giving details of dimensions and performance ratings of their bifurcated fan units.

Freight Rolling Stock.—An illustrated catalogue describing heavy-duty wagons for steelworks, also scale cars and railway wagons, has been published by Head, Wrightson & Co. Ltd., Teesdale Iron Works, Thornaby-on-Tees.

Machine Tools.—Burton, Griffiths & Co. Ltd., Marston Green, Birmingham, have published a catalogue listing the machine tools manufactured by all the companies for whom they are the agents. They have also issued an illustrated catalogue and a number of illustrated broad-sheets describing the products of B.S.A. Tools Ltd., for whom they are the sole distributors in Great Britain.

Automatic Controllers.—Negretti & Zambra, Ltd., 122, Regent-street, London, W.1, have sent us an illustrated manual of 108 pages describing the many types of instruments they manufacture for controlling temperature, pressure, humidity, electric currents, etc.

Flexible Couplings.—We have been sent an illustrated broadsheet relating to the flexible couplings made by the Renold & Coventry Chain Co., Ltd., 28, Deansgate, Manchester, 3.

Expansion Joints for Steam Pipes.—An illustrated catalogue describing expansion joints of the piston-ring type for steam pipes and other similar installations has been sent to us by Foster Brothers, Ltd., Lea Brook Works, Wednesbury, Staffs.

Vibrating Feeders.—Podmores, Ltd., Pyenest-street, Shelton, Stoke-on-Trent, Staffs, have issued an illustrated pamphlet concerning their electrically-powered vibrating tables for handling, sorting and packing granular materials or small components.

Moving-Coil Headphones.—Standard Telephones & Cables Ltd., Aldwych, London, W.C.2, have sent us literature on the moving-coil headphones which they manufacture for a frequency range of 50 cycles to 10 kilocycles per second.

Electronic Control Equipment.—Details of their electronic process timers and of their electronic pyrometer controller are given in leaflets received from Elcomet Ltd., 10, Wyndham-place, London, W.1

CONTRACTS.

THE BRUSH ELECTRICAL ENGINEERING CO., LTD., Loughborough, have obtained an order for a second 12,500-kW Brush Ljungström turbo-alternator set from the Jamaica Public Services. Both sets are to be installed in the Hunts Bay power station, Kingston, Jamaica.

TERSONS LTD., 1, Seward-street, Goswell-road, London, E.C.1, have obtained the contract for the provision and removal of a temporary footbridge, and repairs to the footbridge, roofs and buildings at Harrow and Wealdstone station, London Midland Region, British Railways.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have obtained the contract for two television installations, each complete from cameras to receivers, from the Department of Public Relations, Government of Thailand. Each installation consists of a Marconi image Orthicon television camera, camera control, together with low-power sound and vision transmitters and associated equipment. Both systems will operate on a 625-line standard. The contract also requires the supply of 16-in. metal-tube domestic receivers for each installation. These will be supplied through the ENGLISH ELECTRIC CO., LTD.

MCCALLS MACALLOY LTD., Templeborough, Sheffield, are to share in an 8 million-dollar contract to build what is described as the longest bridge in the world in Florida, U.S.A. The Lee McCall system of prestressed concrete is to be adopted for about three miles of trestle bridge at Tampa Bay, part of a crossing of 15 miles, including 11 miles over water. The bridge completes the gulf-coast highway along the west shore of Floriada.