EXHIBITION OF OLD MACHINE TOOLS AT BIRMINGHAM.

THE most recent addition to the exhibition rooms at the Birmingham Museum of Science and Industry, Newhall-street, Birmingham, is a display of machine tools of the Eighteenth and Nineteenth Centuries. It is to remain open in its present form until April 26; after that date, changes will be made in some parts of the display. The term "machine tool" has been interpreted in its widest sense in bringing together the exhibits, and, while most of them are lathes of various patterns, there are examples of machines for ornamental turning, planing, wire-drawing, press working, and thread-rolling. Practically all of the exhibits have a definite connection with one or other of the staple trades of Birmingham, and several have only been withdrawn from use in local factories in recent years.

The oldest type of machine on exhibition is the goldsmith's pole lathe illustrated in Fig. 1, herewith. It is representative of a principle that was in use for centuries, though the date of construction of the exhibit is about 1800. The lathe is complete with a selection of wooden chucks, and was used until a year or two ago for finishing watch backs and bezels. It is complete with the typical leather apron used to catch the gold turnings for re-melting. Contrasting sharply with the pole lathe, which is of extremely simple design, are the two treadle centre lathes, shown in Fig. 2, above, and Fig. 3, on page 290. The lathe shown in Fig. 2 is claimed to have been the property of Matthew Boulton. It can swing a work-piece about 12 in. in diameter, and can take 3 ft. 6 in. between the centres. The lathe is almost entirely of wooden construction, but it has a cast-iron tailstock and slide rest, and on the bed there are two strips of 2 in. by $\frac{1}{4}$ in. wrought iron. The bearings are simple cone pivots on the flywheel shaft, and the same type of bearing is used to take the thrust at the back of the headstock. A split cast-iron bearing carries the main spindle at the face-plate end. The flywheel is of built-up wooden construction, with large blocks of lead fixed near the rim to give the necessary weight. Two of the most interesting features of the lathe are the method of driving, and the slide rest. As will be seen from the illustration, there is a two-step cone pulley on the headstock, and the flywheel is made to match. The original driving belt is missing, but an old photograph in the possession of the Museum shows that there were, in fact, two driving belts normally in position. Each belt was made endless by the unusual contrivance of a buckle, and either speed could thus be used simply by tightening one buckle and slackening the other. The belt not in use hung free. The slide rest is clamped to the bed by a screw and a T-handle, as can be seen from the illustration, and has two screw-controlled slides at right angles to each other. It is thus a true compound slide rest. There is a good selection of box chucks, face plates, and driving carriers with the lathe.

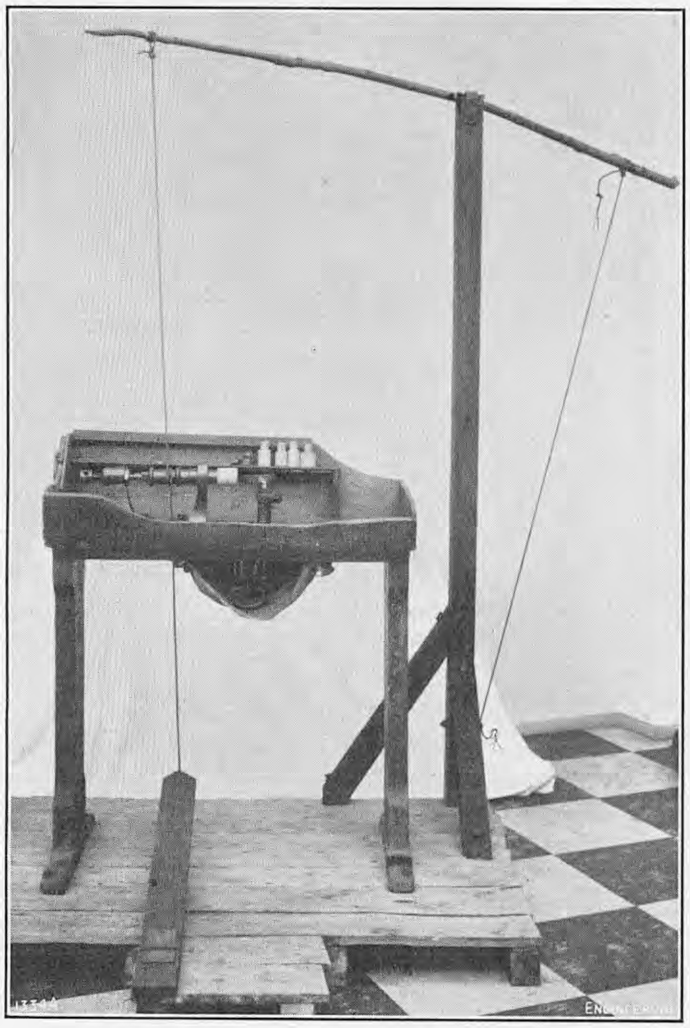


FIG. 1. GOLDSMITH'S POLE LATHE, c. 1800.

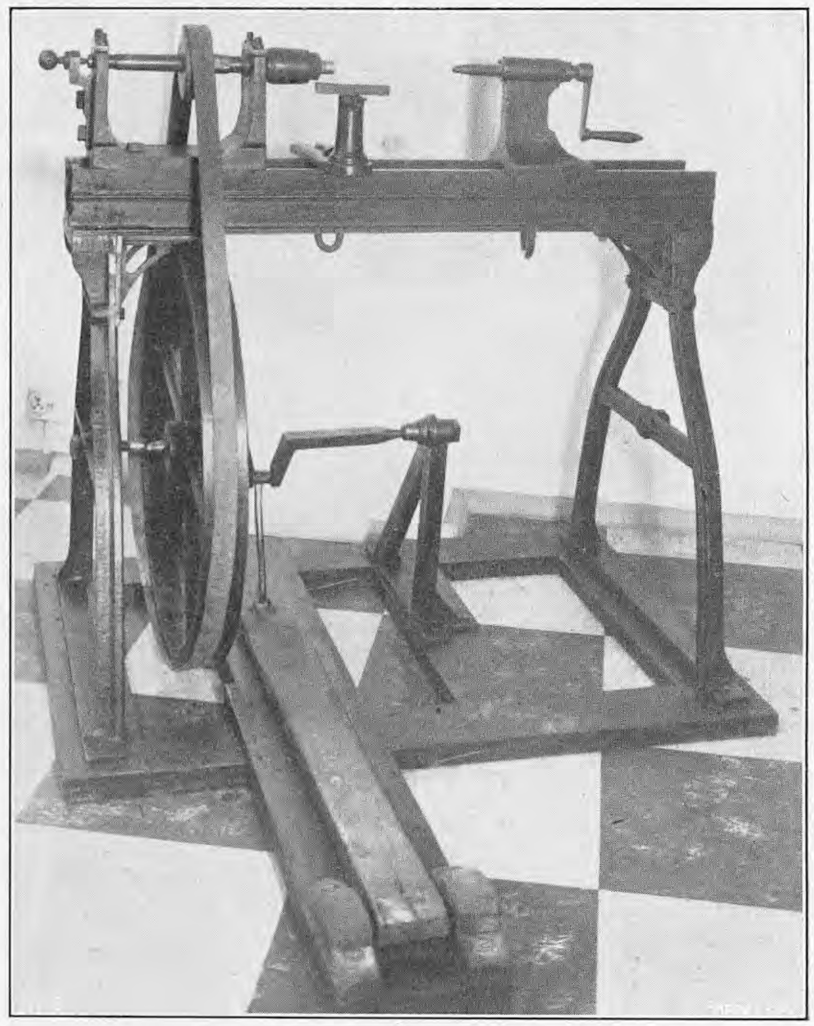


FIG. 2. TREADLE CENTRE LATHE.

The lathe shown in Fig. 3 is of about the same period as the Boulton lathe—mid-Eighteenth Century—and can take work of about the same diameter. It has 7-in. centres, against $6\frac{3}{4}$-in.; but the bed is shorter, and the maximum length between centres is 17 in. It has many features which are of a much more advanced design than that of the Boulton lathe. No wood is used in its construction, which is entirely of cast and wrought iron. The flywheel is carried on cone pivots, and the headstock spindle is mounted in a split cast-iron bearing at the front. The end thrust at the back of the headstock spindle is taken on a cone pivot. The tool rest is of simple form. It is in the method of construction that the most interesting features of the lathe are to be found. It has obviously been designed with the object in mind of producing a number of lathes. Both legs have been made from the same pattern, for, as the illustration shows, the cone-pivot boss, which is only necessary on the left-hand side, has also been cast on the right-hand leg. The bed is cast in two identical halves, and bolted to the legs. This unusual dividing of the bed may be explained by the fact that designing it in such a way avoided the need for coring. No other component required the use of cores, and it was thus possible to cast the entire lathe in simple greensand moulds.

The fly press shown in Fig. 4, on page 290, was used in a tinsmith's shop, and dates from the Eighteenth Century. It is of interest as a fine example of the blacksmith's art. The entire body is a one-piece forging of wrought iron, and has a rectangular drifted hole in the upright portion to carry a stripping plate when the press was used for blanking. There is no machining on the press body except at the top, where the bronze nut for the operating screw is housed. The three-start screw is hand-cut, with a square thread. Evidence of the hand cutting can be seen at the upper end of the screw, where the original scribed lines are still visible.

Another piece of equipment used until recently in the Birmingham jewellery trade is the draw bench shown in Fig. 5, on page 290. It is almost entirely of wood, the only metal parts being the gears, the chain and gripping dog, and the draw plates. The bench was made about 1860, and was used for drawing precious-metal wire for watch-case making. A wide selection of draw plates is exhibited with the machine, showing examples of round, square, and special bezel sections of many kinds. The gear drive, which has a ratio of 6 to 1, consists of a pair of cast-iron unmachined gears, with a wrought-iron crank. The gears transmit the torque to a drum on which is wound a $\frac{3}{8}$-in. wrought-iron short-link

EXHIBITION OF OLD MACHINE TOOLS.

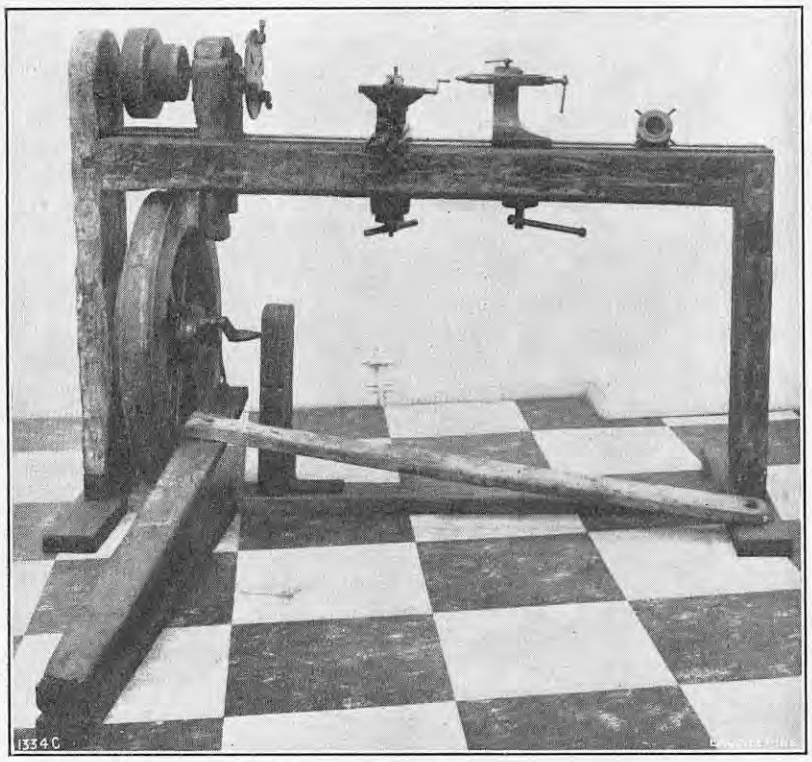


FIG. 3. TREADLE LATHE; MID. 18TH CENTURY.

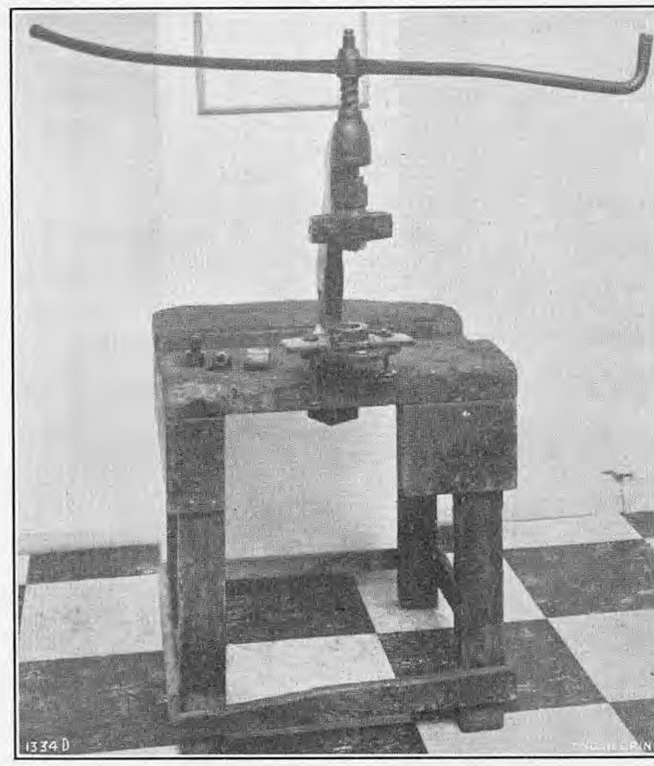


FIG. 4. TINSMITH'S FLY-PRESS.

chain, terminating in a gripping dog. The bed of the machine is enclosed, as will be seen from the illustration, and a hole is provided, behind the draw plate, so that the precious-metal swarf produced during drawing operations can be swept into a drawer for recovery.

Among the other exhibits in the collection are a thread-rolling machine of 1878, a pewterer's spinning lathe, a planing machine, and several scale models. The thread-rolling machine, which was made by Richard Holliday of Birmingham, has three thread-forming rolls, to which access is gained through an aperture in the side of one of the housings. The machine is driven by hand, and one revolution of the hand crank lowers the top roll into its working position, forms the thread on the material inserted, and lifts the top roll again so that the finished screw can be removed. It produces a thread of standard $\frac{3}{8}$-in. Whitworth form, with 16 threads per inch.

The planing machine is capable of taking work measuring up to 3 ft. by 6 in., and is driven by hand, in much the same way as Richard Roberts's machine of 1817. A hand capstan is mounted on a horizontal drum, which traverses the machine table by means of chains passing over guide pulleys on the ends of the bed. The machine dates from the early Nineteenth Century, and it bears clear indications of having been altered to chain drive from an original rack and pinion. The driving chain is of the malleable cast-iron flat type commonly used on agricultural machinery, and the original bearing points for the pinion shaft can still be seen. The Museum authorities believe that the conversion was made because difficulties were experienced with chatter when the rack and pinion were used.

Ornamental turning is represented by two rose engines, one of which, shown in Fig. 6, on Plate VI, is a particularly fine exhibit, both from the point of view of design and from its state of preservation; it is on loan, with a number of other exhibits, from the private collection of Mr. J. F. Parker, F.S.A., of Tickenhill Manor, Bewdley. It was made in France about 1760, probably by Lecroix, and was once in the private workshop of Louis XVI. The bed and legs are of mahogany, and the remainder of the machine is principally of brass. The illustration shows clearly the treadle drive, and the hand crank-operated "inching" device used for setting the machine. The main drive has an interesting belt-tensioning arrangement. Two pairs of anti-friction wheels carry the flywheel spindle, and these wheels are mounted in brackets which can be raised or lowered by means of a screw.

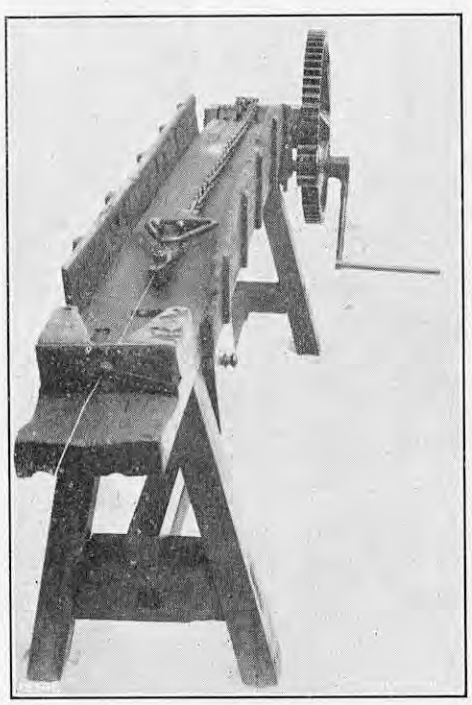


FIG. 5. DRAW-BENCH.

The automatic lathe shown in Fig. 7, on Plate VI, which is on loan to the Museum, was at work recently in a Birmingham factory, and may be put to use again. It was made by the Swiss firm of Petermann, which was founded in 1902, and is claimed to be one of the first machines produced by them. It was used for high-speed automatic turning of taper pins for watch-case hinges, and can deal with wire stock up to a maximum of $\frac{1}{8}$-in. diameter. The work is fed forward to the tools by a cam at the back of the machine.

LITERATURE.

Designing by Photoelasticity.

By DR. R. B. HEYWOOD. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 65s. net.]

THE remarkable advances that have been achieved in photoelasticity during the past 20 years or so have transformed an interesting and rather pretty scientific demonstration into an engineering research method of considerable precision and great power within an important, if still limited, field of stress analysis. These qualities have been tested, proved in practice, and are now generally accepted; the apparatus and techniques have been formalised; and photoelastic investigation now lies, in consequence, within the province of the experimental engineer rather than of the applied physicist, dependent for its future exploitation more upon the phenomena of mechanical stress than those of polarised light.

The scope and arrangement of Dr. Heywood's book are influenced by this point of view. With the research engineer in mind, he introduces his subject by a concise and somewhat simplified, but adequate, account of the physics of polarised light and photoelastic phenomena. The reader is thus prepared for the ensuing discussions which deal, in turn, with the specific functions and components of polariscopes for photoelastic investigation, with the construction, treatment and loading of photoelastic models, and with the photography of strain fringe patterns. As a photoelastic designer of long experience, Dr. Heywood can speak with authority on all such practical matters, and he presents a wealth of useful information about the properties and peculiarities of the various synthetic plastic substances that have been developed for photoelastic research, and about the methods that have been found most appropriate for conducting experiments and interpreting their results. The importance of the physical behaviour of new substances, synthesised and pre-treated specifically for photoelastic work, and of the techniques that have been devised to achieve the most satisfactory results with them, are well exemplified in an excellent

EXHIBITION OF OLD MACHINE TOOLS AT BIRMINGHAM.

(*For Description, see Page* 289.)

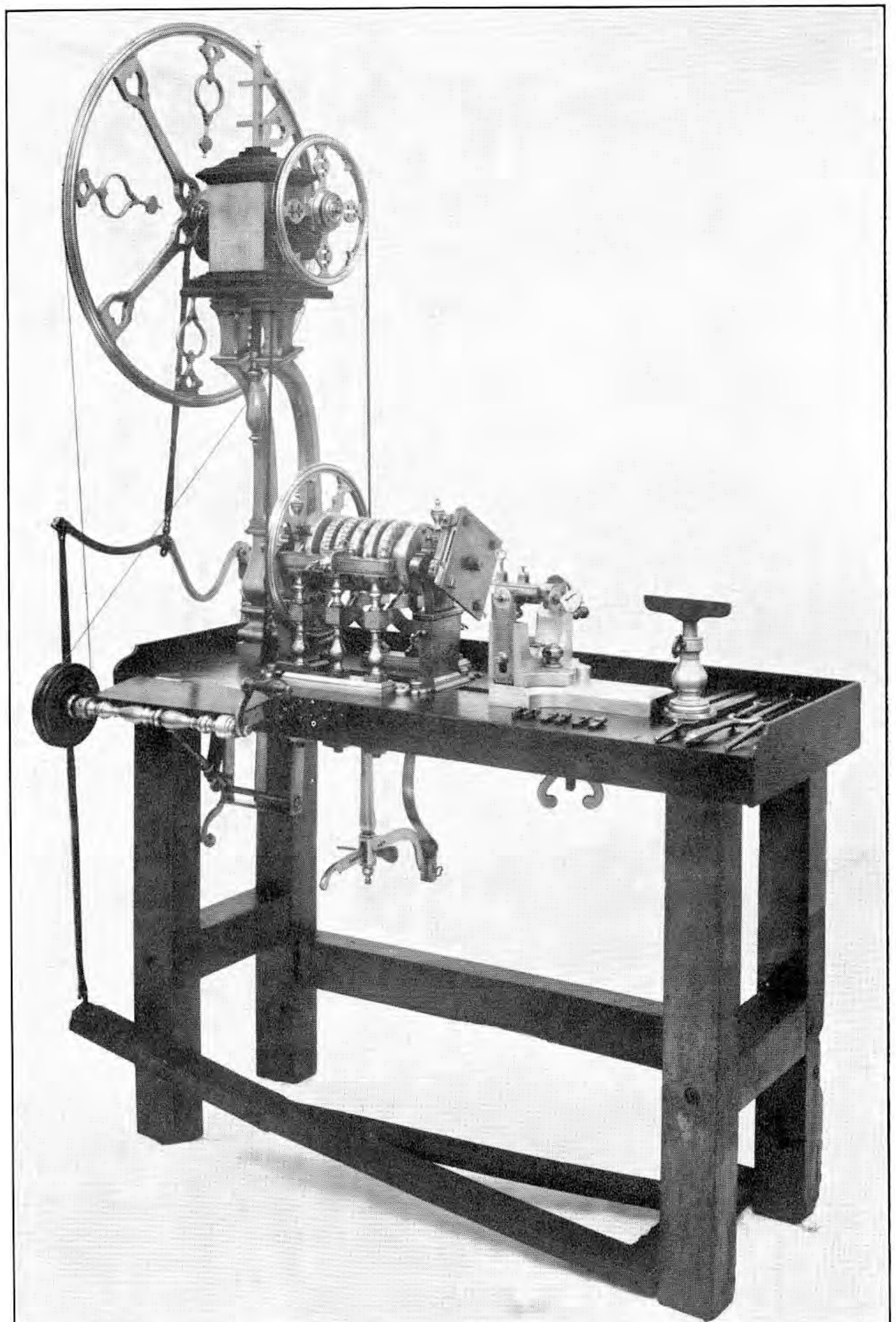


FIG. 6. 18TH-CENTURY ROSE ENGINE.

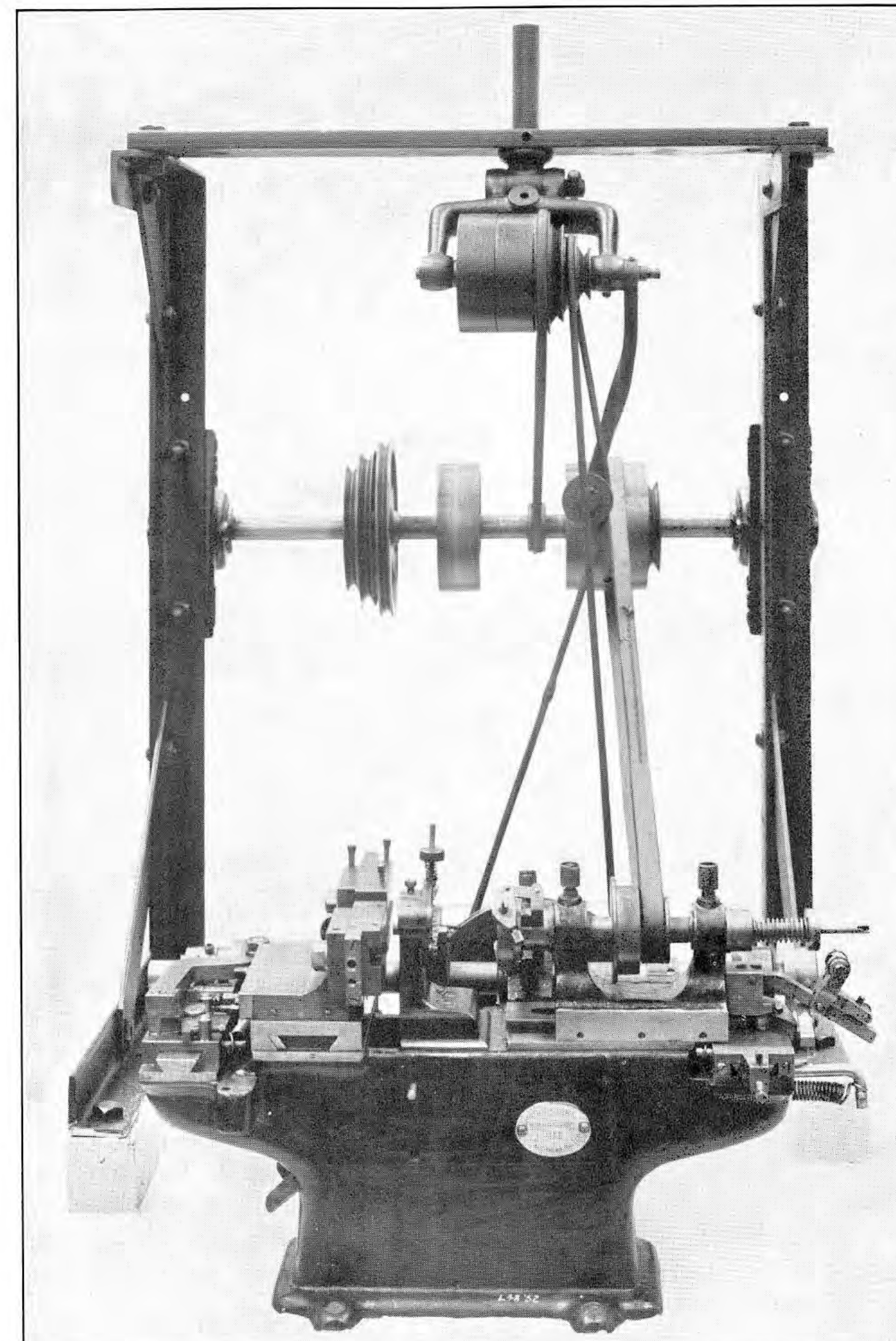


FIG. 7. AUTOMATIC LATHE FOR TURNING TAPER PINS.

survey of "frozen-stress" and other procedures for three-dimensional stress analysis.

The second, and slightly the larger, part of the book is concerned with the solution of design problems by means of photoelastic models. For the most part, they are studies of the stress concentrations due to abrupt changes of cross-section, for which photoelastic analysis offers a convenient and convincing alternative to the often intractable or unduly approximate mathematical approach. Dr. Heywood deals in considerable detail with the concentrated local stresses due to notches, holes, screw threads, gear teeth and fillets, comparing and supplementing the results of mathematical analyses, when they exist, with those achieved by himself and other photoelastic experimenters. The emphasis is strongly on the contribution of such work to precise engineering design; not solely as a means whereby designers can solve their own new problems, or have them solved for them by a photoelastic analyst, but also as providing final and satisfactory solutions to typical classical problems of stress distribution.

The quantitative applications of photoelastic research to design, facilitated by the author's presentation of tabulated and graphical data, are discussed in his concluding chapters; along general lines on the whole, yet with particular reference to the relationships between numerical stress-concentration factors and the shape, physical properties, mode of straining and actual service behaviour of the engineering materials in which they occur. Dr. Heywood writes instructively, in this connection, about cyclic as well as static regimes of stress, and describes how optimum forms and proportions of fillet junctions have been developed by experimental photoelasticity. Here, as elsewhere, he makes it abundantly clear that, while the potentialities of photoelasticity are as yet far from being fully explored, the results already achieved and represented in this book warrant the careful study of all engineering designers, especially those engaged on any type of aeronautical work, where reliable knowledge of stress means so much when translated into weight reduction and increased safety.

Nomography and Empirical Equations.

By PROFESSOR LEE H. JOHNSON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 3·75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 30s. net.]

THE collection of reliable quantitative experimental and operational data is of primary importance, but it can serve little purpose unless presented in a form in which it can be most readily and effectively used. The object of this book is to explain two useful techniques for making the most efficient use of such data. These are nomographs, which furnish quick graphical answers where numerical data have to be transmuted into formulæ, and empirical equations, which provide mathematical expressions for data plotted in the form of curves.

Nomography is treated first and is introduced by a description of scales and their graduation, scale and plotting moduli, and matching points, simple illustrations of which are supplied by pairs of scales on the same axis. The remainder of the first part deals, in turn, with parallel-scale nomographs, Z-charts, parallel and perpendicular index lines, concurrent scales, recurrent variables and combined nomographs. Though nomographs are easy to use, they are not always easy to construct. The underlying theory is here presented in its simplest form, based on the properties of similar triangles. Professor Johnson shows how desirable it is to make a preliminary study of the form of the equation and of the ranges of all the variables in the equation in order to determine the most practically useful arrangement of the scales before plotting the nomograph. There is also a valuable discussion on the effect of scale arrangement upon relative errors, and on the advantages and disadvantages of alternative types of nomograph. For plotting subdivisions on uniform, square root and logarithmic scales, the two separate charts contained in a pocket attached to the back cover will be found of assistance. Practical hints are provided on the technique of reading off results from nomographs; and the exercises, covering a wide variety of problems in science and engineering, will serve to familiarise the reader with the construction of all types of nomograph.

Empirical equations are dealt with in Part II, which opens with a general account of methods of curve fitting, the aim of which is to ascertain the type of curve which most closely fits the plotted observational data and to determine the constants in the equation of that curve. The important classes of curves involving two constants which can be "rectified," by a suitable choice of variables, to yield a straight-line plot are considered first. For evaluating the constants represented by the slope of the line and its intercept on the ordinate axis the methods of selected points, of averages and of least squares are described and compared. The abscissa values are assumed to be free from error and no attempt is made to apply the least-squares criterion where both abscissa and ordinate values are liable to error, though such a situation does often arise. Curves of three constants are less easy to handle, though, when the form of the corresponding function can be predicted, it is generally possible to devise special methods to simplify the task of evaluating these constants. A few of the recognised procedures adopted for this purpose are described and illustrated. Curves involving four constants are occasionally encountered and those dealt with include the commonest polynominal form, together with certain special types consisting of a pair of superimposed curves, one of which makes a negligible contribution over a certain range of values of the independent variable and a predominating contribution over another range. Each chapter ends with a representative selection of problems and there is, in conclusion, a summary indicating the appropriate test plots for each of the curves considered. Though quite short, this book provides a handy and thoroughly practical introduction to an important subject.

The Agricultural Tractor.

By P. H. SOUTHWELL. Temple Press, Limited, Bowling Green-lane, London, E.C.1. [Price 15s. net.]

THE author of this book is a member of the staff of the National Institute of Agricultural Engineering and has had considerable experience in the testing of agricultural tractors, some of which experience was embodied in the article on "The Elements of Agricultural Tractor Performance" which we published on page 6, *ante*. The book, he states, has been written "for readers with some knowledge of engineering or agriculture and . . . particularly for agricultural engineering students" and, with the interests of the latter class in mind, begins with chapters on engine design and performance. These chapters, while assuming little specialised knowledge on the part of the reader, do assume that he has some acquaintance with engineering; and they are followed by others which take him into fields that require some familiarity with the principles of design. The later chapters, indeed, are such as to justify the expressed hope that the book will "prove to be of value to professional agricultural engineers." Mr. Southwell writes clearly and concisely, and his treatment of tractor performance and testing, especially, should assist those who own and have to maintain tractors to treat them with an understanding of their capabilities and needs that cannot fail to be of advantage.

STRUCTURAL STRENGTH OF THIN-WALLED CHANNEL SECTIONS.

By J. M. HARVEY, B.Sc., A.R.T.C.

THIS article presents a theoretical analysis of local instability conditions under flexure in structural sections, utilising the conception of a "coefficient of edge fixity" introduced by S. Timoshenko.* This is applied to estimate the strength of uniformly compressed channel columns. The sections are of such proportions that failure is due to local instability of the plate components, which are assumed to be simply-supported at their ends. The theoretical variations obtained are compared with the results of experiments carried out on plain and lipped channel columns of varying section, proportions and constant length. This analytical and experimental work was carried out at the Royal Technical College, Glasgow, for the Ayrshire Dockyard Company, Limited, of Irvine.

NOTATION.

The following notation is employed, these symbols being used for the unstable "buckling" plate which defines the strength of the section. The same symbols with suffixes denote corresponding quantities for the stable "supporting" plate.

x, y, z = Rectangular co-ordinates of a point in the plate.
a, b, t = Length, breadth and thickness of the plate.
w = Deflection of the plate at the point (x, y, z).
σ = Poisson's ratio.
E = Modulus of elasticity in tension or compression.
$D = \dfrac{E t^3}{12(1-\sigma^2)}$ = Flexural rigidity of the plate.
M, V, T = Bending moment, shearing force and torque at the point $(x, y, z.)$
N_x = Compressive force per unit length of section perimeter.
f_c = Critical stress at a point.
f_y = Yield point stress.
m = Number of half waves in the direction of compression.

THEORETICAL ANALYSIS.

The same method is used for both the plain and the lipped channel sections and, as an illustration, the buckling of the flange of a plain channel section is worked out in detail. The results relating to the buckling of the web of a plain channel and the flange and web of inwardly and outwardly turned lipped channels are summarised in the form of graphs.

Assuming the axial load to be uniformly compressive, each plate component is subjected to a constant compressive force per unit length of section perimeter of magnitude N_x (Fig. 1, page 292). The differential equation for the deflected form of a longitudinally compressed plate, with N_x positive for compression, is given by Timoshenko† as

$$\frac{\partial^4 w}{\partial x^4} + \frac{2\,\partial^4 w}{\partial x^2\,\partial y^2} + \frac{\partial^4 w}{\partial y^4} = \left(-\frac{N_x}{D}\right)\left(\frac{\partial^2 w}{\partial x^2}\right). \quad (1)$$

Assuming that the plate buckles in m sinusoidal half waves, the solution of this equation can be written in the form

$$w = f(y) \sin \frac{m \pi x}{a}, \quad . \quad (2)$$

where w is the deflection of the plate perpendicular to its plane. This satisfies the condition that the ends are simply-supported, i.e., that the

* *Theory of Elastic Stability*, by S. Timoshenko, pages 342-344.

† *Loc. cit.*, page 337.

STRENGTH OF THIN-WALLED CHANNEL SECTIONS.

Fig. 1.

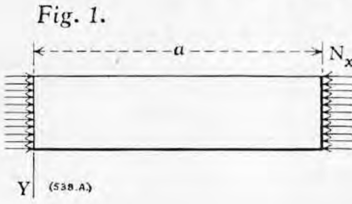


Fig. 2.

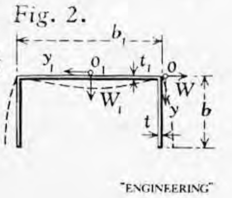


Fig. 3. NUMERICAL VALUES OF k IN EQUATION (19) FOR FLANGE FAILURE OF A PLAIN CHANNEL SECTION.

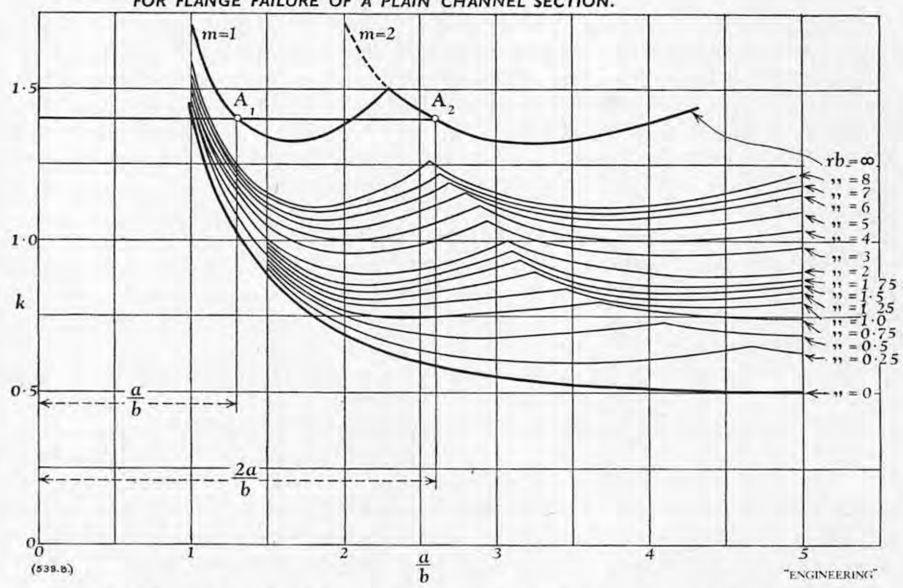
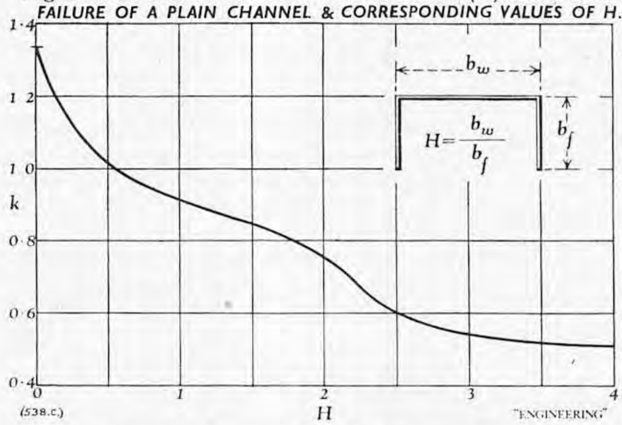


Fig. 4. NUMERICAL VALUES OF k IN EQUATION (19) FOR FLANGE FAILURE OF A PLAIN CHANNEL & CORRESPONDING VALUES OF H.



deflection and moments are zero at the ends, since $w = 0$ and $\frac{\partial^2 w}{\partial x^2} + \sigma \frac{\partial^2 w}{\partial y^2} = 0$ for $x = 0$ and $x = a$.

The general solution can then be represented in the form

$$w = (C_1 e^{-\alpha y} + C_2 e^{\alpha y} + C_3 \cos \beta y + C_4 \sin \beta y) \sin \frac{m \pi x}{a}, \quad (3)$$

where

$$\alpha^2 = \frac{m^2 \pi^2}{a^2} + \left[\left(\frac{N_x}{D}\right)\left(\frac{m^2 \pi^2}{a^2}\right)\right]^{\frac{1}{2}},$$

$$\beta^2 = -\frac{m^2 \pi^2}{a^2} + \left[\left(\frac{N_x}{D}\right)\left(\frac{m^2 \pi^2}{a^2}\right)\right]^{\frac{1}{2}}.$$

An equation such as (3) holds for both the flange and the web, and the constants of integration C_1, C_2, C_3, C_4 in each case must be determined from the conditions of constraint along the edges $y = 0$ and $y = b$.

Considering first the supporting plate: in this case, the web

$$w_1 = (C_1' e^{-\alpha_1 y_1} + C_2' e^{\alpha_1 y_1} + C_3' \cos \beta_1 y_1 + C_4' \sin \beta_1 y_1) \sin \frac{m \pi x}{a}. \quad (4)$$

The boundary conditions are

$$w_1 = 0 \text{ for } y_1 = -\frac{b_1}{2}, \quad . \quad (5)$$

$$w_1 = 0 \text{ for } y_1 = \frac{b_1}{2}, \quad . \quad (6)$$

$$\frac{\partial w_1}{\partial y_1} = 0 \text{ for } y_1 = 0, \quad . \quad . \quad (7)$$

the origin being taken at the centre of the web plate (Fig. 2).

The fourth necessary condition is obtained by assuming that the bending moment at the edge connecting the web and flange varies in a sinusoidal fashion along the length of the plate, i.e.,

$$M y_1 = M \sin \frac{m \pi x}{a}, \quad . \quad (8)$$

where M is the bending moment at the connecting edge at the centre of a longitudinal half wave.

Substituting these boundary conditions in equation (4), the values of the constants are obtained as

$$\left.\begin{aligned} C_1' = C_2' &= -\frac{M}{\left(\frac{2 D_1 \cosh \alpha_1 b_1}{2}\right)(\alpha_1^2 + \beta_1^2)}, \\ C_3' &= +\frac{M}{\left(\frac{D_1 \cos \beta_1 b_1}{2}\right)(\alpha_1^2 + \beta_1^2)} \\ C_4' &= 0. \end{aligned}\right\} \quad (9)$$

Considering now the buckling plate; in this case the flange

$$w = (C_1 e^{-\alpha y} + C_2 e^{\alpha y} + C_3 \cos \beta y + C_4 \sin \beta y) \sin \frac{m \pi x}{a}. \quad (10)$$

The boundary conditions are

$$w = 0 \quad \text{for} \quad y = 0, \quad . \quad (11)$$

$M = 0$ for $y = b$, *i.e.*,

$$\frac{\partial^2 w}{\partial y^2} + \sigma \frac{\partial^2 w}{\partial x^2} = 0 \quad \text{for} \quad y = b, \quad (12)$$

$V = 0$ and $T = 0$ for $y = b$, *i.e.*,

$$\frac{\partial^3 w}{\partial y^3} + (2 - \sigma) \frac{\partial^3 w}{\partial x^2 \partial y} = 0 \quad \text{for} \quad y = b, \quad (13)$$

the origin being taken at the edge of the flange plate (Fig. 2).

The fourth necessary condition is obtained from the web. By substituting the values of the constants given in (9) in equation (4) and differentiating, the slope at the connecting edge, i.e., for $y_1 = \frac{b_1}{2}$ is

$$\frac{\partial w_1}{\partial y_1} = -M \sin \frac{m \pi x}{a} \left\{ \frac{\alpha_1 \tanh \alpha_1 \frac{b_1}{2} + \beta_1 \tan \beta_1 \frac{b_1}{2}}{D_1 (\alpha_1^2 + \beta_1^2)} \right\}$$

$$= -M y_1 \times \frac{1}{r D_1}, \quad . \quad . \quad . \quad . \quad (14)$$

where r is the coefficient of edge fixity and

$$r = \frac{\alpha_1^2 + \beta_1^2}{\alpha_1 \tanh \alpha_1 \frac{b_1}{2} + \beta_1 \tan \beta_1 \frac{b_1}{2}}. \quad . \quad (15)$$

At the connecting edge,

$$\frac{\partial w_1}{\partial y_1} = -\frac{\partial w}{\partial y}; \; M y_1 = -M y,$$

and $$M y = -\frac{D \, \partial^2 w}{\partial y^2}.$$

So equation (14) becomes

$$-\frac{\partial w}{\partial y} = \frac{\left(-\frac{D \, \partial^2 w}{\partial y^2}\right)}{r D_1},$$

or

$$\frac{\partial^2 w}{\partial y^2} = \frac{r \, \partial w}{\partial y}, \quad \text{since} \quad D = D_1 \quad \text{for} \quad t = t_1. \quad (16)$$

This gives the fourth condition, which is

$$\frac{\partial^2 w}{\partial y^2} = \frac{r \, \partial w}{\partial y} \quad \text{for} \quad y = 0. \quad . \quad (17)$$

Applying the boundary conditions (11) and (17) in equation (10), the values of the constants C_1 and C_2 are obtained in terms of C_3 and C_4. Then, using conditions (12) and (13) and eliminating C_3 and C_4 from their relevant equations, a single equation defining the critical condition for the flange is found to be

$$\begin{aligned} &2 \beta s t + \beta (t^2 + s^2) \cos \beta b \cosh \alpha b \\ &- \left(\alpha t^2 - \frac{\beta^2 s^2}{\alpha}\right) \sin \beta b \sinh \alpha b \\ &+ \beta q s^2 \cos \beta b \sinh \alpha b \\ &- q \alpha t^2 \sin \beta b \cosh \alpha b = 0, \quad . \quad (18) \end{aligned}$$

where

$$s = \alpha^2 - \sigma \frac{\pi^2}{a^2}, \; t = \beta^2 + \sigma \frac{\pi^2}{a^2} \text{ and } q = \frac{\alpha^2 + \beta^2}{\alpha r}.$$

Since α and β contain N_x (see equation (3)), equation (18) can be used for the calculation of the critical value of N_x if the dimensions of the plate and the elastic constants of the material are known. The smallest value of N_x is obtained by taking $m = 1$, i.e., by assuming that the plate buckles in one half-wave in the direction of compression. The magnitude of the corresponding critical stress can be represented by the form

$$f_c = \frac{(N_x)_c}{t} = k \frac{\pi^2 D}{b^2 t}, \quad . \quad (19)$$

in which k is a numerical factor depending on the magnitude of the ratio $\frac{a}{b}$ and the coefficient of fixity r. The results of the calculations made for various values of rb and for $\sigma = 0 \cdot 25$ are given in Fig. 3. Additional curves for $m = 1, 2, 3$, etc., may be obtained by keeping the k ordinates the same, but multiplying the corresponding $\frac{a}{b}$ ordinates by the value of m. The construction is indicated in Fig. 3 with respect to points A_1 and A_2.

Considering the equation for the coefficient of edge fixity r, i.e., equation (15)

$$r = \frac{\alpha_1^2 + \beta_1^2}{\alpha_1 \tanh \alpha_1 \frac{b_1}{2} + \beta_1 \tan \beta_1 \frac{b_1}{2}},$$

the substitutions can be made of

$$b_1 = H b, \quad \text{where} \quad H = \frac{b_1}{b},$$

$$\alpha_1 = \alpha,$$

and

$$\beta_1 = \beta,$$

since, referring to equation (3), $D = D_1$ for a section of uniform thickness.

STRENGTH OF THIN-WALLED CHANNEL SECTIONS.

Fig. 5. NUMERICAL VALUES OF k IN EQUATION (19) FOR FLANGE OR WEB FAILURE OF A PLAIN CHANNEL & CORRESPONDING VALUES OF H.

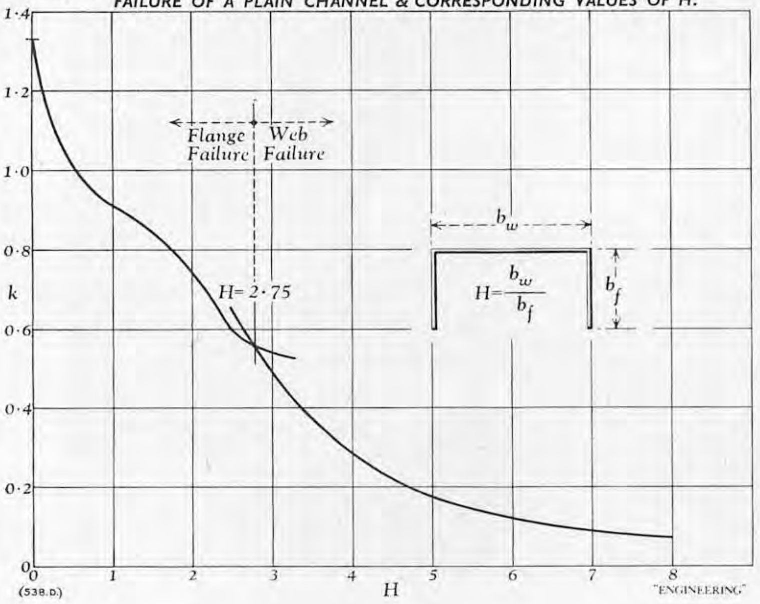


Fig. 6. NUMERICAL VALUES OF k IN EQUATION (19) FOR FLANGE OR WEB FAILURE OF AN INWARDLY TURNED LIPPED CHANNEL & CORRESPONDING VALUES OF H.

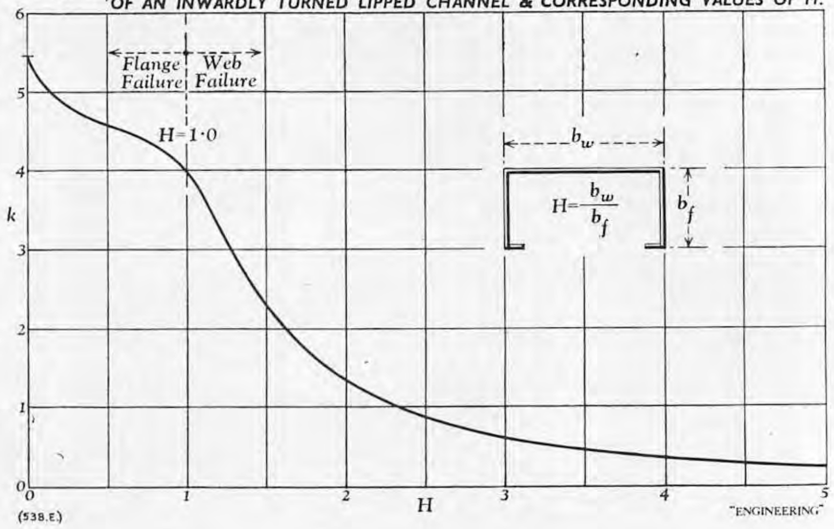


Fig. 7. COMPARISON OF THEORETICAL ELASTIC & ULTIMATE STRESS CURVES WITH EXPERIMENTAL RESULTS FOR PLAIN CHANNELS.

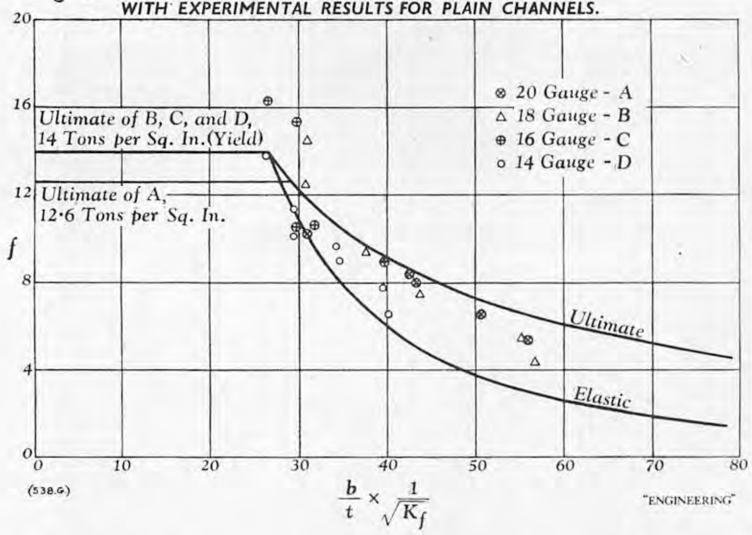


Fig. 8. NUMERICAL VALUES OF k IN EQUATION (19) FOR FLANGE OR WEB FAILURE OF AN OUTWARDLY TURNED LIPPED CHANNEL & CORRESPONDING VALUES OF H.

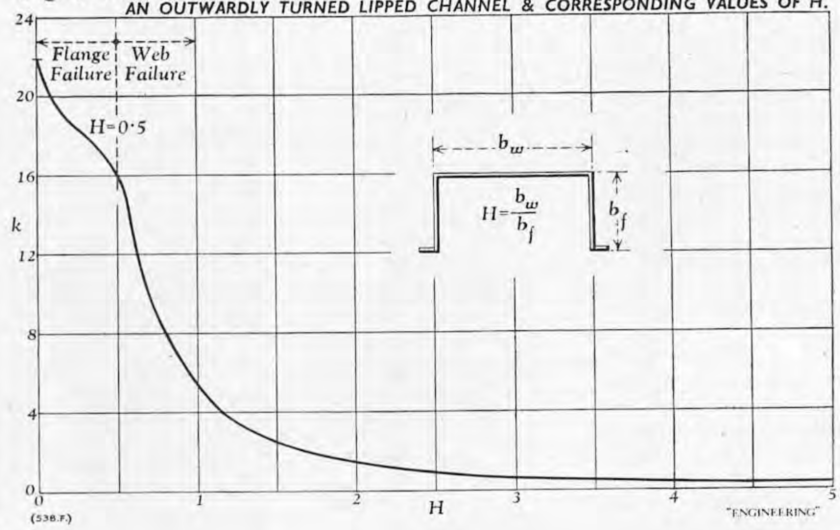
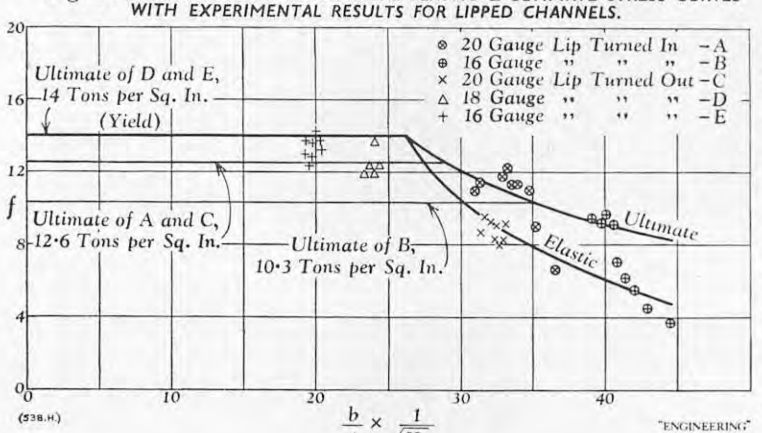


Fig. 9. COMPARISON OF THEORETICAL ELASTIC & ULTIMATE STRESS CURVES WITH EXPERIMENTAL RESULTS FOR LIPPED CHANNELS.



Equation (15) thus becomes

$$r = \frac{\alpha^2 + \beta^2}{\alpha \tanh H \alpha \frac{b}{2} + \beta \tan H \beta \frac{b}{2}}. \quad (20)$$

For any value of $r\,b$, the ratio $\frac{a}{b}$ at which k is a minimum can be obtained from Fig. 3. Using these values, the corresponding value of H is then obtained from equation (20). The results of these calculations are shown in Fig. 4.

Fig. 5 shows the values of k in equation (19) for web or flange failure of a plain channel section with the corresponding values of H.

This includes the values shown in Fig. 4. Figs. 6 and 8 show the corresponding values of k and H for inwardly and outwardly turned lipped channel sections, respectively. These were obtained by assuming that the lipped edge is equivalent to a simply-supported edge and that the number of half-waves across the width of the flange is 1 for inwardly turned lips and 2 for outwardly turned lips.

It should be noted that as, throughout the analysis, the determination of the critical stress of the section is based on the flange proportions, the values of k shown in the web failure range are equivalent values referred to the flange.

The experimental work was carried out on plain and lipped channel-section columns, fabricated by cold rolling or by pressing from sheet material. The mechanical characteristics of the finished sections were of the order, Young's modulus = 11,000 tons per square inch and yield stress = 14 tons per square inch. The columns were loaded through ball-and-socket end bearings and tested to destruction; the loads recorded were thus ultimate loads. Using the theory presented above, the elastic buckling stress for each section can be calculated using the values of the factor k obtained from the relevant Figs. 5, 6 or 8. Assuming the effective width conception, as proposed by Kármán and given by Timoshenko (*loc. cit.*, page 396), to hold, the ultimate load P is given by

$$P = \frac{(k)^{\frac{1}{2}}\, \pi\, t^2\, (E f_y)^{\frac{1}{2}}}{[12\,(1-\sigma^2)]^{\frac{1}{2}}}. \quad (21)$$

Therefore, by inserting the factor k already obtained for the elastic buckling stress in equation (21), the ultimate stress for each section can be estimated.

The theoretical elastic and ultimate stress curves thus obtained are compared with the experimental results in Figs. 7 and 9, the basis of plotting being selected to give single theoretical curves for all thicknesses in the instability range. The limiting stress for zero flange width is given by the yield stress value for the material or by the relevant ultimate stress for the web in the particular gauge, whichever is the smaller.

From Figs. 7 and 9 it can be seen that reasonable agreement between experiment and theory is obtained. The scatter shown, particularly when approaching or in the material-failure range, is due to the variation in the value of the yield stress for the different gauges, that for 18-gauge lipped channels being lower than the average of 14 tons per square inch. For design purposes, a scatter of this type can be allowed for by fitting a Perry-Robertson type of transition curve to the lower scatter boundary of the experimental results.

40-MVA SYNCHRONOUS CONDENSER.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., MANCHESTER.

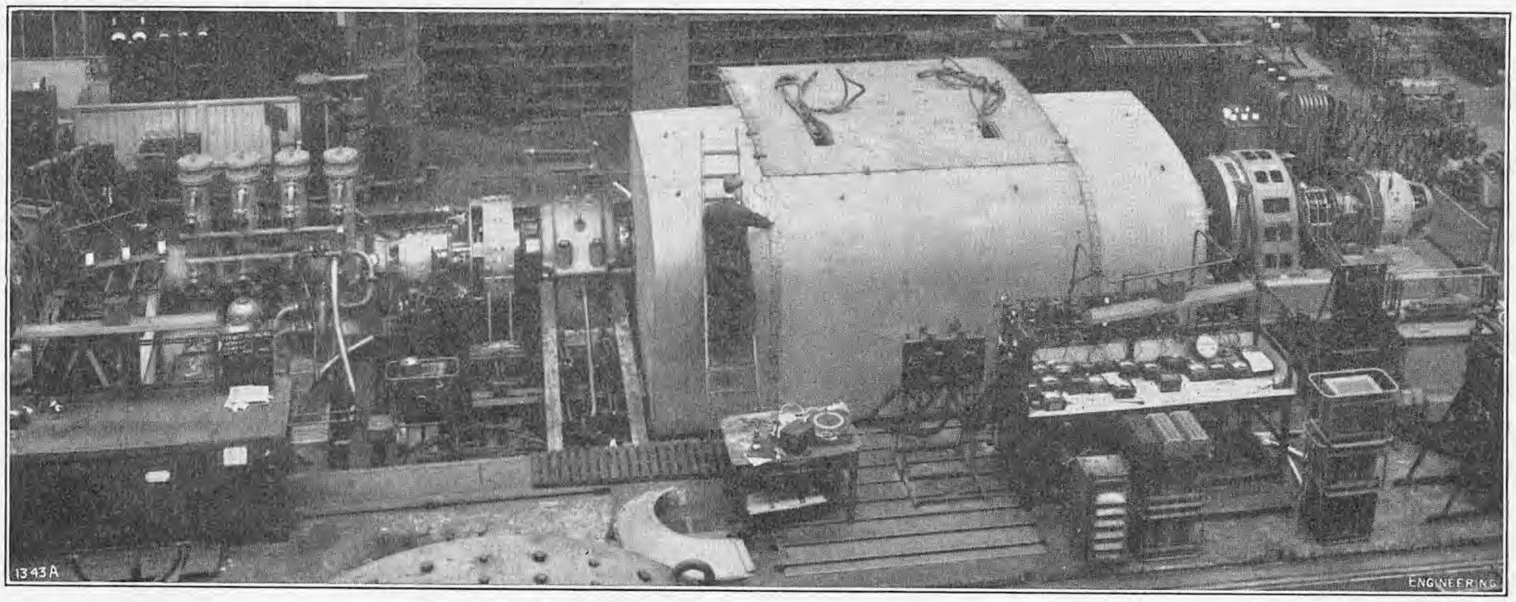


FIG. 1. 40-MVA CONDENSER ON TEST BED.

40-MVA SYNCHRONOUS CONDENSER FOR AUSTRALIA.

It has now become common practice in countries where electricity is transmitted over long distances without intermediate tapping points to install synchronous condensers at the receiving ends of the lines. It is thus possible to compensate for a lagging power factor when the system is fully loaded and for a leading power factor at times of light load; while, what is more important, the use of these machines enables a constant voltage to be maintained automatically at all loads. A further result of the employment of these machines is that the stability limits of the system are increased and the operating costs reduced. Moreover, higher power factors are permissible on the alternators, thus giving increased economy, which may be set against the cost of the condenser itself.

The Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, have done a considerable amount of pioneer work in connection with the development of synchronous condensers, a number of which, with capacities up to 20 MVA, are in operation on the system of the South African Electricity Supply Commission, and elsewhere. They have also recently completed a set for the State Electricity Supply Commission of Victoria, Australia, which is the largest of its type to be manufactured in this country and, besides having a number of other special features, to which reference is made below, is peculiar in being designed for a speed of 1,000 r.p.m., compared with the usual figure of 750 r.p.m., or less. This machine, which is shown on the test bed at Trafford Park in Fig. 1, has a rating of 40 MVA at 20 kV and zero leading power factor (over excited) and of 25 MVA at the same voltage and zero lagging power factor (under excited). It is to be installed in the Malvern station on the outskirts of Melbourne, which forms the terminal of a 220-kV line, and will be directly connected to 22-kV 'bus-bars and used to control a distribution system operating at that voltage. It may also be used for charging the 220-kV line.

STATOR CONSTRUCTION.

The stator frame is built up of steel plates which are welded together to form a rigid structure of hollow box form. The core consists of silicon-alloy segmental stampings of the "straight back" type with non-magnetic tooth supports and vent spacers, and is supported on bars welded to the ribs of the frame. The winding, which is shown in course of assembly in Fig. 2, is of interest owing to the unusually high voltage. It is of the two-layer type, all the coils being identical, with formed involute ends. These ends are supported on segmental rings, which are carried by Permali brackets bolted

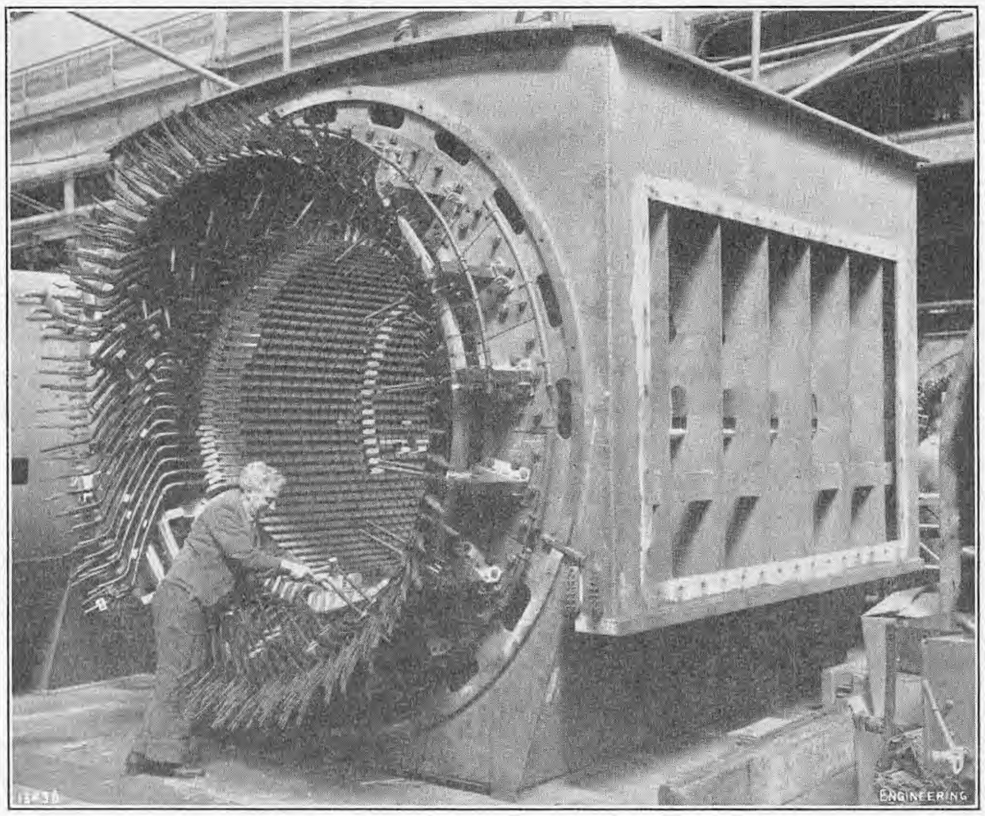


FIG. 2. STATOR IN WINDING BAY.

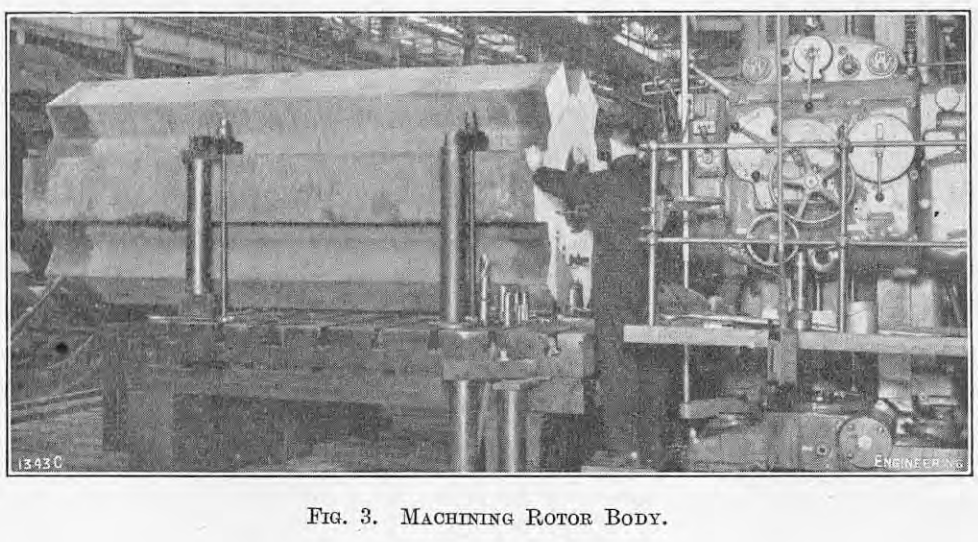


FIG. 3. MACHINING ROTOR BODY.

40-MVA SYNCHRONOUS CONDENSER.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., MANCHESTER.

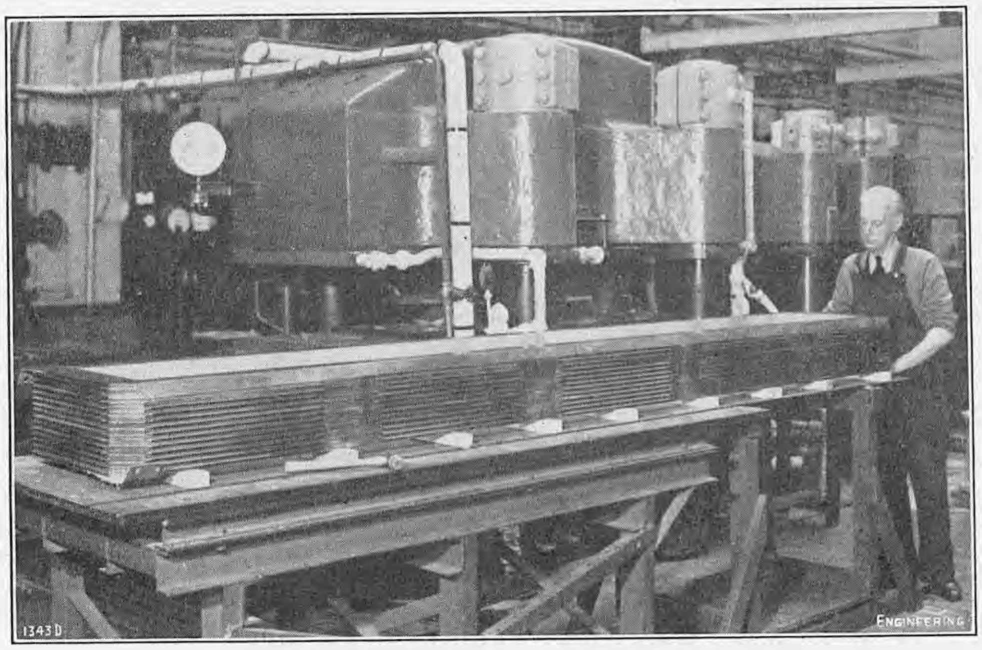


FIG. 4. FABRICATED ROTOR COIL IN PRESS.

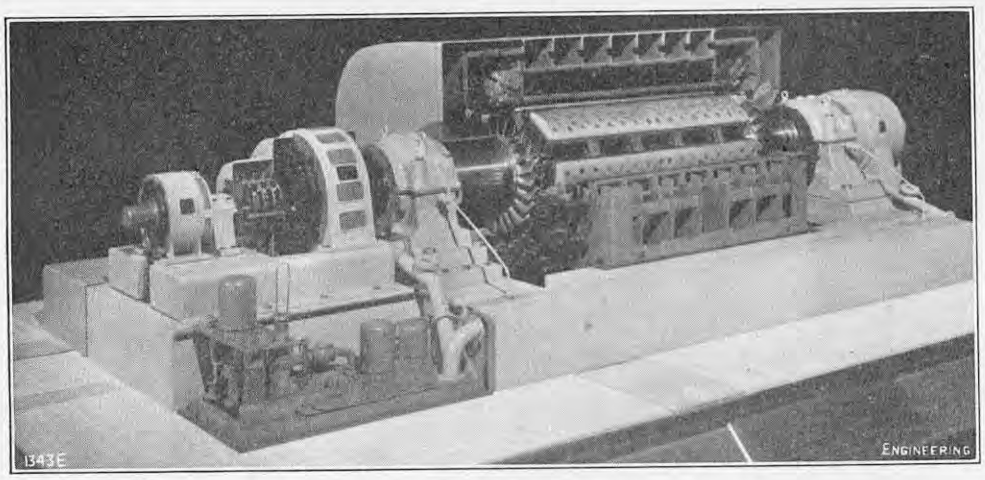


FIG. 5. SECTIONED MODEL OF CONDENSER.

to the core end plates. Packing blocks are placed between adjacent coils to prevent any lateral distortion due to short-circuit forces. The individual strips of the laminated-copper conductors are insulated with mica-silk tape, which was dried and vacuum-impregnated with bitumen before being placed in position. After impregnation, a stripping tape was removed and the bars were hot pressed to the required dimensions for placing in the slots. The coils were joined at both ends by electrical butt welding to facilitate insertion or removal without distortion. The weight of the stator complete is 45 tons.

ROTOR DESIGN.

The rotor body and poles were formed from a steel casting which weighed about 35 tons in its rough state. It was bored with holes for the insertion of the bolts securing the stub shafts, which are necessarily heavy owing to considerations of critical speed. These shafts, in turn, were drilled to receive the bolts holding the pole tips in position. Flanged shaft ends were also bolted on and a hole was bored in the body to allow the casting to be inspected for blow holes and other defects. The poles and body were machined all over to the correct dimensions, as shown in Fig. 3. Slots were also machined to take dovetailed clamps which protect the field coils from lateral deformation when the machine is running at full speed. The solid-pole construction used enables high operating speeds to be employed and thus reduces the cost.

The field coils are of the rectangular "fabricated" type, as can be seen in Fig. 4, and were built up from side and end bars with a dovetailed brazed joint at each corner. Every fifth bar is wider than the others, thus forming a projecting cooling fin. Adjacent bars are separated by asbestos paper, which was bonded with a thermal hardening varnish and solidified under heavy pressure. Each coil is insulated from its pole by flat sheets of Bakelite-glass board with collars of Bakelite-fabric board at the top and bottom. Slots are provided at the tops of the poles to allow a drift to be inserted, so that the steel liners, which were placed between the pole and field coil insulation to ensure a tight fit of the coil, can be removed. Axial-flow fans with blades of cast aluminium-alloy are fitted at each end of the rotor, air being directed to them by a baffle, while circulation is assisted by the poles. Cooling is effected by units which are built into the yoke. The rotor in the finished state weighs 61 tons.

EXCITATION.

The condenser is excited by a main exciter, the continuous rating of which is 575 amperes at 200 volts, while the peak output for super-excitation is 1,050 amperes at 370 volts. It is provided with a differential field winding to give a voltage variation of 10 to 1 over the whole output range. The field of this exciter is supplied from an auxiliary exciter with a continuous output of 28 amperes at 230 volts and a peak output of 36 amperes. These outputs are controlled automatically by a regulator. Both exciters are overhung from an extension of the main shaft at the slip-ring end of the unit, and can be seen on the left in Fig. 1.

Although the condenser is inherently self-starting, a starting motor of the synchronous-induction type, which is supplied from the 2·2-kV 'bus-bars, is provided at the opposite end of the shaft to the exciters so that the machine can also be used for charging and synchronising an unloaded transmission line. This motor, which has the same number of poles as the main machine, and can be seen on the right in Fig. 1, is rated at 1,160 h.p., a figure which is based on its duty when the set is generating 25 MVA at zero leading power factor. It is excited from a separate overhung exciter, which has a rating of 660 amperes at 54 volts. This arrangement obviates the use of some form of voltage-reducing apparatus for starting purposes.

Oil for lubrication is obtained from a tank, which is partly below floor level at the starting-motor end of the set. It contains two motor-driven low pressure pumps which supply oil to the main bearings through a bank of four coolers in parallel. One of these pumps acts as a stand-by and is started automatically should the circulation fail. The tank also contains a motor-driven double-outlet high-pressure pump for forcing oil under the two main journals when starting up.

STARTING ARRANGEMENTS.

To start the machine, the synchronous induction motor is connected to the 2·2-kV 'bus-bars and the set is run up to slip speed using normal induction-motor methods and an external resistance. During this period the kilovolt-amperes taken by the motor do not exceed 5 per cent. of the rated kilovolt-amperes of the condenser. When the motor reaches 98 per cent. of its full speed, excitation is applied to its rotor and the set is synchronised with the mains. The condenser is then excited in turn so as to produce the desired voltage; and the phase angle is adjusted by varying the relative excitation of the three phases of the starting-motor rotor. When both the voltage and phase angle are correct, the machine is connected to the 22-kV mains. When the machine is in actual use the phase relationship between the voltage supplied to the motor and that generated by the condenser will be such that either can be immediately synchronised with the mains and the starting motor disconnected. The excitation of the condenser can then be adjusted, either manually or by an automatic voltage regulator, so that the machine operates at the required load.

The correct phase relationship between the motor and condenser will be established at the works before the set is shipped. Normally, a rocking stator is required to rotate the voltage vector of the condenser into phase with the system to which it is being synchronised. This solution of the problem is, however, expensive and would not have been suitable for the conditions at Malvern. A method of rotating the rotor by changing the position of the poles on the rotor of the driving motor has therefore been developed, thus allowing the current distribution in the field windings of the synchronous condenser to be altered. The three-phase windings are connected in star, two of them being joined in parallel during synchronous operation, while the direct-current supply is connected to the terminal of the other phase and the common terminal. To change the current distribution in the windings a phasing resistance is connected between the parallel winding; and the distribution of field current is altered by moving the tapping point along this resistance, the value of which is such that a variation in the phase angle of $\pm$ 18 deg. can be obtained. Larger changes of angle, up to 360 deg., can be effected by reversing the condenser excitation; by changing over the phasing resistance to another pair of phases; and by altering the position of the coupling between the motor and the condenser.

ERECTION AND DISMANTLING.

An interesting feature of the Malvern machine is that it has been designed for erection on a concrete plinth with the air coolers at the back of the yoke, the enclosed circuit for the ventilating air being formed by an outer sheet steel casing as shown in Fig. 2. The other equipment, with the exception of the lubricating system tank, which is borne on a shallow grid, is also mounted above floor level. This layout has eliminated the necessity for any major excavation, thus considerably reducing building costs, while by arranging for the stator and rotor to be removable on rollers with the aid of jacks, the cost of a heavy crane has also been avoided. In fact, all the parts can be handled by a 3-ton portable crane.

The machine is also constructed with joints between the adjacent covers of the stator so that any one section can be quickly removed without disturbing the others. The removal of either side cover gives access to one of the air coolers and to its cooling-water inlet and outlet valves, while the removal of one half of either end cover exposes the inner guard which carries the fan-shrouding ring and the inner shaft cover. The winding guard is made in four parts, one lower quarter being displaceable laterally so that it can be lifted over the plinth without disturbing the upper quarter.

The main bearing at the driving-motor end of the set stands on the closed end of the concrete plinth, while that at the exciter end is carried on a deep steel beam spanning the open end. Dismantling is effected by first removing the main and auxiliary exciters and bolting an extension shaft to the main shaft in their place. The enclosing covers and fan-shrouding rings are next removed and the outer end of the extension shaft is lifted by two 20-ton jacks, operated by a portable oil pump, through a distance sufficient to allow the main bearing bush to be removed. The beam with the pedestal it supports can then be withdrawn on skid plates a sufficient distance to allow the shaft to rest on packing blocks under the main journal. The jacks and beam can then be taken away. The next operation is to remove the air coolers, after which four jacks are inserted under the stator frame. When the frame has been lifted slightly, roller trolleys are placed on a rail under that side of the stator and the lifting operation is repeated on the opposite side. Two jacks are now transferred to the outer end of the extension shaft, the packing blocks are removed and the stator is withdrawn on a roller trolley so that most of the rotor body is exposed. Subsequently, the driving motor is uncoupled from the main shaft and the complete motor assembly on its baseplate is pulled back sufficiently to allow a lifting bracket to be bolted to the main shaft. By lifting this end slightly with two jacks, the bearing bush can be removed and a wheeled truck and cradle assembled under the centre of the rotor. Finally, all the jacks are lowered and removed, so that first the stator and then the rotor can be withdrawn.

As many of the constructional features of this machine cannot be seen when it is assembled, the manufacturers have built a one-twelfth scale model to show them. Fig. 5 is reproduced from a photograph of this model taken from the starting motor end with the covers and quarter stator removed. The oil pumps and strainers are visible in the foreground. The model, which is a fine example of that branch of the engineer's art, can be fully dismantled so that the methods of erection and dismantling which have just been described can be demonstrated.

DOCUMENTARY FILM ON CONVEYORS.—The Mechanical Handling Engineers' Association, 94-98, Petty France, London, S.W.1, have produced a film entitled "Conveyors are Your Servants." The film, which is obtainable on loan, free of charge, on application to the Association, is intended to serve as a supplement to the documentary film, "Mechanical Handling," released in 1948. The new film shows applications of mechanical-handling equipment in a university library, a large cablegram station, a food-industry installation, breweries, etc. It is a 16-mm. film in colour, has a sound commentary, and runs for 36 minutes.

DOMESTIC USE OF SOLID FUEL.—A detailed survey of the manner in which solid fuel is used in British homes has been published by the Coal Utilisation Council, 3, Upper Belgrave-street, London, S.W.1. The survey revealed that solid fuel is used in 98 per cent. of the households to heat the main living room. In 65 per cent. of the cases investigated the fuel was burnt on an ordinary open fire; in 24 per cent. a range or cooker was employed; and in the remaining 9 per cent. some other type of solid-fuel appliance was in use. The Council state that there is an overwhelming preference for solid fuel for space heating, but that only one in seven preferred solid fuel for cooking. Copies of the survey can be obtained from the Council at the above address. [Price 6s. net; or 3s. to the Council's constituent organisations.]

THE ENGINEERING OUTLOOK.

VI.—TEXTILE MACHINERY.

IN the textile-machinery industry, 1952 was a year of record output and exports, the trend of which is shown in Figs. 1 to 14, on pages 297 and 298; but it was not one in which manufacturers could regard their achievements with complacency. The world recession in textiles inevitably has affected their order books, and most are now facing an exceptionally stiff sellers' market. To some extent, a reduction of orders in hand is to be welcomed, since it permits manufacturers to quote as prompt delivery as their competitors, but the fall has been so severe as to cause redundancy among workpeople. Even so, however, there is nothing radically unhealthy in the situation. For many types of textile machinery—in particular, machinery for cotton and wool spinning and weaving—the world market is declining now that much of the exceptional demand from the textile industries abroad has been met. Textile-machinery manufacturers have long been aware of the eventual necessity to adjust capacity and re-organise production in the most effective way to secure, in the face of increasing competition, the maximum share of the reduced but more permanent demand; in 1953, they will merely be exchanging an exceptional inflation for more compact strength. Mr. K. H. Preston, chairman of Platt Brothers and Company (Holdings), Limited, at the annual general meeting of the company in June, 1952, spoke on a confident note when he said that, "provided the textile industry of the world prospers sufficiently to enable it to expand and modernise itself, we should continue to obtain a volume of business which, although it will not reach the level of past years, should be sufficient to secure the future of our Group." The strength of the British manufacturer, as he pointed out in the case of his own group, lies in technical supremacy, the result of heavy expenditure on research and development; in very competitive prices; and in the enterprise of an active sales force.

Not all branches of the textile-machinery industry have to contend with falling markets; manufacturers of jute-processing machinery will be heavily occupied for a long time in supplying plant for the rapidly expanding jute industry in Pakistan. The extent to which orders may be expected to fall will vary considerably between different sections and subsections; advanced types of knitting and lace machines should continue to supplant more traditional types, and automatic looms make headway against non-automatic looms. Makers of the simpler accessories are in the most vulnerable position; local manufacture of such components in the principal overseas markets has been growing, since it presents no undue difficulties, even in relatively backward countries. The accessories branch has already lost proportionately more workers than any other branch of the textile-machinery industry.

While redundancy in the industry as a whole can be attributed to secular influences, it has been aggravated by special circumstances. The volume of export orders has been depressed by the defection of Brazil in sterling payments, and at home the Government's policy, supported by onerous taxation, of restricting capital investment has restricted demand unduly. Adequate tax reliefs in the forthcoming Budget might go far to restore the level of employment.

EXPORT DIFFICULTIES.

As will be seen from Tables I and II, herewith, exports of textile machinery in 1952 reached nearly 50·5*l.* millions, a record for the industry, and accounted for about 55 per cent. of the total production, compared with 50 per cent. in 1951. Most of the increase in 1952 was in machinery for spinning, twisting and preparatory processes, but this section of the industry, representing more than half of the total exports, has encountered some serious marketing difficulties, and it is likely that exports will be reduced in 1953. One of the most serious is the crisis in the Brazilian balance of payments. Brazil, the second largest market, in 1952 took nearly 11 per cent. of British exports of textile machinery, and makers of cotton-spinning machinery had very large Brazilian orders on hand. The slump in the prices of raw material, however, which set in during the autumn of 1951, had seriously weakened the Brazilian economy, and by the end of May, 1952, not only were war-time reserves of sterling exhausted, but there were transfer delays of five to six months in Brazilian sterling payments. The Exports Credits Guarantee Department, who had long been pressed to concede generous credit terms in order to put British manufacturers on an equal footing with their German and Japanese competitors, were forced to give notice that cover for shipments to Brazil would be suspended at the end of July. The total liability of the Department at that time was estimated at 32*l.* millions. By January, 1953, the Brazilian defection had necessitated a Board of Trade supplementary estimate for 14·8*l.* millions, of which 9*l.* millions were required to defray payments already made or under consideration, and the remaining 5·8*l.* millions for claims expected in the last quarter of the present financial year.

One of the consequences of the Board of Trade action was unemployment in the textile-machinery industry, and Mr. L. Hale, M.P. for Oldham West, was not slow to question the wisdom of a decision which affected the livelihood of his constituents. In the debate on the supplementary estimate on January 26, he pointed out that two months' notice for suspending shipments was most inadequate for manufacturers who, at the time, were manufacturing machinery for delivery twelve months afterwards; that the Brazilian economy was an expanding one, in which textile machinery was urgently required; and that the present difficulties were purely monetary and impermanent. Mr. H. R. Mackeson, Secretary for Overseas Trade, however, stressed that the difficulties were not temporary and that, in fact, there was little likelihood of Brazil having any appreciable amount of sterling available until April, 1954, at the earliest. He pointed out that the cover extended to textile machinery, either exported to Brazil or under production for export, amounted to nearly 5*l.* millions. Even if the E.C.G.D. were to grant further cover, a substantial volume of business could not now be carried out, because the Brazilian authorities had refused to grant import licences.

Brazilian difficulties with payments are by no means confined to sterling; the deficit with the

TABLE I.—UNITED KINGDOM: EXPORTS OF TEXTILE MACHINERY, BY MAIN MACHINERY GROUPS.

Type of Machinery.	1950.		1951.		1952.	
	Cwt. (1,000).	Value (£1,000).	Cwt. (1,000).	Value (£1,000).	Cwt. (1,000).	Value (£1,000).
For spinning and twisting and all preparatory processes ..	1,129	20,551	1,122	20,848	1,298	26,716
For processes preparatory to weaving, but subsequent to spinning and twisting ..	76	1,724	67	1,651	61	1,499
Looms and other weaving machinery	335	4,495	362	5,402	359	5,684
Bleaching, dyeing, printing and other finishing	147	2,636	151	3,002	136	3,098
Hosiery and other knitting ..	38	3,060	48	3,921	50	4,413
Bobbins separately consigned ..	15	540	13	538	14	611
All other sorts	221	6,366	221	7,309	216	7,252
Used	137	1,063	117	976	120	1,174
Total	2,098	40,435	2,101	43,647	2,254	50,447

United States is estimated at 300 million dollars, compared with 56 million dollars with the sterling area, and the total of Brazil's trade debts may be as much as 1,000 million dollars. While it is true that Brazil's is an expanding economy, the rate of expansion will be conditioned very much by the level of world prices for raw materials and the extent to which foreign funds are made available for investment. Since the United States is the only country with sufficient funds available, progress will depend upon the ability of the Brazilians to convince the United States Government that they are a "good risk." It was announced recently that the United States is to make 300 million dollars available through the Export-Import Bank, but this is little more than a stop-gap measure. The terms of the loan have not been announced, but the risk is evidently assessed as high, since stiff terms are expected; repayment will probably be required in four to five years at 3 or 4 per cent. interest. So far as trade with the United Kingdom is concerned, it may remain for a long time on the barter basis exemplified in the recent agreement for exchanging cotton for aircraft, which we recorded on page 231, *ante*.

FIGS. 1 TO 7. UNITED KINGDOM: DELIVERIES OF TEXTILE MACHINERY, BY VALUE (£1,000.) (YEARS TO SEPTEMBER 30.)

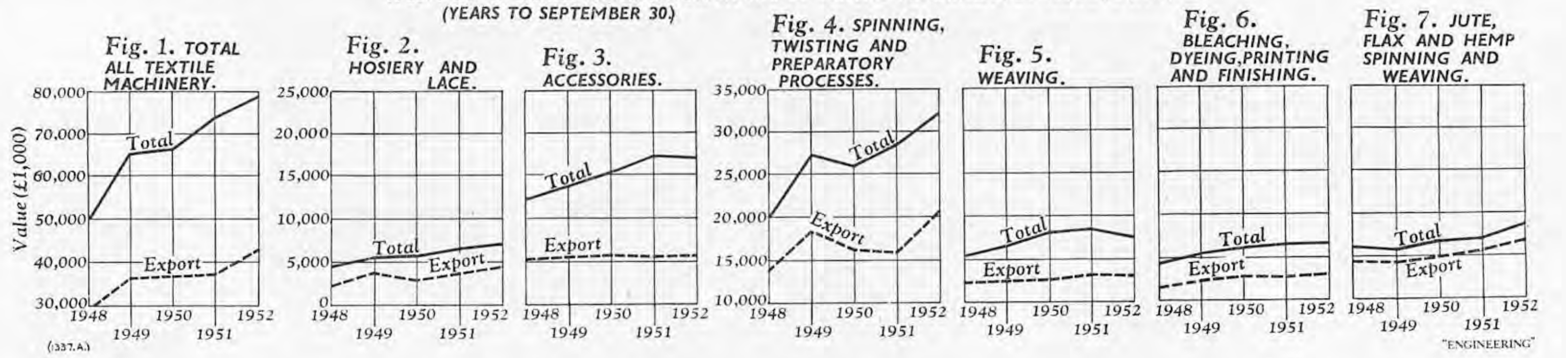


TABLE II.—UNITED KINGDOM: EXPORTS OF TEXTILE MACHINERY, BY COUNTRIES.

—	Quantity (1,000 Cwt.)			Value (£1,000).		
	1950.	1951.	1952.	1950.	1951.	1952.
Union of South Africa	40	59	69	760	1,182	1,440
India	445	305	395	7,731	6,273	8,670
Pakistan	46	170	214	553	2,152	3,191
Hong Kong	22	37	37	406	743	736
Australia	80	75	69	1,605	1,697	1,788
New Zealand	14	14	17	329	351	420
Canada	36	60	58	820	1,273	1,437
Other Commonwealth Countries	23	13	27	379	273	513
Irish Republic	25	43	25	469	755	478
Finland	18	40	24	406	870	613
Sweden	76	53	26	1,591	1,438	813
Norway	27	22	18	578	506	462
Denmark	23	14	13	538	360	340
Poland	39	25	23	656	480	420
Germany	51	46	54	1,083	1,231	1,586
Netherlands	91	70	59	1,919	1,553	1,300
Belgium	76	60	61	1,521	1,398	1,494
France	107	129	86	2,444	3,182	2,514
Switzerland	10	9	8	340	366	368
Portugal	74	47	40	1,200	806	879
Spain	9	5	5	224	160	196
Italy	70	99	225	1,549	1,914	4,625
Austria	13	21	10	299	452	311
Czechoslovakia	37	3	5	598	66	92
Yugoslavia	—	112	3	16	1,810	100
Greece	58	25	20	1,012	508	461
Turkey	55	68	98	988	1,192	1,982
Egypt	57	44	33	1,082	934	782
Iran	43	23	6	646	425	130
China	25	15	22	450	360	495
United States of America	40	52	40	1,065	1,506	1,213
Mexico	25	27	36	530	612	810
Peru	11	8	20	227	202	424
Chile	22	10	8	478	311	288
Brazil	139	165	265	2,860	3,514	5,833
Uruguay	10	7	5	236	258	151
Argentine Republic	56	40	24	1,070	910	722
Other Foreign Countries	105	85	108	1,781	1,626	2,370
Total	2,098	2,101	2,254	40,435	43,647	50,447

India, the largest market for textile machinery and accounting for 17 per cent. of the total exports, also has an expanding economy, but again the demand is restricted by financial difficulties. The cotton textile industry in India is now the second largest in the world, and its export earnings are an indispensable source of foreign currency for India. At the Buxton conference in September, the Indian delegation announced that it was planned to export a million square yards of cotton textiles in 1953; this is no more than in 1950, but it is nearly twice as much as in 1952. The number of spindles in the Indian cotton industry has been expanding rapidly; in 1951, about 400,000 were added to the installed capacity, which is now nearly 11·5 million spindles, but the capacity was clearly surplus to requirements in the difficult marketing conditions of 1952. The cloth output of the cotton mills in 1952 was about 4,600 million square yards, and the output of the domestic hand-loom industry about another 2,000 million square yards. This was about 10 per cent. more than in 1951, and, with exports about 25 per cent. below the 1951 total of 736 million square yards, a record quantity of cloth was released upon the home market which could only be disposed of at low and often uneconomic prices. The difficulties have been aggravated by the existence of a high proportion of old badly-organised factories with obsolete machinery, but, far from encouraging rationalisation, marketing difficulties have resulted in the postponement of re-organisation and rehabilitation programmes. While the demand for cotton textile machinery has suffered at least a temporary check, local manufacture has been growing. This is particularly true of accessories, but spinning and carding machinery, and also looms, are now made by several firms. A ban was imposed on imports of automatic looms in June, 1952, in order to promote the manufacture of automatic looms, though the local industry is not in a position to meet home requirements fully.

There has been a large expansion in British exports of textile machinery to Pakistan, which is building up a cotton as well as a jute industry and has placed substantial orders in the United Kingdom for both types of machinery. A six-years' plan for the development of the jute industry was put in hand in 1951, and by July, 1957, the Pakistan Industrial Development Corporation, who have been given the task of executing the plan, hope that 6,000 looms will have been installed. A private company, Adamjee Jute Mills, has been formed with an authorised capital of Rs. 75 millions to operate three mills of 1,000 looms each at Narayanganj, in East Pakistan. These mills, which employ 9,000 workers and have a capacity of 32,000 tons of sacking and 16,000 tons of hessian per annum, are already in production. The remaining 3,000 looms are to be distributed over six mills. Four of these are to be set up in the Khulna district and four at Chittagong. Orders for machinery and plant for some of these mills, valued at 4*l*. millions, were placed in the United Kingdom in December, 1951. Further large-scale purchases will be required to complete the programme.

The dollar markets showed some contraction in 1952, but exports were still well above the 1950 level. Exports of hosiery knitting and lace machinery, moreover, continued to make further progress. In 1952, exports of this type of machinery, valued at about 330,000*l*., were over 60 per cent. higher than in 1951. Mr. H. R. Backhouse, of Mellor Bromley and Company, expressed in May his belief that the American market presented "useful opportunities" for his company's sales of knitting machines, and announced that a subsidiary company had been set up in the United States.

Exports to the Western European markets, and, in particular, to Italy, were at a very high level in 1952. There is undoubtedly a large potential demand for textile machinery in Europe, where a high proportion of the plant in use is obsolescent. The recession in textiles, however, is not encouraging replacement. The production of highly specialised and automatic machinery in Europe has meanwhile reached such a point that there may be chronic over-production unless textile manufacturers renew their equipment more frequently than in the past. It was hoped that the "liberalisation" of intra-European trade would stimulate British exports of textile machinery to the Continent, but progress has been fraught with difficulties; the European Payments Union has helped to smooth out some of the problems in the balance of payments, but currency difficulties still remain which make member nations unwilling to relax import restrictions. In some instances, these restrictions have been increased; France, for instance, found it necessary to restrict the importation of textile machinery in 1952. The United Kingdom has by no means the most favourable record. At one time, quota-free categories covered as much as 90 per cent. of British trade with Western Europe. The British percentage of completely liberalised trade is now only about 46 per cent., compared with a "standard" of 75 per cent. set by the Organisation for European Economic Co-operation. At the meeting of the Steering Board for Trade, it is expected that the United Kingdom will be subjected to considerable pressure, from France and Italy in particular, to modify these restrictions, which greatly curtail their sterling earnings.

STRONG BUT NOT EXCESSIVE COMPETITION.

Two trade fairs in 1952, one in Lyons and the other in Milan, demonstrated clearly the growing importance of German, Italian and French manufacturers among world producers of textile machinery. While output has been increasing, many technological improvements have been made. As in the United Kingdom, these have involved an increase in automatic looms and short-cut processing rather than radical changes in machine design. In the case of looms, automatic operation of the various movements on the newer Continental types has been carried to such a pitch that, in the bewildering complexity of mechanisms, service and maintenance are difficult. British manufacturers, on the other hand, have concentrated on keeping looms as simple as is consistent with high operational efficiency. In general, British textile machinery is as advanced technologically as anything which Continental manufacturers have to offer, and it is more than competitive so far as price and quality are concerned. At the same time, there has been no hesitation in introducing some promising types of Continental machinery into the United Kingdom. During 1952, some successful experiments were carried out in the flax mills with an Italian wet-pot spinning frame. For four years, Messrs. Fairbairn Lawson Combe Barbour, Limited, have been developing the circular jute loom invented by Saint Frères S.A., of Paris, and have now taken over the world sales rights. Many of these looms have already been installed in Dundee, and large orders have been received from overseas.

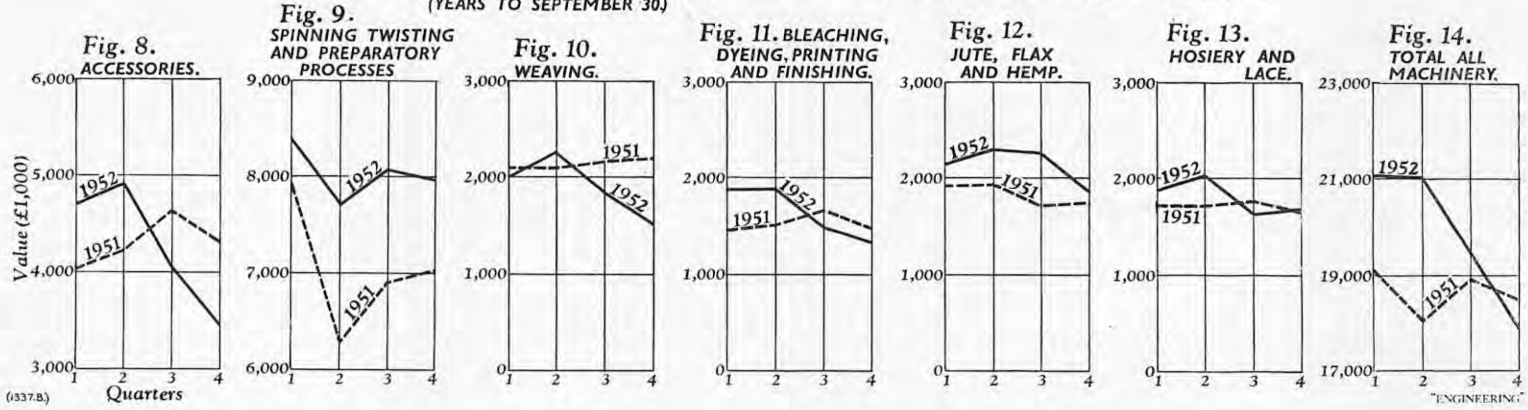
major pre-occupation of the Japanese textile-machinery makers has been their own home market, and the abolition of the successive limits on the capacity of the cotton industry has hitherto assured them of a high level of activity. During 1951, the number of spindles installed in Japan increased by 2·1 millions to 6·5 millions, and in 1952 it reached 7·5 millions. The rate of increase, however, has now slowed down considerably as a result of the recession in textiles, which is bringing home to manufacturers the dangers of excess capacity. The "Big Ten" firms, who control about 68 per cent. of the total Japanese spinning capacity, have checked their expansion programmes, and there have been already several bankruptcies among smaller concerns. Ill-considered expansion by the smaller firms is likely, nevertheless, to continue to cause concern in the Japanese textile industry. Before June, 1950, there were only 25 companies in the cotton-spinning industry, but by April, 1952, the number had grown to 115, compared with 67 in 1937, when the installed capacity amounted to 12 million spindles.

In present circumstances, it seems unlikely that the level of demand can justify the existence of more than 50 per cent. of the spindles installed, becomes available in quantity to the textile industry. It is thought that minor modifications will suffice, and that radical changes in machinery design will be unnecessary. On the dyeing side of the industry, an important new development is the introduction of the "Standfast" molten-metal machine. By passing the cloth through molten-metal alloys at 95 deg. F., held in a U-tube, the dyeing process can be carried out at an even pressure and at an even temperature, and, by sealing off the air prematurely, oxidisation is avoided.

Uncertainty in the Home Market.

The recession in textiles has affected all fibres, and the home demand for all types of textile machinery consequently suffered a setback in 1952. In the case of cotton-spinning, re-equipment schemes which have been undertaken with the aid of the subsidy under the Cotton Spinning Re-equipment (Subsidy) Act of 1948 are largely complete, but criticisms made in the report of the Productivity Team from the United States indicate that there is still considerable scope for re-equipment in Lancashire. The team expressed their regret at the "iron-clad" arguments put forward by the less forward-looking elements of management against

FIGS. 8 TO 14. UNITED KINGDOM: QUARTERLY DELIVERIES OF TEXTILE MACHINERY, BY VALUE (£1,000.) (YEARS TO SEPTEMBER 30.)



Competition from manufacturers in the United States will not be fully effective until and unless the dollar shortage is solved. Even if this obstacle were removed, British textile machinery should continue to be competitive with comparable types made in the United States. The textile productivity teams which visited the United States made very few suggestions for improving British machinery. On the other hand, there is much that United States manufacturers could profitably learn from the British. The Saco-Lowel shops, at Biddeford, Maine, recently announced the production of a new spinning frame which they claim to be the "biggest single improvement in the history of the spinning frame." The main feature of the new machine is the size of the yarn package; the bobbins are said to have a capacity of up to ten times that of the conventional bobbin, and, with yarn of 12s count, a change of bobbins is necessary only after 12½ hours, compared with 58 minutes on traditional machines. The speed of the yarn feed on the final drawing rolls has been increased to about 175 r.p.m., compared with about 126 r.p.m. on older machines. Development has, however, been proceeding on those lines in the United Kingdom for a long time; the problem of big packages and of speeding up the spinning process received early attention from the Shirley Institute and the research station of the Textile Machinery Makers at Helmshore. The results of that research include the Platt MS-2 high draft speed frame, which was noted with special interest in the report on the British Cotton Industry of the Productivity Team from the United States which visited the United Kingdom in 1951. Another British device for speeding the spinning process which impressed the team was the Shirley automatic doffer.

Japanese manufacturers, alone among their competitors, have been able to quote lower prices than British manufacturers, and in the past two years or so have occasionally secured export orders through being able to offer better delivery. The quality of their machinery, however, is not generally considered to be comparable with the British. The and the attempts of small units, far below optimum size, to establish themselves merely aggravate marketing difficulties. The Japanese textile-machinery manufacturers, meanwhile, have been forced to devote much of their attention to the export markets. Their prices are still low, but have been rising lately. The "export check" price, established by agreement among the manufacturers, was raised on January 15, 1952, from 24·6 dollars per spindle to 27·1 dollars. There was much opposition to the new price from some of the leading manufacturers, and it has been conceded that discounts of up to 10 per cent. may be permitted at the discretion of individual firms; spindles made by the Howa Textile Machinery Company, for example, will be sold at a discount of 2 per cent., those of the Osaka Kiko Company at a discount of 5 per cent., and those of the Ishikawa Works at a discount of 10 per cent.

Although, in general, Japanese machinery is not so advanced as Western types, technical improvements are by no means a Western prerogative, and Japanese manufacturers are not slow to welcome Western techniques. It was announced recently that the Shibaura Machine Works were manufacturing a "continuous spinning and processing machine" for rayon, the invention of Mr. Harry A. Kuljian, president of the Kuljian Corporation of Philadelphia. This machine, it is claimed, completes in less than three minutes yarn processing formerly requiring four or five days. In the United Kingdom, there have also been important developments in rayon-spinning machinery. A notable machine is the "Pacific Converter," an American invention now on trial in the United Kingdom. The "tow" of parallel continuous filaments is fed into the machine and, after being cut or broken into staple lengths, is drafted to the required fineness and spun in the same way as on a standard ring frame. Work is being carried out by the T.M.M. research station and at the Shirley Institute, in close co-operation with Imperial Chemical Industries, Limited, on the problems of machinery adaptation which will arise when terylene re-equipment. "In good times, they seemed to be saying, they did not need to change, and if poor times came they were already preparing themselves with the argument that they could not afford it. It seemed clear to us that the net result of this attitude was bound to be disastrous." The team are not, however, very consistent in their criticisms, for they state that there exists in the British cotton industry the enterprise and the will to improve productivity, and they consider that "American management and labour unions will be gratified to find substantial evidence of the very real efforts which both management and labour in the British cotton industry are making to improve productivity."

The sum which has been spent on re-equipment in Lancashire since the war is certainly not small. It is estimated that, at a cost of about 60*l*. millions, equally divided between the spinning and weaving sections, re-equipment to a greater or less extent has been carried out in 60 per cent. of the British mills. It is true, nevertheless, that much remains to be done, though the situation is not perhaps quite so clear-cut as the American team imagined. They appear to have under-rated the problem of financing modernisation schemes when income and profits taxes make it difficult to put sufficient sums to reserve, and depreciation allowances are totally inadequate. The subsidy scheme in the spinning section of the industry certainly gave a very large measure of assistance, but a grant to smaller firms was conditional upon their amalgamating to form larger units. It is difficult, in many cases, to blame the smaller unit for refusing to submerge its identity. The extent to which modern automatic high-speed equipment can be adopted in Lancashire is much less than in the United States, where a homogeneous market provides the opportunity for long runs of standardised products. With a comparatively small home market, British manufacturers have to compete in a large number of very diverse markets. One of the main selling points is the high quality of the product and for this the mule spinning frame and the Lancashire loom are still indispensable. It is certainly true that the British cotton industry, however well equipped, cannot expect to compete very successfully in the cheapest ranges of cotton goods with Japanese manufacturers whose labour costs are a fraction of their own, or with Indian manufacturers whose labour costs are also low, and who have the added advantage of a cheap indigenous raw cotton supply.

Even if the cotton industry did concentrate more and more on medium-quality and high-quality products, there would still remain considerable scope for re-equipment. Mr. Rowland Smith, in a letter to *The Economist* of January 10, made the point that, in the spinning section of the industry, the fixing of minimum prices by the Yarn Spinners Association reduces the incentive to re-equip. If, in fact, the price-fixing agreement is so operated as to give the less efficient firms a living, the pace of re-equipment is bound to be slow. However this may be, one of the major influences affecting the pace of re-equipment is the assessment which Lancashire cotton manufacturers make of their marketing prospects. They clearly do not expect the world trade in cotton to expand, and therefore hesitate to undertake capital expenditure from which they fear there might be little return. At the Buxton conference, the Lancashire delegation declared that the main factor in the world trade in textiles was the rapid expansion of cotton manufacturing industries in former importing countries.

There is undoubtedly scope for raising the consumption of cotton goods by raising living standards in backward areas—a repetition of the assertion which was being quoted in Lancashire at least 40 years ago, that if only the Chinese peasant could be taught to use a pocket handkerchief, the prosperity of the cotton industry would be assured; but, as past experience has shown, this process is invariably accompanied by the growth of local cotton manufacturing industries. The Japanese, on the other hand, who have been rapidly expanding their capacity, expect world trade to increase at the rate of 100 million yards per annum, and think that the key to the situation lies in the stabilisation of cotton textile prices at lower levels. The Lancashire analysis is probably more accurate than the Japanese, and, since Japanese and Indian competition are likely to restrict the range of goods in which Lancashire manufacturers can be competitive, there is every possibility of a contraction in the exports of the Lancashire cotton trade. In falling markets, however, only the efficient survive, and in the difficult conditions which lie ahead a major effort is required by management and workpeople alike in the cotton industry if their earnings of foreign currency, so vital to the British economy, are not to be drastically reduced.

In the Dundee jute industry, conditions are not dissimilar from those in Lancashire. Considerable re-organisation has been carried out already by the larger and more efficient units, but there remains a large number of small firms which have undertaken very little re-equipment. The Jute Working Party, who estimated in 1948 that an output of 160,000 tons could be achieved by 17,250 workers, working double shifts and using new types of machinery, recommended that the smaller firms should group themselves by voluntary amalgamation into economic units. In fact, little amalgamation has taken place, and in 1951 it required 18,100 workers to achieve the peak production of 112,000 tons. It seems, therefore, that there is scope for increasing production by nearly 50 per cent. without increasing the labour force. The jute manufacturers point out, however, that the working party also recommended a high degree of protection for the industry. Without some assurance of future markets, they argue, they cannot carry re-equipment much farther. The rapid growth of a manufacturing industry in Pakistan, which, like the Indian industry, has the advantage of cheap labour and, even more important, has complete control over the indigenous raw material supply, has naturally caused considerable concern in Dundee. If the existence of a jute industry is considered essential in the British economy, the manufacturers undoubtedly have a strong case for protection and other Government support. If this were made conditional upon amalgamations taking place, the re-equipment problem would cease to exist.

The fall in the demand for hosiery products has been particularly severe, and it came at a time when many hosiery manufacturers were still carrying out expansion and re-equipment programmes. Large orders for hosiery and knitting machinery were still outstanding, some of these for expensive fully-fashioned knitting machines from the United States. Imports of hosiery machinery from the United States in 1952 reached 2·1*l*. millions, compared with 1·7*l*. millions in 1951. The recession does not appear to have resulted in the cancellation of many orders, but manufacturers have obviously been cautious about placing new ones. The British hosiery-machine manufacturers, who have valiantly increased production and developed new machines to meet the needs of the expanding hosiery industry, have naturally felt much concern over what, it is hoped, will be a temporary set-back. British manufacturers, for example, after painstaking development and considerable teething troubles, are now producing fully-fashioned stocking machines in quantity. Needle manufacturers, who have greatly expanded their capacity, can now supply most of the requirements of the British hosiery industry, apart from certain special types and gauges. As in other branches of the textile industry, there is still considerable scope for re-equipment, if not for expansion, in the hosiery industry, and in recession it is more than ever vital that this should be carried out. If the coming Budget provides sufficient incentive for the hosiery manufacturers to re-equip, the makers of hosiery machines should be able to obtain a satisfactory volume of orders.

RE-ORGANISATION IN THE TEXTILE MACHINERY INDUSTRY.

While, on balance, the textile-machinery manufacturers may expect to have a reduced volume of work on hand in the next year or so, there is no cause for regret. The situation offers a challenge to improve efficiency both in the manufacturing process and in the machines they produce. So far as research and development are concerned, the only necessity is to maintain the present rate of progress. Whatever may be said of the backwardness of the British textile industries, there can be little criticism of the quality of the research into production techniques and machinery. As the Productivity Team from the United States commented, ". . . they [the textile industries] had the world's technical information at hand. Our visit to the Shirley Institute showed us that it was equipped to undertake to solve any technical problem referred to it by members of the industry." On the score of raising productivity in their own works, some of the textile-machinery manufacturers have already started to re-organise, now that the state of their order books permits it. Platt Brothers and Company decided, towards the end of 1952, to concentrate their production in Oldham in the Hartford works and to close down the less economic East Works. For the textile-machinery manufacturers, as well as the textile manufacturers, taxation reliefs in the coming Budget would give a welcome spur to increasing efficiency. It is to be hoped that the Chancellor of the Exchequer will consider the case for increasing depreciation allowances more favourably than that for, say, reducing purchase tax, and thus indicate that the Government attaches more importance to the necessity for maintaining the national stock of capital goods than to stimulating consumer demand for luxury goods.

BIBLIOGRAPHY ON SHELL-MOULDING PRACTICE.—The now well-known shell-moulding process was first patented by Herr Johannes Croning, of Hamburg, in 1937. During the past year or two, as references in our columns have indicated, the process has been attracting increasing attention. To assist research workers and industrial firms interested in the process, the Sheffield City Libraries have brought out, as No. 61 of their new series of research bibliographies, one entitled "Shell Moulding Process (Croning) or 'C' Process." This contains 48 references to the process, most of which are taken from periodical sources. We understand that, though supplies of the bibliography are limited, a copy will be sent to any organisation interested. Application should be made to the City Librarian, Central Library, Sheffield, 1.

THE "R.R." POPPET-VALVE GEAR FOR LOCOMOTIVES.

BRITISH RAILWAYS are to make further trials with the "R.R." (Reidinger rotary) poppet-valve gear. A three-cylinder 4-4-0 locomotive, "The Garth," of the North Eastern Region, was fitted with valve gear of this type in 1949; the gear, which was described in ENGINEERING, vol. 168, page 291 (1949), enabled the valve events to be adjusted independently. Now, after three years' reliable service in passenger traffic and after tests at the Rugby locomotive testing station, Mr. R. A. Riddles, C.B.E., M.I.Mech.E., has decided to fit five London Midland Region locomotives with valve gear of this type, though it differs in detail design from the previous gear. The locomotives chosen for the trial are five of the two-cylinder 2-6-0 Class 5MT (Horwich) type, which previously had R.C. (rotary-cam) poppet valves, so the modification will not entail as much work as it would have done with normal piston-valve locomotives. The first to be completed, No. 42825, is now working main-line traffic, and is illustrated in Fig. 1, on page 300. Fig. 2 is an outline drawing showing the arrangement of the gear.

Four of the modified engines will have cams which provide a predetermined steam distribution for any given cut-off, the range and combination of valve events for this purpose having been based on experience with the R.R. gear fitted to "The Garth." The fifth locomotive will have vernier-adjustable cams so that the valve events can be adjusted independently and the effect studied on this two-cylinder locomotive in the same way that a study has been made with "The Garth," which is a three-cylinder engine. The driver cannot vary the events separately, however; he reverses and notches up in the ordinary way, but for any alteration to the events relatively it is necessary to open the cam box in order to gain access to the vernier adjustment on the cams. The R.R. valve gear being fitted to the five locomotives has been evolved and designed by Mr. A. Reidinger, of Messrs. Rendel, Palmer and Tritton, consulting engineers. The valve gears are supplied by Locomotive Valve Gears, Limited, 47, Victoria-street, London, S.W.1, to whom Mr. Reidinger is technical adviser, and are made by J. L. Jameson, Limited, West-street Works, Ewell, Surrey.

The object of the valve gear is to increase the thermal and mechanical efficiencies of the steam locomotive by improving the steam distribution, reducing maintenance costs and increasing both power and availability. Fig. 3, which gives part sections in the same plane as the longitudinal axis of the cylinder, shows that the cylinder has a valve chamber at each end, each chamber housing one inlet valve and one exhaust valve arranged in the horizontal position. This arrangement allows the valves to be withdrawn for examination without disturbing the cam boxes, the main drive or the reversing-gear connections. The valves are of the double-beat type, giving large openings for a relatively small lift, thus maintaining moderate roller and cam contact pressures. The inlet valves are held by steam pressure in place of the usual spring control, but the exhaust valves have controlling springs; they are, therefore, continuously actuated by the cams. This arrangement provides an effective automatic by-pass when coasting, and renders the use of special drifting or by-pass devices unnecessary.

The cam boxes are placed between the valve housings and bolted to footings at the top of the cylinder barrels with the axis of the camshafts at right-angles to the longitudinal centre-line of the cylinders. Fig. 4 is a section on the axis of the camshaft. The cam boxes are self-contained complete assemblies, each comprising a camshaft with inlet and exhaust cams, a wormwheel drive at the outer end, intermediate-lever assemblies and reversing gear. The main drive comprises a wormwheel gearbox, mounted on a return crank on each side of the engine, fitted with floating rods to counteract the torque and having universal shafting with flange connections to the cam-box wormshaft. The reversing gear consists of a universal shaft connecting the engineman's control in the cab with a self-locking reduction gearbox, which securely holds the gear in its set position; also bevel gears and shafting coupled to the cam boxes on each side of the engine. When the engine is stationary, the inlet valves are in the open position. On opening the regulator, steam passes through piping from the regulator valve to the valve-closing pistons in the valve covers, thus bringing the valves under the control of steam pressure and at the same time bringing the valve spindles under the positive control of the cams through the tappets in the sides of the cam boxes. The exhaust valves, as already mentioned, are spring-controlled and are, therefore, at all times actuated by the exhaust cams. Pressure is not used to control the exhaust valves because of the difficulty of maintaining a steamtight packing for the actuating pistons; such a packing is clearly essential in the case of the exhaust valves, though not for the inlet valves. This arrangement also makes the engine more responsive to the regulator, because the exhaust valves are always correctly located in relation to the cams.

The camshafts rotate at the same speed as the driving wheels and are driven by a dog having helical keys engaging with helical spline-ways in an inner driving sleeve. One key and spline-way are made a different width from the others to ensure that the camshaft can only be fitted in its correct position in the driving sleeve. The main-drive wormwheel is mounted on, and bolted to, the driving shank, in the bore of which is fitted the inner splined sleeve. The camshaft is splined in such a manner as to impart angular movement to the cams, assisted by the helical spline ways in the inner driving sleeve. Reversal or adjustment of cut-off is effected by moving the camshafts in an axial direction, thus drawing the camshaft through the cams, the splines which engage keys in the bores of the cams causing the cams to be moved in an angular direction relatively to each other. All valve events are based on the cut-off cam, and for any cut-off the pre-admission cam opens the inlet valves for admission and, as the cut-off is shortened, pre-admission becomes earlier and lead is increased. For all running cut-offs a full valve lift, and hence a full port opening for steam inlet, is obtained. For any cut-off, the release cam opens the exhaust valves fully and, as the cut-off is shortened, release gradually becomes earlier, but it is always later relatively to that obtained with link-motion gears. Shortening the rate of cut-off causes the exhaust valves to close earlier, thus positively controlling the point of compression relative to the cut-off.

There are four intermediate-lever assemblies in each cam box, one for each valve-spindle tappet working in circular guide bushes fitted in the sides of the cam box. The intermediate levers are fulcrumed at their lower ends, working on rods fitted in the bottom of the cam box. At their upper ends the levers contact the cam-box tappets. The function of these levers is to increase the lift of the valves over that given by the form of the cams, to give a direct thrust on the tappets and to carry the follower rollers which run on the cam profiles. The steam-inlet levers are fitted with a rocking beam having two rollers, one at each end of the beam, one running on the cut-off cam and one on the pre-admission cam. This arrangement is necessary owing to the differential cam action and the relatively large angular displacement given to these cams when the gear is reversed from forward to backward gear, or vice versa, or when altering the rate of cut-off. These steam-inlet levers are fitted with coil compression springs acting between their lower ends. The springs keep the follower rollers in constant contact with the cams. This arrangement on the steam-inlet side is required because valve control springs are not used, the valves being steam-controlled. On the exhaust side, the intermediate levers also have two rollers, one for each of the exhaust cams, though, in this case, they are not fitted on a rocking beam as the angular displacement of these cams relative to each other is small. The valve spindles are mechanically lubricated, and the lubrication of the cam boxes, return-crank gears and the reversing cam boxes is effected by oil baths. Fig. 5 is a detail drawing showing the vernier-adjustment cams which are to be fitted to the fifth locomotive to provide for fully variable valve events.

"R.R." POPPET-VALVE GEAR FOR LOCOMOTIVES.

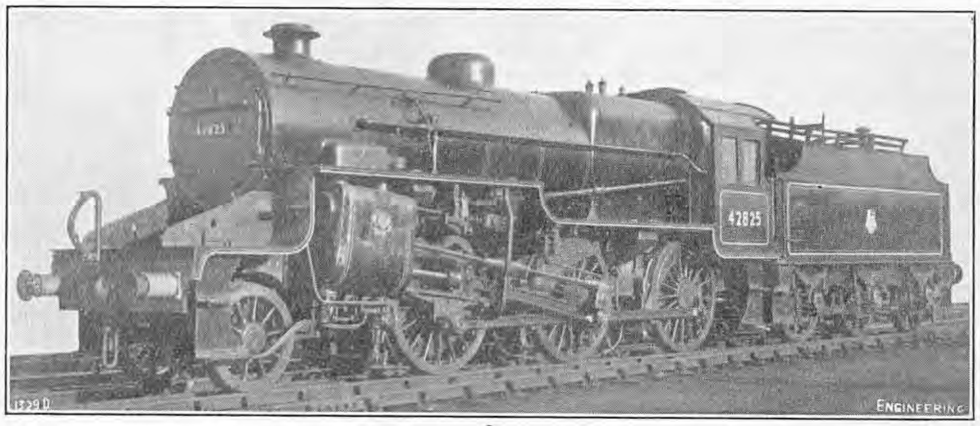


Fig. 1. 2-6-0 LOCOMOTIVE FITTED WITH "R.R." GEAR.

Fig. 2.

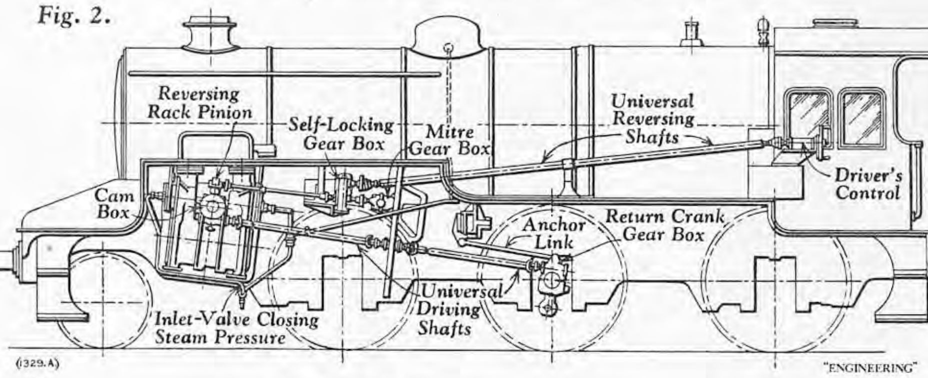


Fig. 3.

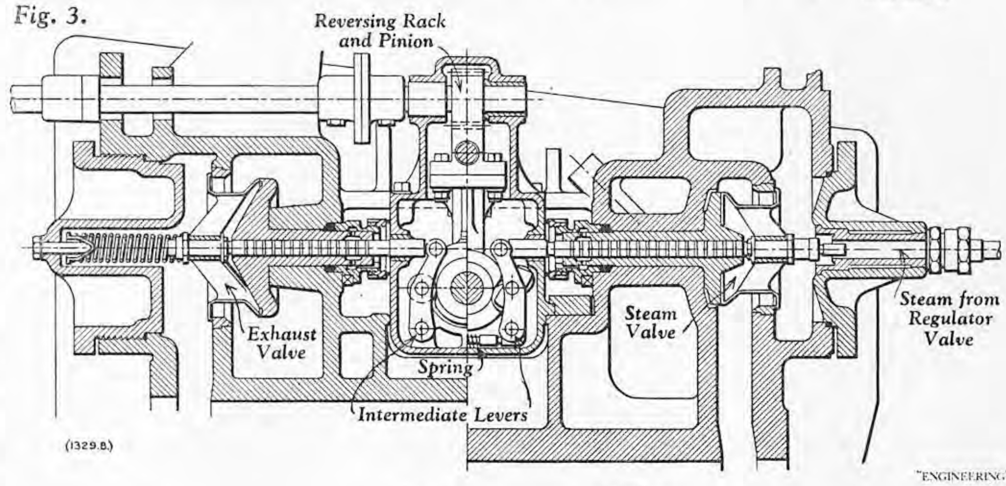
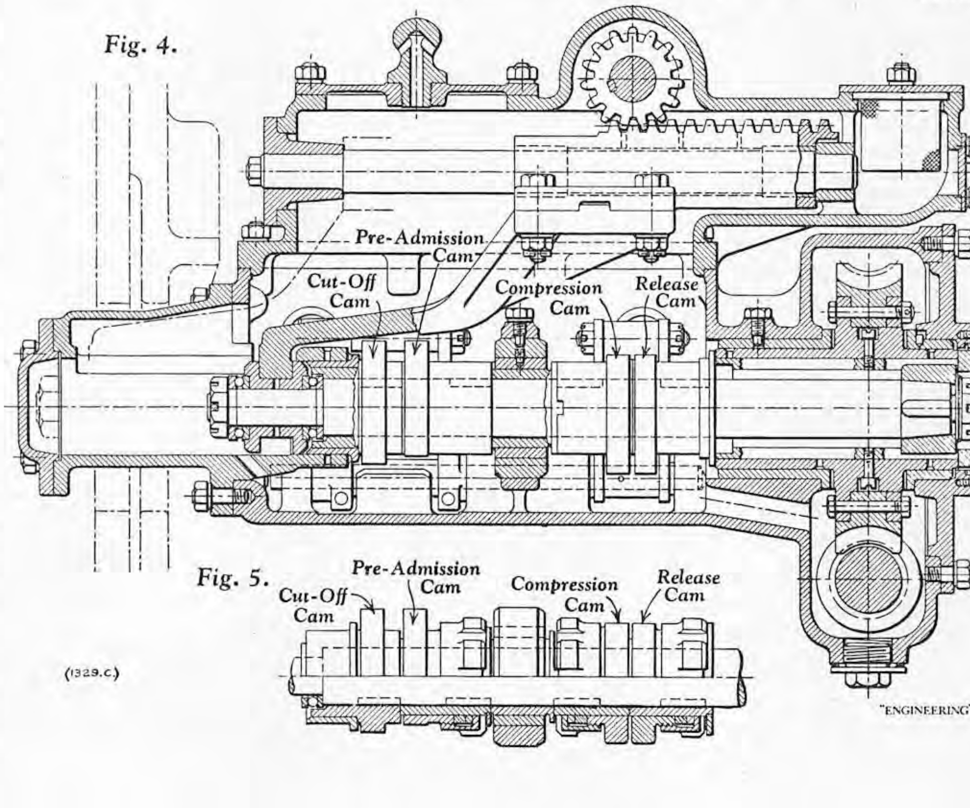


Fig. 4.



12,000-TON HYDRAULIC FORGING PRESS FOR ALUMINIUM.

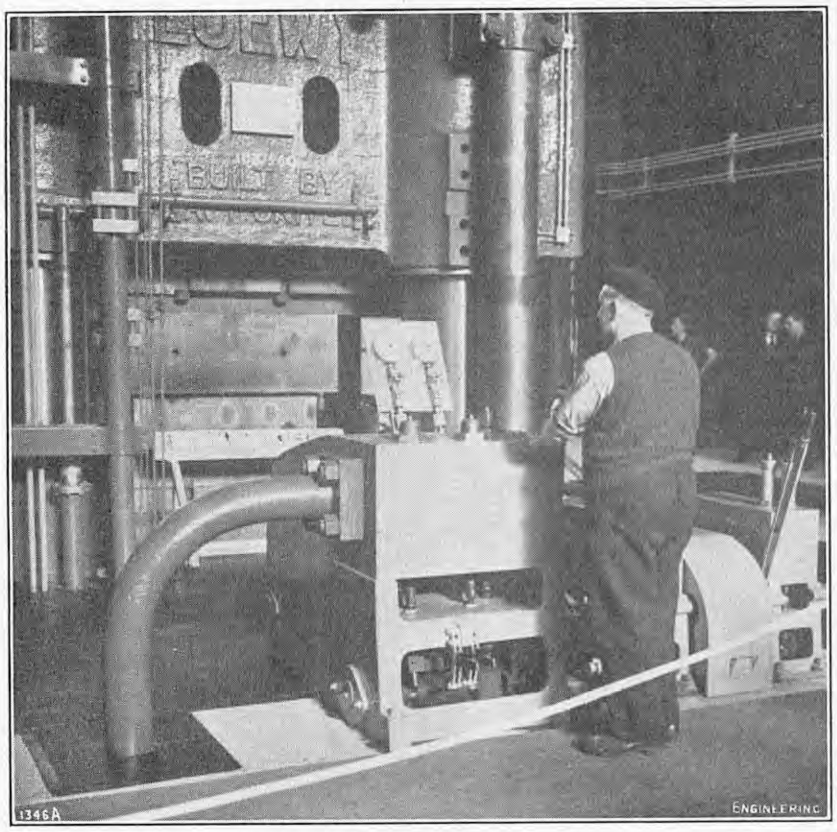
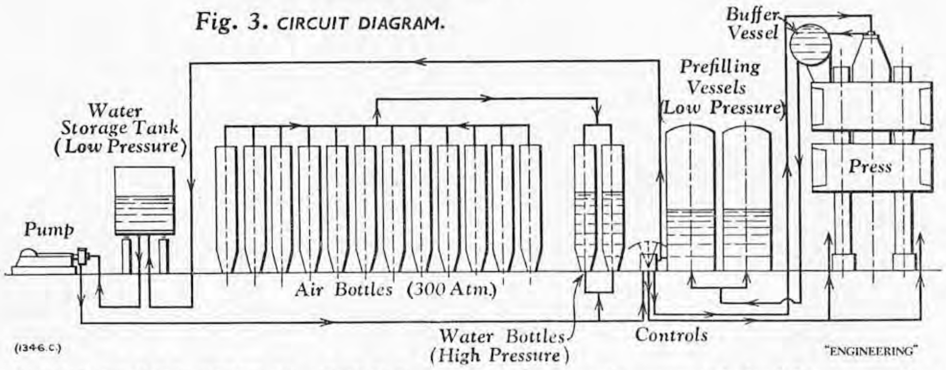


FIG. 1. CONTROLS OF PRESS.

FIG. 2. AIR BOTTLES.

Fig. 3. CIRCUIT DIAGRAM.



12,000-TON HYDRAULIC PRESS FOR ALUMINIUM.

THE 12,000-ton hydraulic forging press illustrated in Figs. 1 to 3, above, and Figs. 4 and 5, on page 304, has been constructed by the Davy and United Engineering Company, Limited, to the basic designs of the Loewy Engineering Company, and was set to work on February 24 at the Redditch works of High Duty Alloys, Limited. The Redditch works, built in 1938-39, was a major centre for the supply of light-alloy forgings and stampings during the subsequent war and, since 1945, has been responsible for the whole of the company's forgings —mainly required for aircraft work, High Duty Alloys, Limited, being a subsidiary of the Hawker Siddeley Group. The Redditch works is well equipped with heavy plant, having two Schliemann forging presses, of 1,000 tons and 3,000 tons capacity, respectively, and a number of hammers, including one, made by B. and S. Massey, Limited, of 18 tons capacity. There are also two other hammer shops, with lighter equipment, a die shop, a heat-treatment shop, a foundry producing light-alloy ingots up to a ton in weight, a machine shop for rough-machining forgings of any dimensions that the plant could produce, a well-equipped laboratory, and a department for the production of blades for gas-turbine compressors.

The new press is designed to work at total pressures of 4,000, 8,000 or 12,000 tons, according to requirements. It weighs 800 tons and has a total height of 56 ft. 4 in., of which 42 ft. 9 in. is above the floor level. Much of the hydraulic equipment is below the floor, and is accessible by lifting a section of the surrounding chequer plating; a feature which involved the excavation of 2,500 tons of earth and the provision of a foundation of 500 tons of concrete. The roof of the shop, which is 220 ft. long, was raised from 40 ft. to 87 ft. above the ground level, and heavier stanchions had to be provided to support the travelling crane, which has a main hoist of 100 tons and an auxiliary hoist of 25 tons capacity. Near the press, an electrical substation was constructed, containing two 1,500-kVA transformers and the necessary switchgear. The current is supplied to the transformers at 11,000 volts. The four treble-ram pumps are driven, through reduction gears, by 550-h.p. motors. The water-storage tank has a capacity of 6,500 gallons, and the twelve air vessels are charged to a pressure of 300 atmospheres by two compressors. Two pre-filling tanks are provided, as shown in the diagram, Fig. 3.

The press has two bedplates, each weighing 14 tons, on which are placed four recessed plates to receive the feet of the columns, each of which is 31 in. in diameter and 44 ft. 9 in. long, and weighs 53 tons. The columns pass through the lower platen and the moving crosshead, for which they form the guides, and are rigidly attached to the top platen. The lower platen consists of three castings —a centre section weighing 64 tons and two 42-ton side sections—which are dowelled, dovetailed and bolted together. The centre section forms the bed for the moving table, and supports the bolster and bottom die. The top bolster and dies are held in T slots and spigoted recesses in the lower face of the crosshead, which weighs, with its bushes, 108 tons. The three hydraulic rams which actuate the press are each 4 ft. 3 in. in diameter, 15 ft. long, and weighs $28\frac{1}{2}$ tons. They are attached to the upper platen, which weighs 94 tons, and work in cylinders weighing 36 tons each. Mounted above the upper platen, as shown in Fig. 3, is a "buffer vessel," the pressure water being released into it before returning to the prefilling vessels.

The press is controlled by a single lever on the operator's panel. The first forward movement from the neutral position takes up the idle stroke, using only the prefilling pressure of about 40 lb. per square inch and the weight of the crosshead and rams. Movement of the lever to the second position applies the pressure of 4,000 to 12,000 tons, as the case may be. If the lever is then returned to the neutral position, the pressure is sustained. Pulling the lever back releases the pressure to the buffer vessel and lifts the crosshead. Subsidiary controls operate the moving table and the ejector mechanism, and are interlocked to prevent movement of the table while the ejector is raised. The safety devices include low-level and high-level audible warnings and an automatically-actuated stop valve, which shuts if the water level falls too far in the bottles. No more water can then be drawn from them until the pumps have restored the normal water level. A siren sounds if the water level is too low, and a hooter if it is too high. An illuminated indicator panel shows which pumps are on load, and the position of the low-level automatic valve. It is expected that the availability of this press will encourage designers of aircraft, in particular, to use forgings of types, sizes and weights greater than they have been able to employ hitherto; and it should lead also to the adoption of aluminium forgings in many new fields.

ARMSTRONG WHITWORTH GUIDED-MISSILE TRIAL STATION IN AUSTRALIA.—A field trial centre for rockets and guided missiles is being established in Australia by Sir W. G. Armstrong Whitworth (Aircraft), Limited, Baginton, Coventry. The station will be located at Salisbury, near Adelaide. Launching ramps, electronic gear and test equipment are being installed and a team of British and Australian technicians and executives have recently left London to take up their duties at the new station.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

TERMINAL BUILDING, RENFREW AIRPORT.—Preparatory work has begun on a new two-storeyed air-terminal building at Renfrew airport, after approval of the architect's plans by the Scottish Aerodromes Board on February 25. The roof of the main concourse, in cantilever construction, will be suspended from a main arch of reinforced concrete, forming the dominant feature of the front elevation. Estimated to cost 150,000*l*., the terminal is intended to be ready for use in time for next year's summer services.

EXPORTS OF COAL.—Coal export cargoes from Scottish ports increased sharply during January as compared with a year ago, the total reaching 69,402 tons, against 37,821 tons. The corresponding figure for January, 1951, was 37,136 tons. Shipments to Denmark were mainly responsible for the expansion.

UNDER-WATER TELEVISION IN SHIP-REPAIR WORK.—Mr. W. P. D. McIntyre, chairman, presiding on February 26 at the annual meeting of the Association of Underwriters and Insurance Brokers in Glasgow, said that he understood that under-water television had reached a stage of development at which it might be used successfully for the survey of damage to ships' hulls below the water line, for salvage work, and for harbour inspection. By shortening the time spent upon salvage work, the apparatus could lessen costs. This would be of benefit to underwriters, being reflected ultimately in the cost of insurance.

INCREASES IN ELECTRICITY TARIFFS.—Increases in the commercial electricity tariff throughout the South-East of Scotland and in the industrial tariff in Edinburgh were announced on February 24 by the South-East Scotland Electricity Board. They will take effect on April 1. The advances do not allow for the latest rise in the price of coal, and Sir Norman Duke, chairman of the Board, said that further tariff increases might be inevitable. The rises announced are expected to amount to an average increase of 8 per cent.

CLEVELAND AND THE NORTHERN COUNTIES.

THE NEED FOR MORE COAL.—A call to leaders of the National Union of Mineworkers to correct the apparent and "sadly erroneous belief" in coalfields that coal consumers are only of minor importance is made in an editorial article in the current issue of the *Journal* of the Tees-side Chamber of Commerce. The article states that, in 1952, there was a drop of nearly 1 per cent. in productivity at the coal face, and the amount of coal lost through disputes was the highest since the pits were nationalised. Man-power is now not the problem in the mines that it has been. In 1953 the miners are to get two weeks holiday, which will cost 4,000,000 tons of coal. Past experience makes it doubtful whether the miners' wage increase will result in higher productivity. Sir Hubert Houldsworth, chairman of the National Coal Board, is aware that buyers will transfer their custom if delivery schedules are constantly fluctuating and prices rising. This danger, the writer concludes, is one which the leaders of the National Union of Mineworkers should emphasise in coalfields.

MEMBERSHIP OF ELECTRICITY CONSULTATIVE COUNCILS.—Criticism of electricity consultative councils was expressed at a meeting of the Tees-side and South-West Durham Chamber of Commerce, at Middlesbrough, on February 20. Mr. T. H. Summerson commented that the chairmen of these councils were members of the Area Electricity Boards, and the councils invariably acted, not as independent people, but as apologists for the Electricity Boards. Mr. E. M. Fisher, of the North-Eastern Electricity Board, stated that chairmen of consultative councils automatically became members of the Electricity Boards. It was not a case of Board members being appointed chairmen of consultative councils. Mr. Summerson commented that, of an average membership of 28 on these councils, industry and commerce, which used about two-thirds of the total electricity consumed, had only three members.

POSSIBLE ATOMIC-ENERGY DEVELOPMENTS.—Addressing members of the King's College Stephenson Engineering Society at Newcastle-on-Tyne on February 24, Mr. B. L. Goodlet, deputy chief engineer of the Atomic Energy Research Establishment, Harwell, controverted the idea that the use of atomic power in industry would be an early development. Dealing with the production of power from heat generated by atomic piles, he said that it had still to be decided whether these projects were technically feasible and economic. The general conclusion was that it was likely to be on the generation of steam that a commencement would be made.

FACTORY FOR TEAM VALLEY.—Tenders are being invited by North-Eastern Trading Estates, Ltd., Gateshead, for the erection of a factory having a floor space of 30,000 sq. ft. on the Team Valley trading estate, Gateshead.

STEEL PIPES FOR FLOODED AREAS.—The South Durham Steel and Iron Co., Ltd., Middlesbrough, have again completed, within a few days, an order for 1,000 metres of 24-in. diameter steel pipe for the flooded areas of Holland. The firm have received a letter from the authorities in the Netherlands thanking them for their efficiency and co-operation.

AN OPINION ON DOUBLE SHIFTS IN ENGINEERING.—At the annual luncheon meeting of the North-East Engineering Bureau at Newcastle-on-Tyne on February 26, Mr. R. W. Mann, of Victor Products, Ltd., Wallsend-on-Tyne, said that a 44-hour week was too short for a firm to use effectively expensive and highly-productive machine tools. Double shifts were needed and, with the prospect of keener competition, the engineering industry would have to re-orientate its ideas. Firm quotations were now necessary and there was no room for guesswork.

THE LATE MR. A. R. FAIRBAIRN.—The death has taken place, at Ryton-on-Tyne, of Mr. Arthur Rees Fairbairn, who had been works engineer and traffic manager with Vickers-Armstrongs Ltd. He was 68 years of age.

LANCASHIRE AND SOUTH YORKSHIRE.

STAINLESS-STEEL FORGINGS.—The first of two stabiliser fin shafts which Hadfields Ltd. are making for the new Royal yacht has left the East Hecla Works, Sheffield. Each weighs 14½ tons and is 26 ft. long. They are produced from stainless-steel ingots, each weighing about 22 tons. The steel has been made by the basic electric process.

INCREASE IN SHORT-TIME WORKING.—In Sheffield in February there was a decrease of 59 in the number of men out of work, but an increase in the number of employees on short time from 178 to 617. The continued depression in the cutlery and small-tool industries is the cause of more short-time working. Between the January and February counts of unemployment, made by the Ministry of Labour, an average of ten more operatives was paid off or put on short time each week. In the Rotherham district the number of men on short time has risen from six to 122. Five steel-making firms are affected. The main cause is said to be a shortage of orders rather than of materials.

FARADAY LECTURE.—Mr. A. R. Cooper, Divisional Controller for Generation in the North-Western Division of the Electricity Board, delivered at the Sheffield City Hall, on March 4, the Faraday lecture of the Institution of Electrical Engineers. This year's lecture, "Power and its Development Through the Ages," traced electricity from early days to the present atomic age.

FOR NEW STEELWORKS IN ISRAEL.—Intended for a new steelworks in Israel, six steel casting ladles, each of 35 tons capacity, have been designed and constructed at the Thorncliffe works of Newton, Chambers & Co., Ltd., Sheffield, for the Wellman Smith Owen Engineering Corporation, Ltd.

THE MIDLANDS.

BIRMINGHAM SAFETY CENTRE.—The Birmingham and District Industrial Safety Group have opened a permanent "Safety Centre" at the rear of the Museum of Science and Industry, Newhall-street. The Group held two series of courses on industrial safety, in 1951 and 1952, and it was the success of these courses which led to the establishment of a permanent centre where the work of training can be carried on continuously. Member firms have presented machines, tools and equipment of various types, including a capstan lathe, a power press, a metal-cutting bandsaw, and a polishing lathe. Additional plant will be installed later. Three rooms are occupied by the safety centre—a machine shop, a lecture room, and an exhibition room where safety appliances are shown. Safety officers from large firms in the Birmingham district will give their services to conduct courses in the centre. Small firms who have no safety training schemes will be invited to send employees to the centre for short courses, and special efforts will be made to give immediate accident-prevention instruction to young people who are entering industry.

AMALGAMATION OF MOTOR-CYCLE MANUFACTURERS.—Associated Motor Cycles, Ltd., of Plumstead, London, S.E.18, have acquired the entire share capital of Norton Motors, Ltd., of Birmingham. The Norton company will continue to operate as a separate concern, under the present management, as will the Norton subsidiary company, R. T. Shelley, Ltd., of Birmingham.

MOTOR-CAR DEVELOPMENTS.—Jaguar Cars, Ltd., Holbrook-lane, Coventry, state that all Mk. 7 Jaguar cars ordered for North America are now being fitted with automatic transmission. The transmission gear is made by the Borg-Warner Corporation, of Detroit, Michigan, and Treasury sanction has been obtained for the purchase of complete transmission units from America. The Borg-Warner transmission is a hydraulic torque-converter, with a direct-drive top gear. Another item of Coventry interest is the conclusion of an agreement between Willys Overland Motors, Inc., and the Standard Motor Co., Ltd., Banner-lane, Coventry, for the manufacture by the latter company of the Willys "jeep" in this country. The Coventry-made vehicle will be completely standardised with the American one, and equipment and parts will be interchangeable.

FILM OF ELDERLY WORKERS.—The Ministry of Labour, Midland Region, are prepared to lend to employers and professional bodies in the Midlands a 16-mm. sound film, running for about 15 minutes, which deals with the question of finding employment for elderly persons. It was produced for the Canadian Department of Labour.

GAMMA-RAY APPARATUS FOR AMERICA.—Gamma-Rays, Ltd., Foundry-lane, Smethwick, 40, have made arrangements with the Delta Tank and Mining Corporation, of the United States, for the manufacture in America of the British gamma-ray operating and storage container. The British container has been designed to use radio-active isotopes produced at Harwell and at similar plants in America, and can be used for the examination of a single specimen, or a number of specimens arranged round it in a circle.

SOUTH-WEST ENGLAND AND SOUTH WALES.

TEMPORARY CLOSING OF TIN-PLATE WORKS.—Production at all old-type tin-plate works belonging to the Steel Company of Wales, Ltd., and Richard Thomas and Baldwins, Ltd., stopped on Monday, March 2, for "at least three or four weeks." Announcing this to trade-union representatives at a meeting in Swansea Mr. Ernest H. Lever, chairman of the two companies, said that about 5,000 men at 12 works in an area from Lydney in Gloucestershire to Llanelly would be affected. He explained that the firms were carrying heavy stocks of unsold and unordered plates. He said that it had been decided against closing more works than those announced last month permanently and completely, because they expected the demand to improve in a few months' time. The men concerned, in accordance with the four-day guarantee in the tin-plate trade were entitled, if they reported to the works, to a maximum of 30*s*. a day, or 90 per cent. of their wages, according to grade. On the other two days they would sign on at the Labour Exchanges.

CAMPAIGN FOR INCREASED COAL OUTPUT.—Opening the campaign for increased output in South Wales, Sir Hubert Houldsworth, chairman of the National Coal Board, told a conference representative of the miners, the management and administrative staffs that, of the extra 7,000,000 tons of coal which the miners of Britain were asked to produce this year, more than 1,000,000 tons would have to come from the South Wales coalfield.

KERRY'S (GREAT BRITAIN), LIMITED.—Following a serious fire in their premises at Alphington-street, Exeter, on December 18, Messrs. Kerry's (Great Britain), Ltd., whose head office is in Warton-road, Stratford, London, E.15, have secured temporary accommodation in North-street, Heavitree, Exeter, where they re-opened their show-room on March 2. It is expected that their premises in Alphington-street will be rebuilt by the end of the year.

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, March 9, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Is the Presentation of Technical Literature Adequate?" opened by Professor M. G. Say. *Western Centre:* Monday, March 9, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *North-Eastern Centre:* Monday, March 9, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Performance of Natural-Draught Water-Cooling Towers," by Mr. H. Chilton. *East Midland Centre:* Tuesday, March 10, 6.30 p.m., Offices of the East Midland Electricity Board, Derby. "Electricity in Farm Crop Drying," by Mr. C. A. Cameron-Brown and Mr. P. G. Finn-Kelcey. *Radio Section:* Wednesday, March 11, 5.30 p.m., Victoria-embankment, W.C.2. "Low-Level Modulation Vision Transmitters, with Special Reference to the Kirk o'Shotts and Wenvoe Stations," by Mr. E. McP. Leyton, Mr. E. A. Nind and Mr. W. S. Percival. *North Midland Centre:* Wednesday, March 11, 7 p.m., Stafford Arms Hotel, Wakefield. "Electricity Supply: A Statistical Approach to Some Particular Problems," by Mr. R. B. Rowson.

INSTITUTE OF FUEL.—*North-East Section:* Monday, March 9, 6.30 p.m., King's College, Newcastle-upon-Tyne. "Methane Drainage," by Mr. R. L. Cauley and Dr. J. H. Jones. *Midland Section:* Tuesday, March 10, 6 p.m., James Watt Memorial Institute, Birmingham. Open Meeting. *North-Western Section:* Wednesday, March 11, 6.30 p.m., Engineers' Club, Manchester. Film Evening.

ILLUMINATING ENGINEERING SOCIETY.—*Sheffield Centre:* Monday, March 9, 6.30 p.m., The University, Western Bank, Sheffield. "Road Vehicle Lighting," by Mr. J. Nelson. *London:* Tuesday, March 10, 6 p.m., Royal Society of Arts, John Adam-street, W.C.2. Discussion on "Lighting of Office Buildings," opened by Mr. P. V. Burnett. *Manchester Centre:* Thursday, March 12, 6 p.m., Offices of the North Western Electricity Board, Town Hall Extension, Manchester. "Transport Lighting," by Mr. E. G. Wotton.

INSTITUTION OF WORKS MANAGERS.—*Manchester Branch:* Monday, March 9, 6.45 p.m., Grand Hotel, Manchester. "Human Relations in Industry," by Mr. R. Craig Wood. *Tees-Side Branch:* Wednesday, March 11, 7.30 p.m., Vane Arms Hotel, Stockton-on-Tees. "Modern Legislation," by Mr. R. Hillier.

INSTITUTION OF THE RUBBER INDUSTRY.—*Midland Section:* Monday, March 9, 6.45 p.m., James Watt Institute, Birmingham. Discussion on "Saving Materials." *Preston Section:* Monday, March 9, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. "Belt Conveying," by Mr. J. J. Hickey. *Institution:* Tuesday, March 10, 5.30 p.m., Royal Society of Tropical Medicine and Hygiene, 26, Portland-place, W.1. (i) "Latex Dipping," by Mr. L. Landau; and (ii) "Ageing and Weathering of Rubber," by Mr. J. M. Buist. *Southampton Section:* Wednesday, March 11, 7.30 p.m., Polygon Hotel, Southampton. "Pigments," by Mr. C. R. M. Oehlske. *West of England Section:* Wednesday, March 11, 7.45 p.m., Melksham House, Melksham. "Racing Tyres for Two- and Three-Wheeled Vehicles," by Mr. T. J. P. Joy.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section:* Monday, March 9, 7 p.m., 16, St. Mary's Parsonage, Manchester. Film Evening. *Sheffield Section:* Monday, March 9, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. "Colour Psychology as Applied to Industry," by Mr. J. L. Brooke. *Institution:* Friday, March 13, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Electrical Components: the Elements of an Industry," by Mr. J. D. Hinchcliffe.

INSTITUTE OF WELDING.—*Sheffield Branch:* Monday, March 9, 7.15 p.m., College of Commerce and Technology, Sheffield. Brains Trust Meeting. *Liverpool Branch:* Tuesday, March 10, 7 p.m., 9, Whitechapel, Liverpool. "The Welder and Working Conditions," by Mr. H. E. Poole. *South London Branch:* Thursday, March 12, 7 p.m., Messrs. Creed & Co., Ltd., Telegraph House, Coulston-road, East Croydon. "Welding Jigs and Fixtures," by Mr. P. J. Henoker. *South-Western Branch:* Friday, March 13, 7 p.m., Radiant House, Coulston-street, Bristol. "Setting-up, Holding and Positioning for Manual and Automatic Arc Welding," by Mr. D. Ross. *Birmingham Branch:* Friday, March 13, 7 p.m., James Watt Memorial Institute, Birmingham. Film on "Hard Surfacing."

INSTITUTION OF MECHANICAL ENGINEERS.—*Automobile Division:* Tuesday, March 10, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Engineering Changes," by Mr. Harold Drew. *London Graduates' Section:* Wednesday, March 11, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Works Administration in an Engineering Factory," by Mr. R. Aldridge. *Institution:* Friday March 13, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Steels for Steam Power Plant," by Mr. A. M. Sage.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, March 10, 5.30 p.m., 85, Minories, E.C.3. "Improvements in Ship Performance," by Dr. J. F. Allen.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, March 10, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Climbing Film Evaporation," by Mr. J. M. Coulson.

INSTITUTION OF CIVIL ENGINEERS.—*Maritime Division:* Tuesday, March 10, 5.30 p.m., Great George-street, S.W.1. "Port of London Authority Engineering Works, 1952," by Mr. G. A. Wilson. *Midlands Association:* Thursday, March 12, 6 p.m., James Watt Memorial Institute, Birmingham. "Claerwen Dam," by Mr. H. D. Morgan and others.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, March 10, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Resistance of Single-Screw Coasters, Part I.—$\frac{L}{B} = 6$," by Mr. J. Dawson.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Tuesday, March 10, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Discussion on "Standardisation of Symbols and the Arrangement of Electronic-Circuit Diagrams," opened by Mr. L. A. Bainbridge-Bell. *North-Eastern Section:* Wednesday, March 11, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Discussion on "Slotted-Aerial Design."

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, March 10, 7 p.m., Grand Hotel, Sheffield. "Analytical Chemistry of Tantalum and Niobium Based on Cellulose Chromatography," by Mr. A. F. Williams.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, March 10, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Vehicle Design in the Past Decade," by Mr. W. C. Wilson. *East Midlands Centre:* Wednesday, March 11, 7.30 p.m., Mechanics Institute, Nottingham. "Choice of a Crankcase Lubricating Oil," by Mr. A. Towle. *Western Centre:* Thursday, March 12, 7.30 p.m., Grand Hotel, Bristol. "Costing of Vehicle Maintenance," by Mr. H. Rossington.

INSTITUTION OF PRODUCTION ENGINEERS.—*Dundee Section:* Tuesday, March 10, 7.30 p.m., Queen's Hotel, Dundee. "Case Hardening and Induction Hardening," by Mr. W. J. G. Cosgrave. *Birmingham Section:* Wednesday, March 11, 7 p.m., Cadena Café, Worcester. "Materials Handling for Batch Production," by Mr. F. E. Rattlidge. *Halifax Section:* Wednesday, March 11, 7.15 p.m., George Hotel, Huddersfield. "Engineering Potentialities of Spheroidal Graphite Cast Iron," by Dr. A. B. Everest. *Preston Section:* Wednesday, March 11, 7.15 p.m., Victoria and Station Hotel, Fishergate, Preston. "Organisation of Production and Planning," by Mr. B. E. Stokes. *Eastern Counties Section:* Friday, March 13, 6.30 p.m., Public Library, Ipswich. Annual Meeting and Symposium on "Machine Tools." *Western Section:* Friday, March 13, 7.30 p.m., Wheatstone Hall, Brunswick-road, Gloucester. "Activities of the Production Engineering Research Association," by Dr. D. F. Galloway.

ROYAL SOCIETY OF ARTS.—Wednesday, March 11, 2.30 p.m., John Adam-street, Adelphi, W.C.2. "The High Paddington Scheme," by Mr. Sergei Kadleigh.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch:* Wednesday, March 11, 6.30 p.m., Mackworth Hotel, Swansea. "Tubular Structures," by Mr. J. R. M. McEwen. *Institution:* Thursday, March 12, 6 p.m., 11, Upper Belgrave-street, S.W.1. Joint meeting with the INSTITUTE OF WELDING. "Construction of the New Testing Laboratory of the British Welding Research Association at Abington," by Mr. E. M. Lewis.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Wednesday, March 11, 7 p.m., Engineers' Club, Manchester. "A Simple and Cheap Mechanical Layout for the Small Jobbing Brass Founder," by Mr. F. C. Evans. *Lincolnshire Branch:* Thursday, March 12, 7.15 p.m., Technical College, Lincoln. "Application of Ferrous Alloys in the Iron Foundry," by Mr. H. P. Hughes. *Scottish Branch:* Saturday, March 14, 3 p.m., Royal Technical College, Glasgow. Annual Meeting "Modern Ideas in the Brass Foundry," by Mr. J. M. Douglas and Mr. W. S. Richardson. *West Riding of Yorkshire Branch:* Saturday, March 14, 6.30 p.m., Technical College, Bradford. "Production of Castings for Internal-Combustion Engines," by Mr. H. Haynes and Mr. C. R. van der Ben.

INSTITUTION OF ENGINEERING INSPECTION.—*Leeds Branch:* Wednesday, March 11, 7.30 p.m., Church Institute, Leeds. Film Evening.

ROYAL INSTITUTION.—Thursday, March 12, 5.15 p.m., 21, Albemarle-street, W.1. "X-Ray Optics.—II," by Professor Sir Lawrence Bragg, F.R.S.

ROYAL AERONAUTICAL SOCIETY.—Thursday, March 12, 6.15 p.m., Welfare Hall, Messrs. Rolls-Royce, Ltd., Derby. "High-Performance Jet Aircraft," by Sqdn.-Leader W. A. Waterton.

PERSONAL.

REAR-ADMIRAL (E) F. T. MASON, C.B., is to be promoted to Vice-Admiral (E) and to be Engineer-in-Chief of the Fleet as from April 28. CAPTAIN (E) J. G. C. GIVEN, C.B.E., is to be promoted to Rear-Admiral (E) and appointed to the staff of the Commander-in-Chief, The Nore, as from April 14.

DR. H. L. HASLEGRAVE, B.A.(Cantab.), M.Sc.(Lond.), M.I.Mech.E., M.I.E.E., who has been Principal of Leicester College of Technology since January, 1947, is to be the first Principal of Loughborough College of Technology.

MR. A. UPTON, who has been manager of the switchgear department of Johnson & Phillips Ltd., Charlton, London, S.E.7, since 1947, is relinquishing this appointment shortly to go to America to take up the position of general manager of the switchgear division of a company in the United States.

MR. R. B. ADAMSON, assistant technical manager (gun mountings) Vickers-Armstrongs Ltd., Newcastle-upon-Tyne, has retired after 45 years of service with the company.

MR. T. W. EDWARDS, J.P., F.C.I.S., joint managing director, Park Gate Iron & Steel Co. Ltd., Rotherham, retired on February 28 after 54½ years of service with the company.

MR. ROBERT TELFORD, A.M.I.E.E., formerly assistant to the general manager, Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex, has been appointed to the new post of general works manager of all factories and model shops. MR. J. P. WYKES, A.M.I.E.E., will continue as works manager, Chelmsford, and MR. E. B. GREENWOOD, A.M.I.E.E., has been appointed works manager of the factory now being built at Basildon New Town, Essex.

The Council of the Institute of Welding, 2, Buckingham Palace-gardens, Buckingham Palace-road, S.W.1, have awarded the Sir William J. Larke Medal for 1952 to MR. J. RANNIE, M.Sc., M.Inst.N.A., welding engineer to John Brown & Co. Ltd., Clydebank.

MR. D. N. SIMPSON has been appointed chief planning officer of colliery developments in the Cwmgorse Valley, South Western Division, National Coal Board.

MR. D. J. HAGGIE has been appointed chairman of Spear & Jackson Ltd., Sheffield. MR. G. F. HOWARD has been made deputy chairman and joint managing director, MR. S. M. DE BARTOLOME, joint managing director, and MR. H. BROADBENT, a director.

DR. W. L. LOWE-BROWN, M.I.C.E., consulting engineer, of 39, Victoria-street, Westminster, S.W.1, informs us that he is giving up his office and retiring from practice on March 24.

MR. C. J. RITCHIE retired from the position of general sales manager, Aveling-Barford Ltd., Grantham, on February 28. His successor is MR. J. L. RITCHIE, B.Sc., A.M.I.Mech.E., hitherto export sales manager. MR. G. M. WARREN has become export sales manager.

MR. D. MCKENNA, O.B.E., M.A.(Cantab.), M.Inst.T., at present commercial manager, has been appointed chief commercial and public relations officer, London Transport Executive, 55, Broadway, S.W.1.

MR. C. E. WEEDEN has been appointed publicity officer to the Glass Manufacturers' Federation, the offices of which have been moved to 19, Portland-place, London, W.1. (Telephone: LANgham 6952.)

MR. W. D. WHEELER, A.M.I.E.E., is to be chief representative in South Africa of Kennedy and Donkin, 12, Caxton-street, London, S.W.1. He will be in charge of their office at 22, Amershoff-street, Braamfontein, Johannesburg.

MR. R. M. BARTON has been made sales manager, British West Indian Airways, Stratton House, Piccadilly, London W.1. MR. R. E. W. WILLIS is to be manager, Jamaica.

The registered offices of LANCASHIRE DYNAMO HOLDINGS, LTD. and the offices of the LANCASHIRE DYNAMO GROUP publicity services have been moved to St. Stephen's House, Victoria-embankment, London, S.W.1.

B.E.L.A. MACHINE TOOLS, LTD., announce that their address is now 873-879, Old Kent-road, London, S.E.15. (Telephone: NEW Cross 5091/2/3.)

BUCKTON, LTD., 63, Stockport-road, Ashton-under-Lyne, Lancashire, have appointed A. BOND & CO. (EDINBURGH) LTD., 87, Shandwick-place, Edinburgh, 2, to be their Scottish engineers and agents.

MUSGRAVE AND CO., LTD., St. Ann's Works, Belfast, have removed their Newcastle office from Clayton-street, to 34, Great North-road, Newcastle-upon-Tyne, 2. (Telephone: 26311.)

The sole selling and manufacturing rights of SPA hot-forged steel unions, hitherto marketed by STEAM PLANT ACCESSORIES, LTD., have been taken over by SHAY PRODUCTS, LTD., 17, Little St. Leonards, Mortlake, London, S.W.14. Manufacture will be continued by J. E. SHAY LTD., Kingsclere-road, Basingstoke, Hampshire.

12,000-TON HYDRAULIC FORGING PRESS FOR ALUMINIUM.

(*For Description, see Page* 301.)

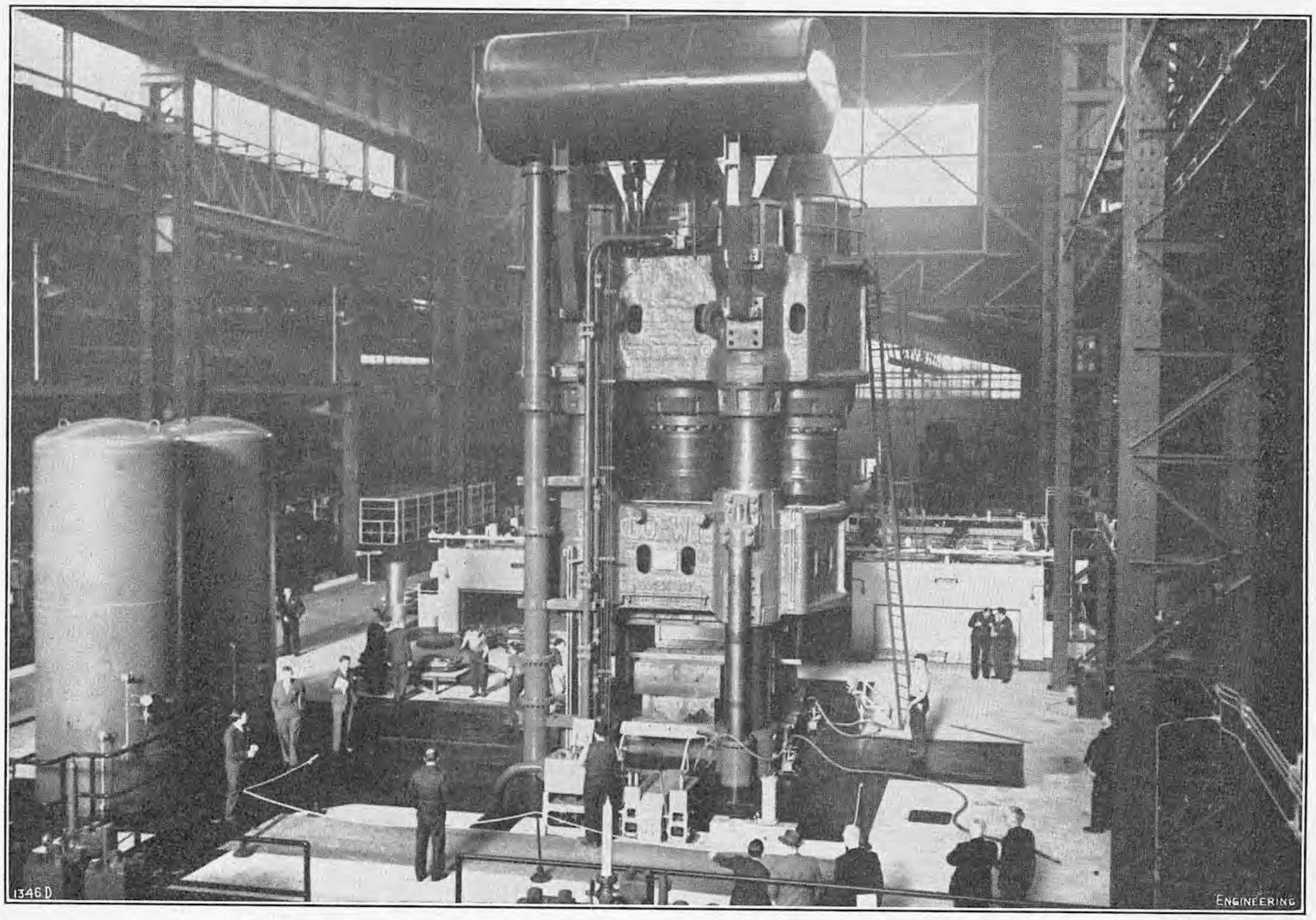


FIG. 4. INAUGURATION OF PRESS AT REDDITCH WORKS OF HIGH DUTY ALLOYS, LIMITED.

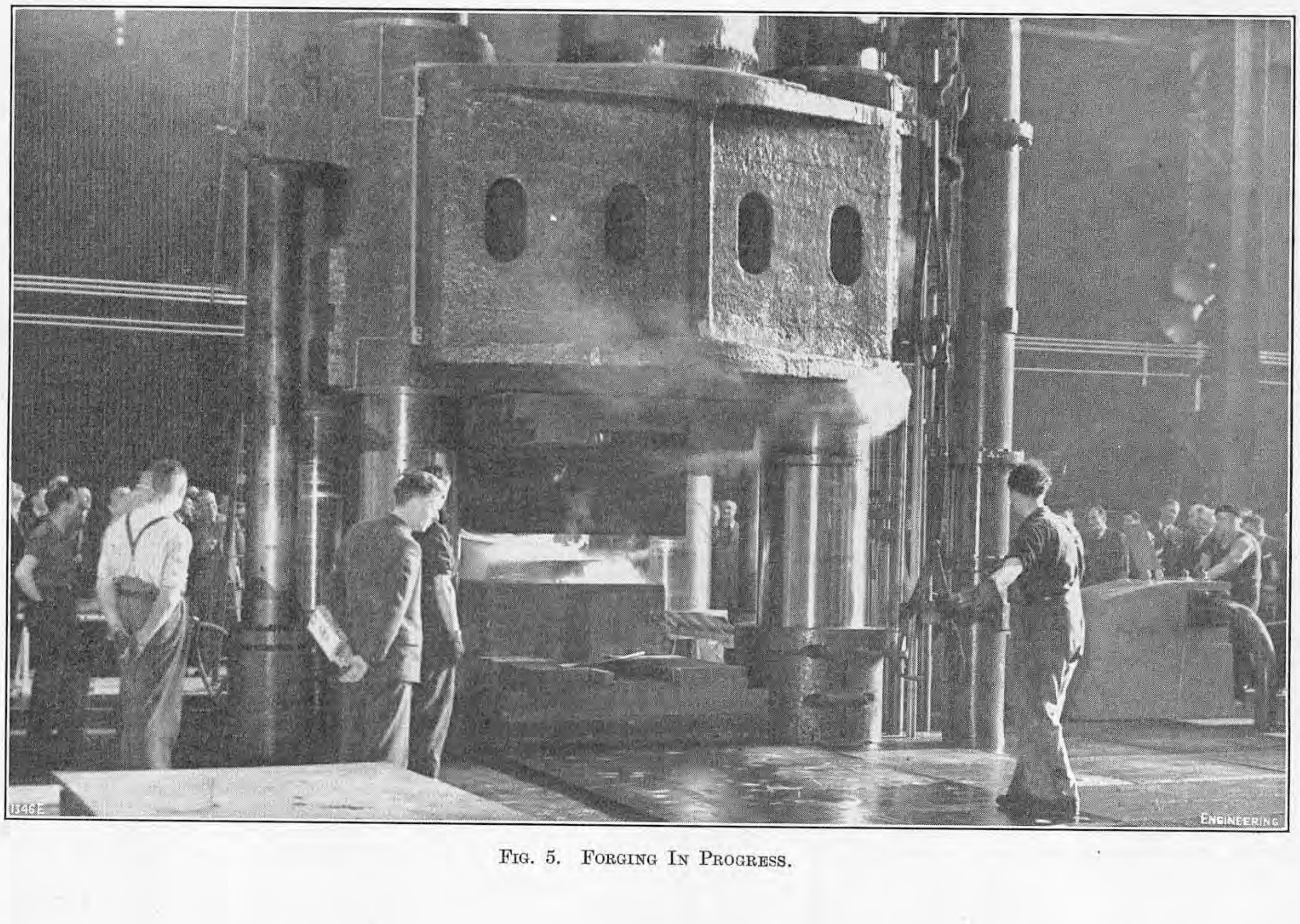


FIG. 5. FORGING IN PROGRESS.

ENGINEERING

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ENGINEERING

FRIDAY, MARCH 6, 1953.

VOL. 175. No. 4545.

FRETTING CORROSION.

THE investigation of fretting corrosion which Dr. K. H. R. Wright described to the Institution of Mechanical Engineers in the paper which he delivered at the meeting in London on February 20 is an important contribution to the solution of a problem that has appeared the more troublesome as the precision of metal-finishing and fitting operations has improved. It is no exaggeration to say that, in a considerable proportion of the high-speed equipment demanding minute clearances and fine surface preparation, the full capabilities and, more particularly, the lasting advantages of modern machining cannot be realised in consequence of fretting corrosion under service conditions. From theory and experience, indeed, it is clear that the severity of fretting corrosion is enhanced by the approach to perfection in adjacent surfaces which suffer relative vibratory slip, and the contrast between what mechanical engineering can achieve and what it has been unable to prevent is a challenge that has been growing steadily more insistent.

Fretting corrosion is not a new phenomenon. More than 40 years ago it was commonly known to occur at the contacting surfaces of wheels and shafts, keys and keyways, and ball bearings, while the incidental trouble it caused during experiments on the fatigue of metals led to some special attention and the conclusion that the oxidation debris was due to cyclic stresses of more than a critical magnitude in the affected material. Subsequent studies, directly concerned with fretting corrosion and its effects on a variety of materials, some of them non-metallic, have revealed not only that the phenomena admit of no such straightforward explanation, but that their ultimate cause and cure become increasingly obscure, the more deeply they are probed. One result of the failure to discover a satisfactory practical means of preventing fretting corrosion is the successive appearance of different theories, most of them apparently well justified by the experimental data advanced to support them. It is seldom possible, however, to anticipate all the factors that may eventually prove to be significant in a physical problem, and correspondingly difficult to design perfectly controlled experiments. Any fresh investigation should therefore be carried out with increasingly precise apparatus and more refined methods of analysis, guided by comprehensive and critical knowledge of previous work.

In these respects, the research on which Dr. Wright is engaged is an admirable sequel to that of G. A. Tomlinson, P. L. Thorpe and H. J. Gough at the National Physical Laboratory in 1939.* That work, recently resumed in the Lubrication and Wear Division of the Mechanical Engineering Research Laboratory, left several obvious lines of inquiry unexplored and others so tentatively examined that some deductions, which appeared reasonable at the time, may well have been incomplete or mistaken. From the more confident conclusions, however, coupled with the results of later investigations in this country and America, it now appears certain that the process of fretting corrosion starts with the production of minute particles of virgin material, which are rapidly oxidised and sometimes otherwise chemically changed according to the environment to which they are exposed. Such compounds may act as abrasives to exacerbate the fretting effect, or they may afford some degree of protection to mating surfaces that are oscillating relatively to each other with minute slip. The complexities of the inherent fretting process and its incidental consequences are evidently sufficient justification for Dr. Wright to have placed the emphasis of his research upon achieving a high degree of experimental reproducibility, adequate to permit quantitative measurements of the extent of fretting corrosion damage to be correlated with a few separately and scrupulously controlled variables.

The somewhat idealised apparatus used to produce fretting was essentially the same as that developed for the later stages of the N.P.L. research, in which two plane annular surfaces, forced into contact by a variable load, were repeatedly oscillated through 0·001 in. relative slip by a motor-driven eccentric linked to one of the specimens. Most of Dr. Wright's present tests have been carried out upon specimens of hardened 1 per cent. carbon steel, on which the prepared test surfaces were lapped to be originally very smooth and flat. The amount of oxidised debris was determined by colorimetric analysis and the state of the fretting-corroded surfaces was appraised by optical measurement and the removal of corrosion pits by progressive lapping. Searching examination, by microscopic and other appropriate techniques, of the details of the surface damage characteristic of fretting corrosion under different conditions of formation and materials is undoubtedly a worthwhile aspect of fretting research. Not only is it likely to throw light on the question, still controversial, of the mechanism whereby the primary and most fundamental stage of the attrition process takes place, but also it should prove instructive as regards the influence of a fretted surface in promoting fatigue fracture across the blemished component. This is a matter of practical engineering importance, since some of the commonest occurrences of fretting corrosion—at the inner end of an interference-fitted wheel-axle assembly, for example—are at situations where the actual agent of fretting corrosion is the predisposing cause of fatigue failure.

* *Proc. I.Mech.E.*, vol. 141, page 223, and vol. 142, page 401, (1939); and ENGINEERING, vol. 147, pages 281 and 293, and vol. 148, page 143 (1939).

The most important new feature introduced in Dr. Wright's apparatus, however, is the provision to enable the humidity of the atmosphere surrounding the specimens to be controlled; or, alternatively, to permit the test surfaces to be flooded with lubricant or other liquid. The immediate result has been to demonstrate that humidity variations exert a pronounced effect on both the form and the total amount of fretting corrosion damage; from which it may be inferred that the large discrepancies among the observations of previous workers may well be atributed to the absence of humidity control in their experiments. Dr. Wright has discovered, moreover, that humidity has unexpected as well as marked influences. In a series of tests upon steel, to correlate the extent of fretting corrosion damage with the number of oscillations causing it, he found that the volume of material fretted away, represented by the product of the maximum corroded area and the depth of the corrosion pits, was twice as great when the humidity was under 10 per cent. as when it was 100 per cent., yet less than half as great for 50 per cent. as for 100 per cent. humidity. A large number of his other test results confirm beyond reasonable doubt that a completely humid atmosphere causes about two and a half times as much damage as one in which the relative humidity is only 50 per cent. Since fretting-corrosion debris from steel is certainly an oxidation product of chemical action, the greater volume of corrosion debris formed at the higher humidity is perhaps to be expected, but that the extent of fretting damage should have a minimum value at some intermediate value of relative humidity poses some questions as yet incompletely explained. It is considerably easier to accept that the extent of surface damage is in closely linear proportion to the number of cyclic oscillations between the test surfaces, and to the magnitude of the load forcing them into contact, notwithstanding that the earlier N.P.L. work led to the conclusion that the effect of normal load variation was insignificant within the limits of experimental condition then explored.

The complex influence of humidity, as a single variable, is additionally demonstrated by Dr. Wright's experiments with steel surfaces fretting against chromium and gold, respectively, the damage to the steel being, in the former case, progressively decreased with increasing humidity, whereas with gold the effect was in the opposite direction and, on the whole, far less marked. Evidently, there are important fundamental agencies in operation which nothing short of careful and imaginative scientific research will suffice to explain. Meanwhile, it is not easy to see how the engineer can improve matters by purely mechanical means. Fretting corrosion takes place at contacting surfaces that, for reasons inherent in his designs, must not be welded together so as positively to exclude humid air, and which form the boundaries of crevices, of capillary thickness, into which moisture is attracted. Without absolutely rigid connection, moreover, the practical possibility of preventing relative surface slip, of as little as one micro-inch or even less, is also too remote to offer any hope of successfully avoiding one of the essential agents of fretting corrosion. Again, from what has been said of the results obtained with chromium and gold, as well as from Dr. Wright's findings with nickel, it is clear that fretting corrosion is no respector of metals; though it must be borne in mind that, when chromium was tested against steel, the damage was confined to the steel, the hard chromium surface being barely marked, irrespective of the ambient humidity. In circumstances where fretting corrosion of one of a pair of mating surfaces is worth avoiding at the cost of heavier damage to the other, chromium plating may thus be regarded as beneficial, if not always practicable; and, while there is experimental evidence that fretting corrosion takes place between two surfaces of chromium, its severity, compared with that between identical steels, may be so much less as to justify, in exceptional circumstances, the trouble and expense of plating both.

Among the surface coatings which suggest themselves as likely to oppose fretting corrosion are materials having low coefficients of friction, like colloidal graphite, polytetrafluoroethylene plastic ("P.T.F.E.") and molybdenum disulphide. The last of these has been found to give good results when bonded to both opposing steel surfaces, though the bonded film is weak and, under high intensity of loading, is liable to fail locally. Whether adsorbed surface films, on steel, of graphite or P.T.F.E. plastic, would prove enduring enough to be useful is as yet uncertain, but it is highly significant that, in an experiment which Dr. Wright made under low loading, steel suffered no fretting corrosion whatever when vibrated against P.T.F.E., and very little against polyethylene plastic. This was in marked contrast to fabric-reinforced phenolic and polymethacrylate plastics, which damaged the steel as extensively as a mating surface of the same steel. Dr. Wright also reports that, for steel surfaces, phosphating one or both of them is extremely beneficial, especially if the porous phosphate structure is impregnated with a lubricant, such as paraffin of British Pharmacopoeia quality, which not only helps to reduce the pick-up between the metals, but also prevents oxygen and water vapour from reaching the contact areas. The benefits of phosphating are not restricted to steel surfaces, and have been proved experimentally to occur with a paraffin lubricated aluminium-steel combination, Anodised aluminium, with lubrication, appears to be even more successful.

The main function of the phosphated or anodised surfaces is evidently to maintain, by virtue of their porous structures, a film of lubricant at the fretting surfaces, and the exceptional friction properties of P.T.F.E. and molybdenum disulphide seem to support this view. It may well be, however, that the resistance of phosphate and anodic coatings to chemical corrosion, and the exceptional chemical inertness of P.T.F.E. plastic, are significant contributory factors; and it is to be hoped that studies of these points figure in Dr. Wright's programme of future research. For the time being, it is a real step forward that mechanical engineers not only have reason to hope that fretting corrosion will eventually be defeated, but also now have clear indications of directions wherein, by full-scale experiments and service trials, they can supplement a research from which they have much to gain.

THE NAVY ESTIMATES.

To some extent, the Royal Navy is always on a war footing; and, in Korean and Malayan waters, it has been actually at war for a considerable time. These are factors which must be taken into consideration in examining the Navy Estimates for 1953-54 and the customary memorandum prepared by the First Lord of the Admiralty in explanation of them. When, in addition, due weight is given to the increasing cost of practically every sort of commodity or service, and to the increases in pay and in pensions, it is not so surprising, perhaps, that a Navy which is but little stronger, in the numbers of its personnel, and very much weaker in the number of its operational vessels, than it was before the recent war, should require an expenditure of 364,500,000*l*. in the twelve months covered by the Estimates. There is some compensation in the undoubted fact that its offensive capabilities, measured by fire-power, are considerably more than its modest numbers might suggest; and that a very large proportion of the expenditure is earmarked for research and new developments which may be expected to add still more to its fighting efficiency. Its primary role is still that of defence, but, more clearly than ever before, it is evident that effective defence is not to be ensured by the concept of a line of floating forts round the coasts of Britain—the view which seemed to be in favour before 1914, when large numbers of semi-obsolete ships were retained in reserve—but only by keeping the active fleets in such a condition that they can be sent to sea at very short notice. In the next war, if it should come, they will be lucky if they get any notice at all.

There can be no doubt that, so far as alertness is concerned, the Royal Navy of to-day will stand comparison with the fleets of any previous era; the doubtful question is whether there is enough of it. The Table entitled "The Strength of the Fleet," figured in the First Lord's statement for many years, but it has now shrunk to such little measure as to suggest that it should be headed simply "The Fleet," without the "Strength"; for, however stupendous the fire-power of a single ship, it can only be in one place at a time, and the Royal Navy, in war, must be in many places all the time. To offer this criticism is not to overlook the existence or the potentialities of the North Atlantic Treaty Organisation, or the fact that long-range aircraft have now assumed many of the functions which formerly belonged to escort vessels and even cruisers. There is still, however, much virtue in the principle that every tub should stand (or be capable of standing) on its own bottom.

According to the First Lord's statement, the "active" British fleets comprise at present a solitary battleship, H.M.S. Vanguard; two fleet carriers, the Eagle and Indomitable; three light fleet carriers, Theseus, Glory and Ocean; 11 cruisers, 31 destroyers and the same number of frigates, two fast minelayers, 37 submarines, and 48 minesweepers, of which 25 are of the "coastal" or "inshore" types. "Training and Experimental" vessels—which, presumably, are sufficiently mobile to be added to the "active" fleets in emergency—include three fleet carriers (Indefatigable, Implacable and Illustrious), the light fleet carrier Triumph, the aircraft maintenance ship Perseus, two cruisers, nine destroyers, 17 frigates, and 14 minesweepers. Vessels in reserve, or in process of reducing to reserve, are the four battleships Anson, Howe, Duke of York and King George V; the fleet carrier Victorious and the light fleet carrier Warrior, both of which are stated to be "modernising"; 13 cruisers, 67 destroyers, 113 frigates, one fast minelayer, two monitors, 16 submarines, 38 ocean minesweepers and 76 of the smaller minesweepers. Many of the ships in reserve have been overhauled within the past couple of years, but they could hardly be made operational in less time than several months.

There remains the category of vessels "in course of construction"; quite an impressive fleet in point of numbers, until the footnote references are studied. They comprise the fleet carrier Ark Royal, seven light fleet carriers (Hermes, Bulwark, Albion, Centaur, Majestic, Leviathan and Hercules); three cruisers—though it is becoming increasingly doubtful whether they are worth listing at all; three destroyers, 13 frigates, and 95 coastal and inshore minesweepers. Of the light fleet carriers, however, work has been suspended on two; and some of the others are rather replacements than additions to the fleet. Some students of naval affairs contend that the aircraft carrier, as a warship type, is "on its way out." This view may be premature, but a carrier in time of war will need its individual destroyer escort, thus reducing the number of destroyers available for the light-cruiser duties which have now devolved upon them. The pattern of naval war may be changing, but it may be questioned whether it has changed quite so rapidly as the strength and composition of the Navy has done since 1939.

NOTES.

RAISING COAL PRODUCTION.

In analysing the many factors involved in the future production of coal in the United Kingdom, Mr. E. H. Browne, C.B.E., Director-General of Production for the National Coal Board, speaking at the Royal Society of Arts on February 25, said he was going to ignore the achievements of the Board; this, he claimed, was essential to enable him to direct attention to the weaknesses, rather than the strength, of the Board's prospects. Mr. Browne was giving the Lord Cadman Memorial Lecture, and, in the course of it, said that, if the Coal Board were to succeed in raising the 260 million tons that the Ridley Committee thought to be the likely demand in 1960, then a number of marginal pits (that is, pits with uneconomical working) would have to be operated. The Ridley Committee had made it clear, however, that, in their opinion, there was ample scope for improving efficiency in the use of solid fuel. The theme of Mr. Browne's lecture was that this improvement in fuel efficiency was essential, because it was not going to be possible for the Board to produce that amount of coal economically. The new pits that were to be opened, were, in general, deeper and had thinner seams than those already being worked, with a consequent increase both in capital charges and day-to-day running costs; output was also dependent on the successful recruitment of labour and the maintenance, if not the improvement, of labour-management relationships. Colliery managers had too much detailed work to do, for them to be able to spend the necessary time on considering reconstruction and development of their pits, and the Board's planning staff of qualified mining engineers was not adequate in numbers for the amount of work that had to be done. In briefly discussing mechanisation at the coalface, as opposed to mechanisation of transport either by Diesel-drawn trains or conveyor belt, Mr. Browne said that only 3 per cent. of the coal mined was as yet being mechanically loaded and he looked forward to the extended use of the Meco-Moore cutter-loader. Particular mention was also made of the coal ploughs developed on the Continent for use in soft seams, but which were likely to be applicable to a wider range of British coals than was at first thought. He added that great improvement had been made in the last few years in the quality of coal-mining equipment being made in this country.

MANCHESTER SHIP CANAL IMPROVED FACILITIES.

A great deal of work and re-equipping has been (and is being) done, to make the Manchester Ship Canal, together with the Manchester Docks, one of the finest organisations for the handling of seaborne trade; extensions are being made and new equipment provided, to adapt facilities to the changed requirements of the present day. During recent months, new fleets of mobile cranes, timber carriers, fork-lift trucks, electric trolleys, tractors, and mechanical shovels have been brought into use, and it is expected that, by the end of this year, the last of the old hydraulic cranes will have been replaced by electric cranes of greater capacity. The Irwell Park Wharf, which handles bulk mineral cargoes such as iron ore, raw sulphur and phosphates, is to be provided with $7\frac{1}{2}$-ton grab cranes, capable of handling more expeditiously greater quantities of material than is at present possible. The new oil dock at Eastham is to be ready by the end of the year, and, when completed, will be the largest of its kind in the British Isles. This oil dock will eventually relieve other docks which are now handling increased supplies of petroleum, consequent upon the large refinery already in production. New timber grounds have already been brought into use and equipped with roads, railways, and the latest types of timber-carrying vehicles. A programme for the replacement of all surface craft and tugs has been put into operation, and most of the vessels are now not above 15 years of age. Radiotelephonic communication is being installed between shore-based control stations and the company's tugs and vessels; the possibilities of using radar for navigation on the canal, during fog or the hours of darkness, are also being explored.

ANNUAL DINNER OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The annual dinner of the Institution of Electrical Engineers was held at Grosvenor House, London, on Thursday, February 26, the President (Colonel B. H. Leeson) being in the chair. Proposing the toast of "The Institution of Electrical Engineers," Lord Cherwell complained that, in some circles at the present time, ignorance of science was regarded as something to be proud of, and classical knowledge was considered to be all that mattered. Actually, electrical engineers, who were applied scientists, frequently had a better general education than many Arts men. The reason was that engineers were not content with words, but dealt with things, which they had to manipulate, organise and manufacture. Electrical engineering was one of the mainstays of Britain's export trade, and should be given every priority, especially in the way of obtaining new recruits and providing better facilities for training them. In reply, the President said that the *esprit de corps* which was so prominent a feature of the Institution would undoubtedly prove of great value if hard times occurred. As it was, the supply and manufacturing branches worked in the closest harmony in furthering the progress of electricity, which now entered into every phase of civilised life. During the past seven years, recruits had been entering the industry at all levels at the rate of 15,000 a year, but more were required and greater facilities were necessary for training them on the broadest possible basis. The future of the country would depend on the progress of engineering, which would be greater if all industries were advancing at the same pace. To achieve prosperity, more plant must be available and resources must be more fully utilised. The toast of "Our Guests" was proposed by Sir John Hacking, and Lord Webb-Johnson replied.

THE SAFETY FACTOR IN CONSTRUCTION.

On Monday, March 2, the second Cantor lecture of the session was presented at the Royal Society of Arts by Professor F. C. Thompson, D.Met., who is president-elect of the Institute of Metals. The first of these Cantor lectures was delivered by Mr. G. A. Gardner on February 23, as recorded on page 275, *ante*. Professor Thompson spoke on the possibility of achieving economy in design by the development of new alloys of improved properties, rather than by the refinement and trimming of safety factors. In contrast with the first Cantor lecturer, who ranged over the general philosophy of constructional design, Professor Thompson confined his attention to materials and to one group—a very important one—namely, alloy steels. He referred first to the enormously high strengths envisaged by theoretical analysis; but, speaking as a practical metallurgist, said that he could see no hope of attaining the very high strength that had been predicted theoretically, and he ventured to suggest the possibility of defects in the theoretical analysis. Much remained to be done, however, by conventional methods of research. More knowledge was required of the interaction of the classical alloying elements to each other; but, he continued, perhaps the greatest opportunities of producing more economical steels lay in a new approach to the residual alloying elements. He advocated serious consideration of high-phosphorus and high-sulphur low-alloy steels, for applications in which the loads were applied statically. Engineers will, no doubt, ask the Professor, in due course, to clarify his limitation of the use of these new steels to structures statically loaded; but, on investigation, it may be found that this will not exclude ordinary structural use, outside crane gantries and bridges. He urged engineers to satisfy themselves that their present demands in respect of ductility could not be moderated, since metallurgists could provide great increases in yield strength while retaining comparatively good ductility and lack of brittleness. All such improvements, said Professor Thompson, would tend to raise the costs of production, and it would be for economists to determine whether the increased costs were justified by the higher strengths which, he had no doubt, would be obtained by continuing advances in metallurgical research.

FINANCIAL AID TO INCREASE PRODUCTIVITY.

Small and medium-sized firms are likely to be the main beneficiaries from a plan to spend about 3,000,000*l*. on schemes to increase productivity. Various existing organisations will probably be affected by, or connected with, the plan, for example, the Federation of British Industries, the Department of Scientific and Industrial Research, the British Institute of Management, the British Productivity Council, the National Union of Manufacturers, and the Trades Union Congress, as well as universities and learned and professional societies. The money is to come from "counterpart" funds arising from the operation of the Economic Aid Scheme of the Mutual Security Agency. According to a White Paper issued last week, the Governments of the United Kingdom and the United States have agreed on the allocation of these funds, which will be expended under the general direction of the President of the Board of Trade. The six main channels of assistance will be loans to industry, research into factors affecting the efficiency of the national economy, the promotion of technological studies, an advisory service for firms, a productivity agency to be established by the Organisation for European Economic Co-operation, and publicity. Loans to industry will be short-term loans for equipment and the reorganisation of plant, and will be used to increase production and productivity. The loans will be available to small and medium-sized enterprises in order to increase their ability to produce under competitive conditions. Expenditure on research will be used to investigate such matters as incentives in industry or agriculture, the effect of restrictive practices, and the relative efficiency of competitive and monopolistic enterprise. The promotion of studies in technological subjects will affect universities and technical colleges, the training of supervisors, and the provision of scholarships, including some for trade unionists, in management subjects. Part of this proposal may take the form of a contribution to the provision of at least one institution of university rank devoted predominantly to the study of the various forms of technology (presumably the Imperial College). The advisory service will be to advise firms on reorganisation and production techniques.

A GAS-TURBINE TANKER.

The Anglo-Saxon Petroleum Company, Limited, who operate the Shell tanker fleet, have ordered from Cammell Laird and Company, Birkenhead, a tanker to be propelled solely by gas turbines. She is the first tanker in the world to be ordered with this form of propulsion only. The ship will be built to a specification prepared by the owners, and the machinery to a specification compiled jointly by the British Thomson-Houston Company, Limited, Rugby, and the owners' research and development departments. The B.T.H. Company will design the gas turbines and alternating-current electrical equipment, and the gas-turbine components will be made jointly by the B.T.H. Company and Cammell Laird and Company. The ship is to be completed in 1956, and will be a single-screw vessel of 18,000 deadweight tons. She will be one of the 50 general-purpose tankers on order for the Shell fleet, and as the others will have either turbo-electric machinery or geared steam turbines, a direct comparison of the operating and maintenance costs of the three forms of propulsion will be obtained. The machinery will comprise two gas turbo-alternators driving the propeller shaft through two electric motors and a two-pinion single-reduction gearbox. Power for all auxiliary requirements in port and at sea will be drawn from the propulsion gas turbines, including that required for the cargo pumps, which will have a capacity of 2,000 tons per hour. A Diesel alternator will supply power for ship's services when the gas-turbine alternators are not in use. Operating on the open cycle, each unit will have two-stage compression with intercooling. The high-pressure line will comprise a turbine, compressor and geared auxiliary alternator with an exciter set; and the low-pressure line a turbine, compressor and propulsion alternatcr. The main turbines will be started by steam turbines, each of 150 h.p. Steam for cargo-heating and tank-cleaning will be obtained from a small oil-fired boiler, in conjunction with waste-heat boilers taking exhaust gas from the heat-exchangers of the turbines. The propeller motors will be of the double-cage induction type. Astern running will be provided by reversing contactors in the main electrical circuit, thus ensuring that full power is available for astern running. The speed of the propeller, between 100 r.p.m. and about 55 r.p.m., will be controlled at the turbine, but lower speeds will be obtained by reducing the voltage applied to the propeller induction motors.

LETTERS TO THE EDITOR.

"HISTORICAL METROLOGY."

To the Editor of Engineering.

Sir,—Will you allow me a little space in which to explain my interest in the number 20·6265, on which you commented in the course of your review of my book, *Historical Metrology*, on page 228, *ante*? While astronomers are more likely than engineers to be really familiar with this figure sequence—because the distance of a star is 206265 $\left(\frac{A}{\theta}\right)$ where θ is its parallax and A is the mean radius of the Earth's orbit—its status will be apparent to all technologists when they are reminded that the radius of any circle measures 206,265 seconds of arc.

Now the physical evidence relating to the cubit that Herodotus called "royal" hovers around 20·62 in. (this was Sir Flinders Petrie's preferred value); and I realised that, if this could be interpreted as 20·6265 in., it would enable me to regard this cubit as radius in a circle that would circumscribe a square in which that cubit had been established as the semi-diagonal by Petrie and Griffith when they showed beyond doubt that the square cubit was reckoned equal to 2 sq. remens in Egyptian land measurement. The numerical rating of the royal cubit, thus geometrically defined, is $\sqrt{2}$ remens = 20 $\sqrt{2}$ digits, and the perimeter of the square measures 8 Egyptian remens = 160 digits = 10 Roman feet on the hypothesis of a common digit.

The circumference of my circumscribing circle measures 129·6 in., and I found that this could be rated 10 Assyrian feet in terms of a linear unit so called by Oppert when he published his analysis of the measurements that he made on the site of Babylon in 1853. The perimeter of the inscribed square, therefore, can be rated 9 Assyrian feet = 6 Assyrian cubits on the hypothesis of a $\frac{9}{10}$ quadrant (chord : arc) length ratio, which geometers of remote antiquity believed (I think) to be a property of the circle. A practical result of the relationship of units derived from this geometric picture is that the land unit called "bur" in the cuneiform texts can be rated 25 Roman jugera, when the cubit of these texts is interpreted as the Assyrian cubit thus defined.

Some of the cuneiform texts, however, refer to a field of 10,000 sq. cubits, and this area can be identified with the Roman jugerum in terms of the Sumerian cubit of 19·8 in., derived from the linear scale on Gudea's statue in the Louvre. This Sumerian cubit is equal to $\frac{24}{25}$ royal cubit when the latter is rated 20·625 = 20$\frac{5}{8}$ in., and this rating can be derived from 20 $\sqrt{2}$ digits in terms of a digit of $\frac{9}{16}$ k in. by writing $\frac{35}{27}$ for k and $\frac{99}{70}$ for $\sqrt{2}$. There are k million seconds in the circle, for $k = 1{\cdot}296$ and this is the value that makes the digit of $\frac{9}{16}$ k in. equal to 0·729 in.; but evidence indicates that metrological relationships arose in which this sexagesimal ratio was represented by $\frac{35}{27} = 1{\cdot}\dot{2}9\dot{6}$, decimal fraction recurring.

I must not encroach further on your space, but I hope I have said enough to indicate the connection in which the significant length of the royal cubit is $50\frac{k}{\pi} = 20{\cdot}6265$ in., and the connection in which its significant length is 20·625 in. = $\frac{25}{24}$ Sumerian cubit. Moreover, it must not be overlooked that this Sumerian cubit measures one-tenth of an English pole and makes the Roman jugerum exactly five-eights of an English acre. Most important of all, therefore, is the reflection that our own linear standards are truly in scale with those of antiquity.

Yours faithfully,
A. E. Berriman.

Oxford,
February 26, 1953.

MARINE CONDENSER TUBES.

To the Editor of Engineering.

Sir,—Following the speech of the Engineer-in-Chief of the Fleet (Engineer Vice-Admiral the Hon. Sir Denis Maxwell) at the annual banquet of the Liverpool Marine Engineers and Naval Architects' Guild, on November 21 last year, the Admiralty issued some "Notes on the Improvement of Steam Turbine Machinery for Merchant Ships," in which certain references were made to the design of main condensers. These "Notes" stated that existing mercantile practice for main condensers is to use $\frac{3}{4}$-in. tubes with a maximum circulating water velocity of approximately 4 ft. per second and suggested that a change to the naval practice, using $\frac{5}{8}$-in. tubes, with circulating velocities of 7 ft. per second, would be advantageous.

This firm have been responsible for the designs of most of the main condensers fitted in the merchant ships built in this country, and we would say that the designs in general are based on a circulating-water velocity of between 6 ft. and 7 ft. per second. This is comparable with naval practice. We have also been responsible for the design of the main condensers for most of the British naval ships and many foreign naval vessels during the past 40 years. The choice of the water velocity and the size of tube depend upon the size of the condenser, the number of water passes, the quantity of circulating water used, and the power required to supply the circulating water. The design of each installation is a compromise between the various factors involved and merchant service designs are comparable in every way with naval designs for the duties to be met.

Yours very truly,
For G. and J. Weir, Limited,
John Davidson, Secretary.

Cathcart, Glasgow, S.4.
February 26, 1953.

PEAT-BURNING GAS TURBINE.

RUSTON & HORNSBY, LTD., LINCOLN.

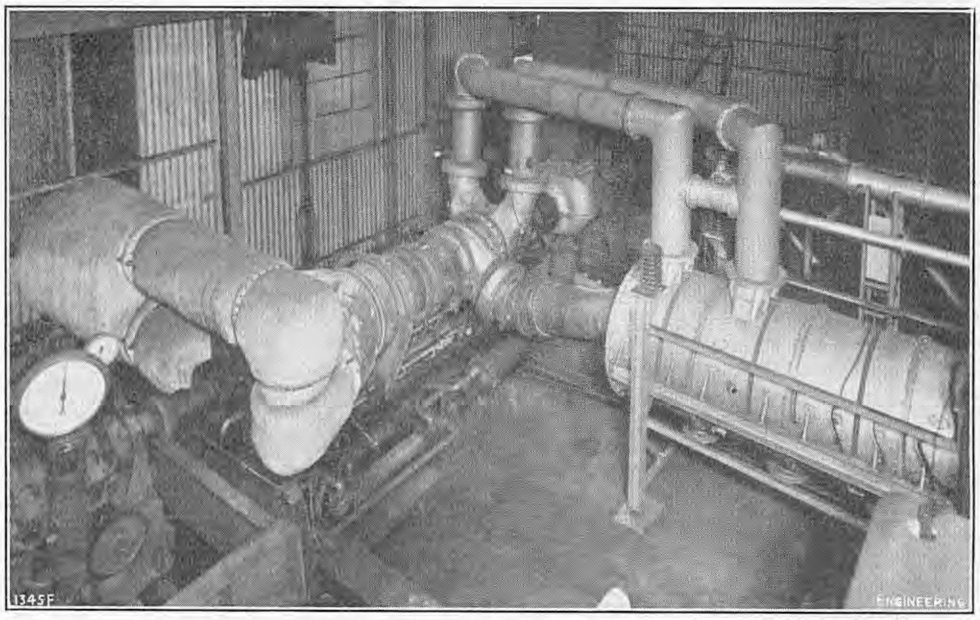

Fig. 1. Gas Turbine in Makers' Works.

DEVELOPMENT OF A PEAT-BURNING GAS TURBINE.

During the past eight years, Ruston and Hornsby, Limited, Lincoln, have made notable progress in the development of lightweight industrial gas turbines of about 1,000 b.h.p. In a branch of engineering which receives wide publicity, and in which claims are freely made but not always so readily substantiated, they have been properly reticent about their work. Now, however, they are in a position to claim practical and commercial success in the design and production of an oil-burning unit, and they are able to release details of a peat-burning gas turbine, shown in Fig. 1, which is expected to provide a method of using this widely-dispersed fuel. The same peat-burning gas turbine, it is hoped, will point the way towards the better use of other potential fuels, such as producer gas, natural gas, sewage gas, brown coal, waste wood from sawmills, and other vegetable products. The potentialities in the export markets, particularly newly-developing countries, are promising, since in many there are by-products which at present are wholly or partly wasted but could be used as fuel in gas turbines. As experience is gained and designs are developed, more and more of these possible fuels are likely to be brought within the ambit of the gas turbine.

The hot exhaust gases of the peat-burning gas turbine are used to dry out the peat partially, thus helping to prepare it for the combustion chamber. There are large supplies of peat in the world, mostly north of the 45 deg. N. latitude and, to a lesser extent, south of the 45 deg. S. latitude. It grows at the rate of between $\frac{1}{4}$ in. and 4 in. in thickness per annum, but as it is 90 per cent. water and 10 per cent. solids, even when the bog has been drained, its calorific value can only be used commercially by removing some of this water. This problem is successfully overcome in the Ruston and Hornsby plant. Difficulty has also been experienced with the dried and powdered peat in finding a method of causing it to flow and feeding it at controlled rates to the combustion chamber. This has been solved by "fluidising" the peat: if air is blown into a mass of powdered peat, and if it flows up through the particles at a critical velocity, the particles are suspended and they will flow, borne on the air stream, out through a pipe connected to the side of the containing vessel. This interesting technique can be applied to the conveyance of other

PEAT-BURNING GAS TURBINE.

RUSTON & HORNSBY, LTD., LINCOLN.

FIG. 2. ARRESTED FLOW OF PEAT IN A FUNNEL.

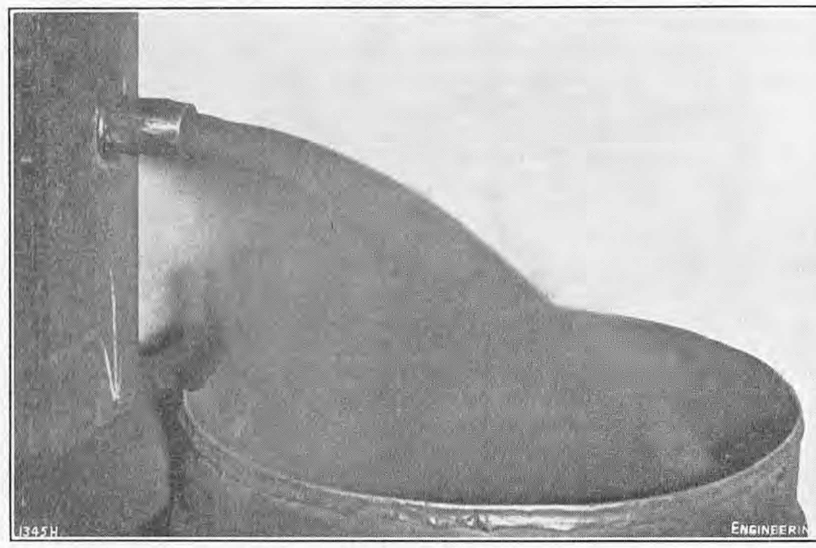

FIG. 3. FLOW OF "FLUIDISED" PEAT.

Fig. 4. PEAT-BURNING COMBUSTION CHAMBER.

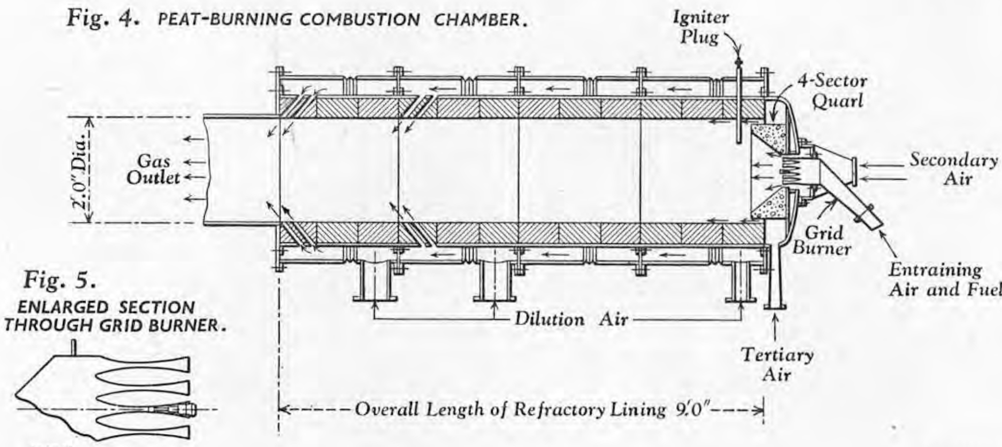

Fig. 5. ENLARGED SECTION THROUGH GRID BURNER.

powdered materials, as described in an article in ENGINEERING, vol. 174, page 88 (1952).

The idea of using peat as a gas-turbine fuel was due to Mr. C. H. Secord, of the Ministry of Fuel and Power, who realised in 1947 that the waste heat in the exhaust of an open-cycle gas turbine could be used for drying the incoming fuel to a sufficiently low moisture content for efficient combustion. In August, 1949, the Ministry placed a contract with Ruston and Hornsby, Limited, for the development of a peat-burning gas turbine based on the design of the firm's existing 750-kW oil-burning gas turbine, which was described in ENGINEERING, vol. 169, page 85 (1950). After initial testing on oil fuel in 1951, the turbine ran for the first time solely on peat in 1952. Last week, the Lincoln works were visited by the Minister of Fuel and Power, Mr. Geoffrey Lloyd, M.P.; the Ministry's chief scientist, Sir Harold Roxbee Cox; other Ministry officials, and a party of technical Press representatives. The visitors also saw the firm's original 750-kW (1,070-b.h.p.) gas turbine running on oil fuel, having completed over 3,000 hours of service on a variety of fuels; and the Mark TA oil-burning gas turbine, which has been developed from the original machine and is now being batch-produced for use in this country and overseas. The Mark TA machine will be described in a subsequent article; here, we deal with the peat-burning turbine. Its development has been aided by close collaboration between the firm and the Ministry's scientific staff, under Sir Harold Roxbee Cox. Ministry backing is, indeed, a valuable feature of gas-turbine development work in this country. It has led to an unfettered exchange of information between the several firms concerned.

Even when it is dry, peat is bulky, and transport over any appreciable distance is likely to be expensive. For this reason, any plant operating on peat should be sited near the peat deposit. Where these deposits are very large, it is possible to site a fair-sized power station near them, in the knowledge that the extent of the deposit will give the power station an economic life. Very large deposits, however, are not common in Great Britain, and it seems likely that a power plant of reasonable size could spend only part of its life on a given deposit. It is therefore desirable that the power plant should be reasonably portable and not require elaborate foundations and buildings. From this point of view, a simple form of open-cycle gas turbine is admirable.

The main items of research required before a commercial peat-burning gas turbine could be designed dealt with dewatering and drying the peat; feeding the peat into a combustion chamber against the cycle pressure, and the associated problem of controlling the plant; burning the peat in a combustion chamber operating under pressure; and ash erosion and deposit on the turbine blades. In examining these problems, the Ministry and Ruston and Hornsby collaborated with many organisations interested in peat, notably the Peat Division of the Department of Agriculture for Scotland, the Bord na Mona in Eire, Staatliche Torfwerke (Seshaupt und Schussenried) in Germany, and authorities in Denmark and Sweden.

Research on the dewatering of peat is being carried out by the Ministry in collaboration with the Peat Division of the Department of Agriculture for Scotland. They have been developing the Madruck process, by which a considerable amount of the water can be pressed out of the peat, after a proportion of dry dust has been mixed with the raw peat to provide leakage channels through which the water can escape. It is thus possible to remove 5 lb. of the original 9 lb. of water associated with each pound of peat solids. There is sufficient heat in the turbine exhaust to dry off the remaining 4 lb. of water. This process appears to have considerable advantage in this country, where the seasonal labour needed for most methods of producing peat fuel may be difficult to obtain. The turbine exhaust dryer being supplied for this duty is a rotary-louvre type made by Dunford and Elliott (Sheffield), Limited, Sheffield, 9. In certain locations, however, it may be advantageous to use an air drying process for winning the peat, in which case the thermal drying required would be much less. If the milled-peat process, one of the most successful means of air drying were used—producing peat having about 1 lb. of water associated with every pound of dry peat—the drying problem would be simple.

PEAT-FEEDING SYSTEM.

For feeding pulverised peat to a combustion chamber against compression pressure, pressurising the fuel appears to be possible, but the only methods taken to a practical stage so far are the lock-hopper system and the pulverised fuel pump. Of these, the latter is the most attractive because of its greater simplicity. Running experience has been gained on a rotary pump designed and made by the Incandescent Heat Company, Limited, Smethwick. The pump comprises a carrier plate containing a number of pockets which receive fuel at atmospheric pressure at one station and carry it round to another station, where entraining pressure air is admitted to carry the fuel into the delivery line. The simplicity of this system is complicated by the seals necessary to restrict air and fuel leakage to a low rate, but in this respect the pump appears to be very successful.

The apparently simple process of getting pulverised fuel out of a hopper, and metering it sufficiently closely for a gas turbine, proved to be a serious problem, for the solution of which a knowledge of the flow of particles of solids was necessary. The flow of solids in a hopper is found to be localised to a vertical zone above the outlet, and this downward-moving column should be replenished by an inward flow at the top. Stoppage of flow can result from failure of the inward flow, causing "coring," as shown in Fig. 2 on page 309. Sometimes inward flow takes place at a level lower than the upper surface, leaving peat above in the form of a dome. The angle of repose of pulverised fuels varies considerably with the settling period, and this, combined with the hygroscopic and fibrous nature of peat, makes it a difficult material to handle. Such methods as inserting steel sheets in the hopper, enamelling the walls, the use of stirrers, air jets, and vibrators, and the application of low-pressure air to the peat surface, met with no success. More successful methods were to rock the hopper at some optimum frequency and amplitude, or to use a rectangular hopper with an elongated discharge aperture. A further disadvantage of the usual type of hopper is that the outflow rate per unit area is low, an average figure for pulverised peat being 0·15 lb. per square inch per second, which necessitates a large discharge aperture and limits the choice of feeder. It has also been found that the quantity discharged is independent of the head of solids in the hopper. Screw feeders were found to be prone to failure by jamming and to introducing undesirable pulsations in the feed.

"FLUIDISING."

A completely satisfactory solution to the problem of feeding and metering was eventually found by keeping the peat in a fluidised state by percolating air through it. In the process of fluidisation, particles of solids are maintained in suspension in a moving air stream. A drag force is thus produced on them equal and opposite to their weight, and the required air velocity will be equal to their free-falling speed. For pulverised-peat particles, the balance between weight and drag occurs at low Reynolds numbers which are confined approximately to the range covered by Stokes Law. In a fluidised peat bed, however, there is a wide range of particle sizes giving rise to inter-particle interference and friction between the solids and the wall of the column. In spite of these factors, conditions of fluidisation can be attained, and, provided the range of particle size is not too wide, there then exists a minimum air velocity which will produce fluidisation, the properties of the resulting solids-gas mixture being similar in many respects to those of a liquid, as shown in Fig. 3. The critical fluidising velocity of the pulverised peat used in the turbine is 4 cm. per second. The fineness of the peat is such that 55 per cent. will pass through a 200-mesh British Standard screen and 7 per cent. is caught on a 60-mesh screen.

The success of fluidisation depends largely on the fine division and uniform distribution of the fluidising air. A satisfactory method was developed using an under-bed of No. 16 steel shot, though for small-scale work sintered stainless steel and porous ceramic discs were used. A study was made of the effect of solids static head, and of fluidising air density and viscosity, on the critical fluidising velocity. In the range of pressures from one to three atmospheres, and at temperatures from ambient to 200 deg. C., the critical fluidising velocity was found to be independent of the three variables. Theoretically, this velocity is inversely proportional to the absolute viscosity, but since the air temperature rapidly drops to that of the peat, viscosity effects are almost eliminated. The flow of fluidised peat from a column, as shown in Fig. 3, was found to be almost directly proportional to the solids static head and to the area of the outlet orifice. A pressurised fluidising column having an effective capacity of 1,000 lb. of peat was tested in conjunction with the peat-fired turbine. Engine control was maintained manually by metering the fluidised peat, using a $\frac{3}{4}$-in. full-way gate valve, and results indicate that the fluidised feeder meets the special requirements of the open-cycle gas turbine.

PEAT-BURNING GAS TURBINE.

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Fig. 6.

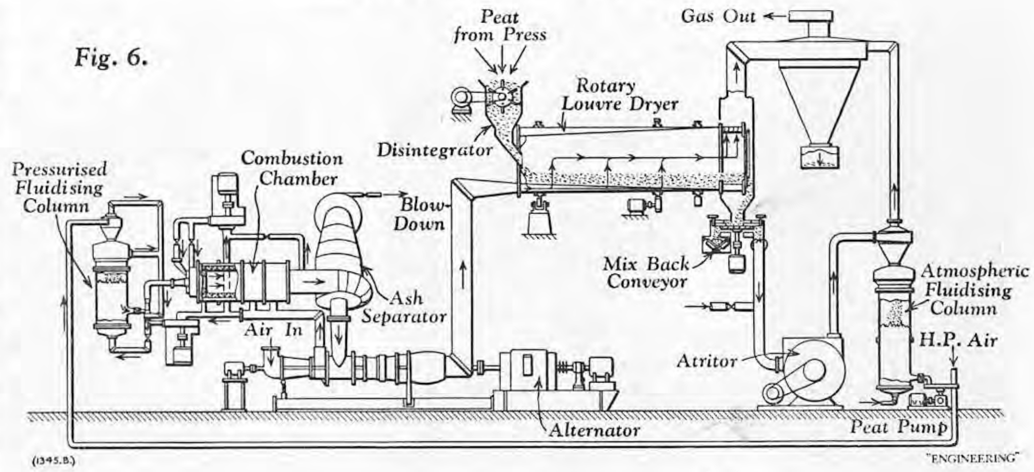
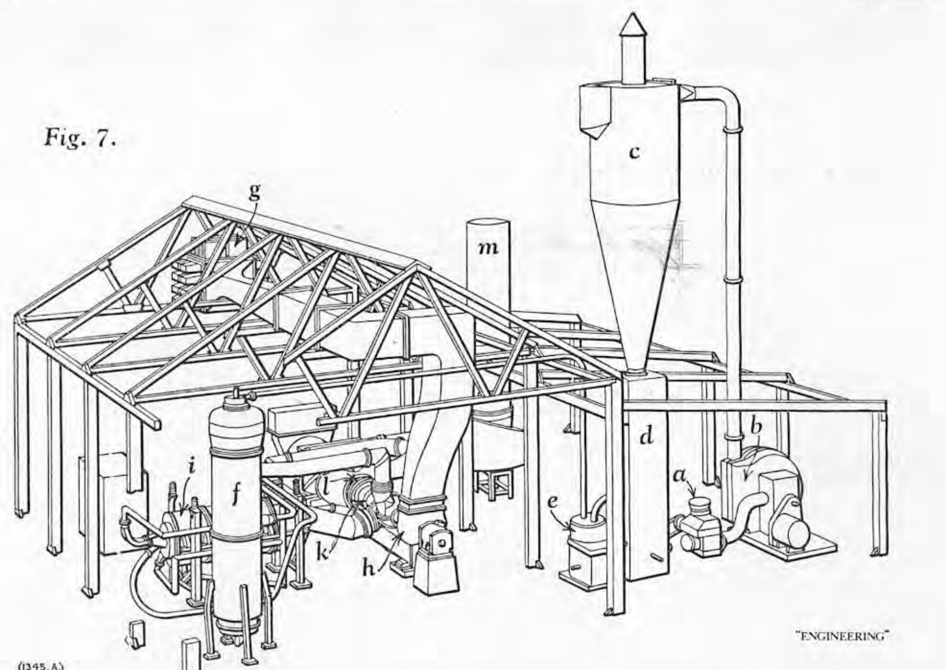


Fig. 7.



a Peat feeder.
b Atritor grinder.
c Peat-separating cyclone.
d L.P. fluidising column.
e Peat pump
f H.P. fluidising column.
g Air-intake filters.
h Compressor.
i Combustion chamber.
k Compressor turbine.
l Power turbine.
m Exhaust.

COMBUSTION OF PEAT.

The choice and design of a combustion chamber to burn peat depend mainly on the moisture content of the peat at entry to the chamber, and on the fineness to which the peat has been ground. Little information is yet available on the combined effect of moisture content and fineness on the combustion of peat, and present practice is to accept the fineness provided by a commercial grinder, which gives an acceptable quality of combustion with up to 35 per cent. moisture content. The chemical properties of peat are also important. From the proximate and ultimate analyses shown in Table I, it will be seen that peat has a high volatile and low fixed-carbon content, leading to a rapid temperature rise in the primary combustion zone. Peat also contains, for a solid fuel, a relatively low ash content, which, combined with the other factors, led to the choice of a refractory-lined non-slagging type of chamber. The basic design for this combustion chamber, together with a grid-type burner, was based on information supplied by the Fuel Research Station, where a combustion system has been developed on these lines to burn coal at atmospheric pressure, and on which some preliminary peat-combustion tests were carried out in the early days of the development. The design is shown in Fig. 4 on page 309.

TABLE I.—*Typical Peat Chemical Analysis.*

Proximate Analysis (Dry Basis), Per Cent.		Ultimate Analysis, Per Cent.	
Volatile matter ..	67·85	Carbon	55·60
Fixed carbon ..	30	Hydrogen	5·50
Ash	2·15	Nitrogen	1·20
		Sulphur	0·25
		Ash	2·15
		O_2 (by difference) ..	35·20

It is desirable with solid fuels to radiate heat rather than convect it into the ignition zone, and for this reason a refractory quarl is used. For starting purposes, the refractories are heated up by means of a pilot oil burner, following which peat, together with "entraining" or "primary air," is admitted to the chamber and ignition can be completed within an inch or two of the grid-burner nozzles. Once ignition of the peat has been established, at a refractory temperature of about 800 deg. C., the pilot oil burner is shut off. It is hoped eventually to correlate the ignition characteristics in a combustion chamber with inflammability, as measured by Godbert's apparatus, for varying degrees of fineness and moisture.

Following ignition, the combustion of volatiles takes place immediately and further (secondary) air is required. This air enters between the fuel nozzles of the burner, and the rate of mixing is controlled by adjusting the relative velocities of the primary and secondary air. The secondary air is preheated to about 400 deg. C. to avoid chilling the combustion process. In order to avoid elevated refractory temperatures, a tertiary air feed is provided close to the wall, and in addition forms a further source of combustion air. Refractory temperatures of 1,000 deg. C. are normal practice, using sillimanite bricks containing about 63 per cent. alumina. The optimum quantity of primary, secondary and tertiary combustion air has been found by rig testing to be about 120 per cent. of that theoretically necessary for complete combustion, but this depends on the volatile content of the fuel. Calculations show that for 30 per cent. wet peat, the temperature rise due to burning the volatiles is then about 800 deg. C., and it has also been found that the velocities through the burner can be higher for finer and drier peat due to its ease of ignition and higher rate of burning.

Combustion of the fixed carbon is a slow process in which large-scale turbulence plays very little part. To gain any assistance at all from such turbulence, the cost in pressure loss would be high. The controlling factors in the combustion of fixed carbon are, therefore, particle size, "residence time" and temperature. The advantage of a refractory-lined chamber in maintaining a high temperature throughout its entire length is, therefore, evident. It can be shown that a 75-micron particle of peat (200 mesh) requires a residence time of about 90 milliseconds to burn, which, using an average gas velocity of 50 ft. per second, represents a distance of $4\frac{1}{2}$ ft. This figure is in general agreement with experimental results. A compromise is, however, required, and with present commercial grinding techniques, fuel which passes approximately 55 per cent. through a 200-mesh screen is used. A combustion efficiency of 95 per cent. can then be attained and the loss is due almost entirely to the few largest particles which would require an extremely long residence time to burn completely. Dilution down to turbine inlet temperature is carried out at the downstream end of the combustion chamber through 1-in. diameter ports.

The combustion intensity of the chamber as a whole is low compared with an industrial gas-turbine oil-fired chamber, being about $1 \cdot 3 \times 10^5$ Centigrade Heat Units per cubic foot per hour per atmosphere, but it is high compared with boiler practice. The volatiles which account for half of the heat release burn in the primary zone with an intensity of about $6 \cdot 0 \times 10^5$ C.H.U.'s per cubic foot per hour per atmosphere. Since the residence time and temperature are high, the loss of combustion efficiency in gaseous products is negligible in this type of chamber. Provided the ash content of the fuel is known, sampling of the exhaust solids gives the complete picture. With typical peat, about 60 per cent. combustible matter in the exhaust indicates a loss of combustion efficiency of 10 per cent. Atmospheric rig tests have shown the grid burner to be particularly flexible in operation, and with fairly dry peat up to 240 per cent. of the stoichiometric quantity of air has been introduced for combustion. This should permit part-load running on the engine down to about 20 per cent., using peat only. Engine tests are now taking place and the performance to date is satisfactory. Referring to Fig. 4, for full-load conditions, the principal temperatures (measured on the Kelvin scale), flows and velocities are as follow: secondary air, 2·67 lb. per second, 673 deg. K., exit velocity 150 ft. per second; entraining air and fuel, 1·48 lb. per second, 453 deg. K., peat: air ratio 0·478; grid burner exit velocity 39·5 ft. per second and throat velocity 122·5 ft. per second; tertiary air, 0·82 lb. per second, 673 deg. K.; dilution air, 15·03 lb. per second, 453 deg. K.; gas outlet, 20 lb. per second, 1,023 deg. K.

Compared with most solid fuels, peat does not contain much ash (about 2 per cent.). The gas turbine assembled in its present form contains only a rudimentary form of ash separator—a screen with $\frac{3}{16}$-in. gaps. The plant has been assembled in this form, with the expectation of some blade erosion and deposits, to obtain quickly an idea of the magnitude and nature of the erosion problem, as it is anticipated that a long period of running will be required before an appreciable amount of erosion occurs, when an effective ash separator is fitted. Once the wear on the turbine blades has become appreciable, a cyclone separator will be inserted between the combustion chamber and the high-pressure turbine. This cyclone has been designed on the principles, and with the collaboration, of Professor ter Linden, of Delft. On the information available at present, this cyclone should be able to separate out most of those larger particles of ash (greater than 20 microns) which are likely to erode the turbine blades. Provision has been made for sampling the ash going to the turbine.

PRESENT LAYOUT AND FUTURE PLANS.

A diagrammatic arrangement of the plant as it is at present is shown in Fig. 6, opposite, and a perspective view is shown in Fig. 7. Air enters through the Vokes air filters; in the compressor its pressure is raised to four atmospheres absolute, and from thence it goes to the combustion chamber. The air from the compressor is divided into several streams, one of which flows as fluidising air to the bottom of the high-pressure fluidised column. Another is the primary air line carrying the peat into the combustion chamber. Other streams supply the secondary and tertiary air to the upstream end of the combustion chamber. The bulk of the air, however, is dilution air which enters at the downstream end of the combustion chamber. The hot gases pass through the screen mentioned in the previous section and enter first the high-pressure turbine, then the low-pressure turbine and finally pass to the exhaust. From Fig. 6 it will be seen that the peat enters the system at the peat feeder, whence it is fed to the Atritor grinder. After grinding, a cyclone separates the peat dust from the carrying air stream, and discharges it into the low-pressure fluidised column. From this column it flows into the peat pump, which transfers it into the high-pressure air stream carrying it into the high-pressure fluidised column. The engine is controlled manually from the $\frac{3}{4}$-in. full-way gate valve at the bottom of the peat-pump fluidising column.

When the turbine plant has been developed in Lincoln to a satisfactory stage, it will be taken to a peat bog in Scotland, there to join the Dunford and Elliott dryer and the dewatering press now being made by Messrs. John Shaw and Sons (Salford), Limited, Salford, 3. The complete plant will then be run for a long period to determine the best method of operating such a power plant and to determine precisely its running economics. In the event of an open-cycle gas turbine being run in conjunction with the milled peat process, there are two possibilities. One is to use the exhaust-gas heat to dry more peat than is required by the gas turbine itself, this dry peat being then briquetted and sold as a domestic fuel—for which it is very satisfactory. Alternatively, a more complex gas-turbine cycle could be used, involving intercooled compression, in order to raise the thermal efficiency of the gas turbine. A preliminary layout for a 3-MW peat gas turbine power station has been prepared. The work on peat has also shown a way to the use of other solid fuels and the possibilities are now being investigated of using similar plants for generating power from waste wood from sawmills, brown coal, etc.

FIRE RESISTANCE OF PRESTRESSED CONCRETE.

THE by-laws of local government authorities stipulate the minimum resistance to fire that must be attained by the various parts of different classes of building, and the very nature of prestressed concrete—dependent as it is upon the maintenance of a load in highly-strained steel cables—makes this composite material suspect in the event of a fire. For this reason, the behaviour of prestressed concrete, during and after fires, is being studied at the Fire Research Station, Boreham Wood, Hertfordshire, in collaboration with the Building Research Station, Garston, both stations being divisions of the Department of Scientific and Industrial Research. The series of tests completed so far has been primarily concerned with post-tensioned beams, but the tests are being continued to gain confirmation of certain points and to extend generally the scope of the investigations. With only a relatively small number of tests available for analysis, the conclusions so far reached must necessarily be tentative but they are believed to be valid and are set out below to give immediate guidance to structural designers and others concerned with prestressed concrete in buildings. Further results will no doubt be published in due course.

The beams tested were pre-cast elements of rectangular or I-section that were fully prestressed before a narrow concrete strip, representing the floor slab, was cast above the beam, provision being made to ensure a composite action. The concrete used was of a uniform composition throughout the tests, as were the size and number of the wires and the magnitude of the prestressing load in the wires. The aim of the investigation was to determine the effects of the applied load, the end restraints applied to the beams, the concrete cover to the cables, the beam size and the protective encasements, on the fire resistance of the sample beams. It was found that the most important single factor affecting the time until collapse occurred was the rate of rise of temperature of the prestressing cable. A concrete cover of $2\frac{1}{2}$ in. was found to give a fire resistance of 2 hours, although this period could be lengthened by increasing the cover, but as the cover was increased above 3 in. it was found desirable to incorporate a steel mesh, or similar reinforcement, outside the cable, to prevent spalling. To achieve a fire resistance of 4 hours or more, an insulating encasement was found to be necessary. Normal *in situ* plastering, with either a gypsum or a cement-lime-sand plaster, gave an additional half an hour of resistance if an adequate bond had been made between the plaster and the concrete; in order to obtain an increase of two hours, however, it was found to be necessary to apply a covering 1-in. thick which contained either vermiculite or some other similar fire-resisting constituent suitable for the purpose.

Although the results are, as yet, insufficient to permit a quantitative statement to be made, it has been observed that effective end-constraints would cause the beam to fail earlier than if the beam was free to expand. Little or no difference in performance was observed between a beam of rectangular section and an I-beam, other factors being equal. Explosive spalling, such as was experienced on very small units that were made with a gravel aggregate, did not seem likely to occur in beams having no part with a thickness less than 2 in. The failure of the beams was slow and seemed unlikely ever to be sudden. Incipient failure was marked by a progressive sagging, which, in beams of large span, would be noticeable, and warning of imminent failure was given by the visible extension of the cracks, accompanied by an increase in the deflection of the beam. Exposure to a fire of shorter duration than that which would have caused failure, representing, say, less than half the fire resistance of the beams, brought about a loss of strength that was much smaller than might have been expected from a cursory examination of the problem. The small loss in the original strength could be accounted for as follows: after cooling, the beams were left with a marked residual deflection, and this deflection was found to be sufficient to maintain the effective prestressing load in the cables.

DEVELOPMENT PROJECTS OF THE STEEL COMPANY OF WALES.

MR. E. H. LEVER, chairman of the Steel Company of Wales, Limited, announced, on November 29, 1952, that the company were to spend a further 40,000,000*l*. on the development of the steelmaking, steel-sheet, and tin-plate industries of South Wales. Particulars of these projects have now been released, and they include a cold-reduction rolling mill to be installed in a new works at Velindre, Llangyfelach, near Swansea. In addition, extensions at the Margam and Abbey Works of the company are to be put in hand.

In order to increase the pig-iron production at the Margam Works, a new blast furnace will be added to the three furnaces now in operation. This, the No. 4 Margam furnace, will have a hearth diameter of 29 ft., and is expected to have an output in the region of 10,000 tons of pig-iron a week. A further 90 by-products recovery coke ovens will be erected to supply fuel for the new blast furnace. These will be in addition to the 144 ovens now in operation. The new ovens will produce 9,000 tons of coke a week, and will bring the total coke output of the Margam Works to 23,400 tons a week. When the four blast furnaces are in operation, the weekly pig-iron output of the Margam Works will be in the region of 29,000 tons.

The capacity of a sinter plant now under construction is to be increased. A new power station is to be erected at the Margam Works, in addition to that which has recently been brought into operation. This will house an 8-MW turbo-alternator and a 125,000-cub. ft. per minute turbo-blower supplying blast to the No. 4 furnace. Steam for the power station will be provided by a boiler having an evaporative capacity of 200,000 lb. per hour, at a pressure of 650 lb. per square inch, and a temperature of 800 deg. F. Firing will be by blast-furnace gas with coke-oven gas and oil as alternative fuels.

The existing steel-melting shop at the Abbey Works will be extended southwards, and four new 225-ton open-hearth furnaces and a third 800-ton hot-metal mixer will be erected. No main alterations will be made to the existing slabbing rolling mill as its capacity is considered to be far greater than that at present in use. Similarly, no great alterations will be made to the existing continuous rolling mill except that a third coiler will be installed. Two additional pickling lines will be erected, one for 74 in. and the other for 44 in. wide strip,

The Velindre Works will be engaged on the cold processing of coils of pickled steel strip, obtained from the Abbey Works, down to the finished sheared black-plate stage, in tin-plate gauges, for tinning at the company's old-type tin-plate works. In designing the layout of the plant, however, space has been provided for the installation of either, or both, electrolytic or hot-dip tinning equipment. The plant, as now envisaged, will comprise four main items of equipment, namely, a five-stand cold-reduction rolling mill mentioned at the outset of the present article, two electrolytic strip-cleaning lines with adequate annealing furnaces, two temper rolling mills, and four finished-strip shearing lines. The cold-reduction mill will be of the four-high, 42-in. wide, five-stand tandem type, and will be suitable for rolling strip down to tin-plate gauges, at a maximum speed of 4,500 ft. per minute. The two electrolytic cleaning lines will be capable of dealing with strip at a maximum speed of 2,000 ft. per minute. The two temper rolling mills will be of the four-high, 42-in. wide, two-stand tandem type, and will be capable of rolling strip at a maximum speed of 4,000 ft. per minute. The four finished-strip shearing lines, which incorporate side-trimming gear and classifying equipment, are suitable for cutting tin-plate gauge strip into lengths of a minimum of 18 in., and a maximum of 43 in., and a maximum width of 38 in., at a maximum speed of 1,000 ft. per minute. The entry and delivery equipment of the Velindre Works will be capable of handling coils having a maximum outside diameter of 72 in. and weighing 30,000 lb. It is estimated that the Velindre Works will be able to deal with 160,000 basis boxes of tin-plate gauge material per week.

LABOUR NOTES.

WRITING on the question of apprentices in the *Monthly Report*, the official organ of the United Patternmakers' Association, the general secretary, Mr. W. B. Beard, O.B.E., expresses the opinion that bad selection and training, in the past, have accounted for much wastage of human material. A great deal, he says, depends on the craftsman in the shop, for without his assistance and experience the apprentice would not get very far, even supposing that the boy has a natural aptitude to learn to use tools, read complicated drawings and absorb technical instruction. Patternmaking is a trade which has become more difficult over the years. It has certainly become more varied and has also become more important to the national economy, for the numbers doing this kind of work have increased considerably over the past ten years or so.

The variety is vast and developments will continue, and, Mr. Beard considers, it should be the concern of his Association to see that, wherever possible, apprentices receive complete training. It should be insisted upon that the boy be made an apprentice-member of the Association, which should ascertain, before he starts, whether he is likely "to make the grade." The Association, Mr. Beard emphasises, have a right to consultation on this. If members insist upon consultation and training, they can secure more highly skilled craftsmen in the future, and these will be more and more essential to the prosperity of the national economy. Members must strive to secure a 100-per cent. organisation of all who engage in patternmaking, and by considering the apprentice and his training and selection as a vital part of their function, they are well on the road to secure this desirable object.

Agreement has been reached between the employers and trade unions whereby shipbuilding, ship repairing and engineering employees in the Tyne and Blyth area will forego their Whit-Monday holiday on May 25 and have it added to the Coronation holiday in the subsequent week. This means that the men will be on holiday from Friday evening, May 29, to Wednesday, June 3. They are substituting a holiday on May 25 for June 1. The men involved, who are stated to number about 60,000, are members of the Tyne and Blyth Confederation of Shipbuilding and Engineering Unions. The agreement means that the various transport undertakings will have to adjust their working arrangements to provide workmen's buses on May 25. It is likely that this holiday arrangement will be adopted in other parts of the North-East.

The North-East Development Association, Newcastle-upon-Tyne, in a report on the labour situation in the area, stated that the present high level of employment should continue for some time, but there were uncertainties concerning the future of shipping, shipbuilding, and associated industries. The activity in the basic industries of the area was likely to continue so long as rearmament lasted, but, farther ahead, there were uncertainties. In addition, redundancy in coal mining in North-West Durham was expected. The report stated that if unemployment arose through foreign competition, shortage of capital or for any other reason, it would, in time, adversely react upon the consumer industries. The North-East was not one of the wealthiest areas of the country, and had a history of serious unemployment in the past. It was still very dependent upon the coal-mining, iron and steel, heavy-engineering, shipbuilding and chemical industries. The report again stressed the need for a further diversification of industry to help offset the possibility of unemployment in the main industries.

Statistics issued by the Ministry of Labour indicate that the total working population decreased by some 20,000 in 1952 and numbered about 23,295,000 at the end of the year. Of this total, 15,876,000 were men and 7,419,000 women. There were 872,000 men and women in the Forces, while 5,000 ex-Service men and women were on release leave. The total number of persons in civil employment was 22,022,000. Those registered as wholly unemployed on December 31, 1952, totalled 396,000, compared with 295,000 on December 31, 1951, while those temporarily stopped aggregated 34,000 at the end of last December, against 55,000 on December 31, 1951. Analyses of the distribution of man-power show that the number of persons employed on coal mining increased from 772,000 in December, 1951, to 794,000 in December, 1952, and that the totals of those employed in the gas, electricity and water industries rose from 372,000 to 375,000 in the same interval. There were declines of 2 per cent. in the total of those employed in agriculture and fishing (from 1,074,000 to 1,052,000), and of $1\frac{1}{2}$ per cent. in the personnel of transport and communication services (namely, from 1,754,000 to 1,729,000).

In the manufacturing industries, the employees in the metal, engineering and vehicle industries remained stationary at 4,229,000, and the largest decline, one of $5\frac{1}{2}$ per cent. from 1,004,000 in December, 1951, to 950,000 in December, 1952, occurred in the textile industries. Employees in the building and contracting industries declined from 1,407,000 in December, 1951, to 1,395,000 in December, 1952, but in the same interval persons engaged in the distributive trades increased from 2,622,000 to 2,645,000. Employees in the service of the Government declined by $2\frac{1}{2}$ per cent., namely, from 617,000 on December 31, 1951, to 601,000 on December 31, 1952. Local Government employees declined by 1 per cent., from 736,000 to 727,000.

The strike of 2,000 vehicle builders at the Longbridge Works, Birmingham, of the Austin Motor Company, Limited, is to continue. Such was the decision arrived at, at a meeting held last Monday. The dispute, it will be recalled, began on February 17, as a result of the dismissal of a senior shop steward, who was among 700 employees discharged on redundancy grounds last September. The strikers demand the reinstatement of the shop steward. The district committee of the National Union of Vehicle Builders, who are organising the strike, are to appeal for financial assistance from branches of the union throughout the country, as the strike is costing some 5,000*l*. a week. In addition to throwing out of work a large proportion of their fellow employees at the factory, persons in other firms are being affected by the stoppage. Thus, some 550 employees of the Dunlop Rubber Company, Limited, engaged on the production of motor-car tyres at Fort Dunlop, Birmingham, have been temporarily suspended, and 360 operatives of the Pressed Steel Company, Limited, Cowley, Oxford, have been stood off on account of the strike at the Austin Works.

A strike at Wombwell Main Colliery, near Barnsley, Yorkshire, was brought to an end as the result of a two-hour meeting held in the pit canteen last Sunday, and the men returned to work on Monday, March 2. The strike, which involved 700 colliers, began on Wednesday, February 25, and is stated to have been due to complaints of the production of excessive dust during coal-cutting operations at the coal face in the Thorncliffe seam. It appears that a system of water infusion, intended to cause the dust to settle, has not yet been installed. Last Sunday's meeting was addressed by branch officials of the men's union and the colliers agreed to go back to work on the understanding that their grievance would be taken up immediately by the National Coal Board.

The weekly statistical statement issued by the Ministry of Fuel and Power shows that the output of saleable deep-mined coal, during the week ended February 21, was 4,348,200 tons, compared with 4,284,100 tons in the week ended February 14, and 4,350,800 tons in that ended February 23, 1952. The voluntary absenteeism in the week ended February 14, 1953, was 6·07 per cent., compared with 5·48 in the previous week and 5·83 in the corresponding week of 1952. The output per manshift, at the coal face, remained almost stationary, the figures being 3·18 tons in the week ended February 14, against 3·17 in the previous week, and 3·20 in the corresponding week of 1952.

HORIZONTAL GEAR-SHAVING MACHINE.

DAVID BROWN MACHINE TOOLS, LIMITED, MANCHESTER.

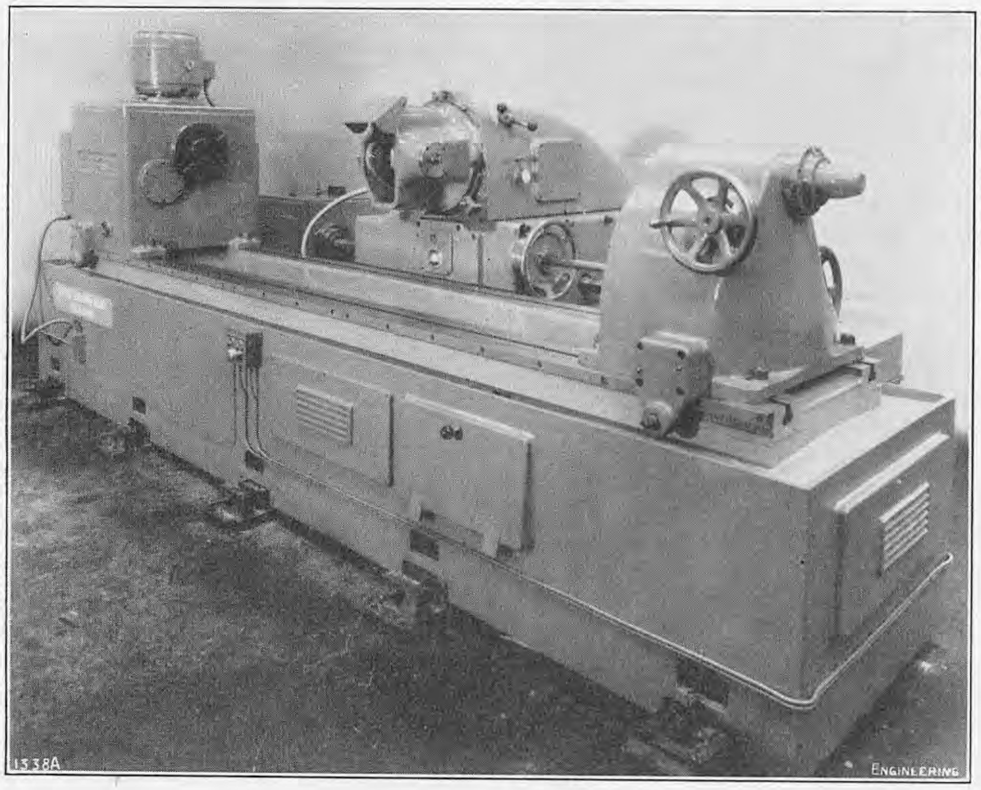


FIG. 1.

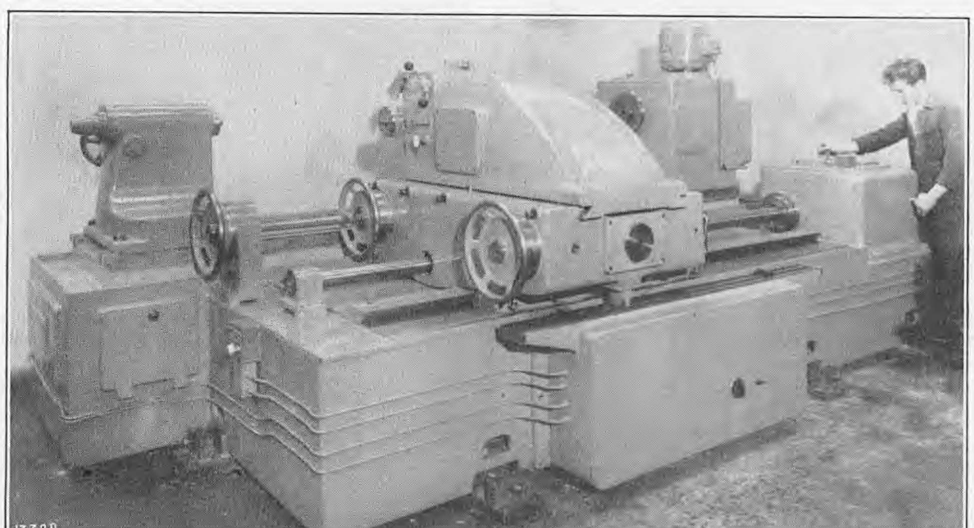


FIG. 2.

HORIZONTAL GEAR-SHAVING MACHINE.

FOR finishing large turbine pinions to close tolerances, David Brown Machine Tools, Limited, Sherborne-street, Manchester, have built a horizontal gear-shaving machine which is believed to be the first of its type in Britain. Known as the David Brown-Muir S24H machine, it has been built to the specifications of the purchaser, the Fairfield Engineering Company, Limited, Glasgow, but its design is one of a new range of horizontal pinion and wheel-shaving machines. It will shave pinions of between 4 in. and 24 in. diameter and up to 100 in. in length over the journals or 60 in. maximum face width. The other machines in the new range include the S48H, for pinions of $4\frac{1}{2}$ in. to 48 in. diameter, and the S100H and S200H, for shaving wheels up to 100 in. and 200 in. in diameter, respectively. These machines embody several features which have been evolved by the makers through recent experience in developing a range of vertical-axis shaving machines.

The general arrangement of the new machine is apparent from Figs. 1 and 2, which show the front and rear, respectively. The pinion is supported horizontally by a workhead and tailstock, the former driving it. The shaving cutter is carried on a head, in which provision is made for rotating the cutter about a horizontal and transverse axis so that, in accordance with the helix angles of the pinion and the cutter, the two can be meshed correctly. This is known as crossed-axis shaving. The cutter has teeth of spur or helical form of the same normal pitch and pressure angle as the work, and it is set with its axis at a predetermined angle to the axis of the work. To permit meshing with crossed axes, the helix angles of the work and cutter must be different: to shave a spur gear the cutter must be single-helical, but for shaving a helical gear use may be made of either spur or helical cutters, depending on the spiral angle of the work and the desired crossed-axis angle, which is the difference between the helix angles of the work and the cutter, taking "hand" into account. When shaving is taking place, the load between the cutter and the work is applied radially, so that both flanks of the gear tooth are cut simultaneously. If required, an oil-cooled brake can be fitted to the cutter spindle to allow single-side or "selective" shaving to be undertaken. The subject of crossed-axis shaving was dealt with in an article by Mr. A. Sykes which appeared in the summer, 1952, issue of *Contact*, the journal of the David Brown companies.

The S24H machine weighs 20 tons. The guide-ways in the main bed—a one-piece casting—locate the driving head and tailstock, as well as the saddle carrying the shaving-cutter head. Provision is made for fitting work-steady brackets in any required position. Complex drives are eliminated by the adoption of independent driving units for both the workhead and the cutter-saddle traverse. A substantial facing locates the unit drive to the cutter-head saddle. Longitudinal hand traverse of the workhead and tailstock is effected by rotating pinions which engage with a rack at the front of the bed. The workhead is a self-contained unit fixed to the bed and driven by a constant-speed 5-h.p. motor. The drive is taken through worm and helical gears, and a series of change gears gives a choice of spindle speeds ranging from 21 to 300 r.p.m. For setting purposes, the driving spindle can be run independently of all other machine motions. The saddle-feed gearbox, fitted as an independent unit at the rear of the machine bed, provides for longitudinal traverse of the cutter. Drive to the saddle-traverse screw is supplied by a 3-h.p. motor, and the rates of feed range from 0·17 in. to 3·3 in. per minute. A rapid power traverse of 20 in. per minute is provided. Adjustable stops control the length of traverse, and a hand-operated reversing switch is used to change the relative directions of motion.

Angular adjustment of the shaving-cutter head is made by a hand-operated worm and wheel, and a vernier scale facilitates quick and accurate setting. The final fine adjustment is achieved by a dial indicator which is in contact with a setting bar located by a slipping ring in the cutter head. A hand-operated in-feed slide engages the shaving cutter in mesh with the gear; three handwheels with graduated scales enable adjustment to be made from any of three positions. The electrical control gear is mounted on a panel at the rear of the machine and an isolator switch is incorporated in the panel door. The various motions of the machine are controlled by duplicated push-button stations, one of which is at the front and one at the end of the machine; a rotary change-over switch selects the direction of rotation of the driving spindle relative to the direction of feed, and limit switches prevent over-running. The standard electrical equipment is arranged for a power supply of 400/440 volts, three-phase and 50 cycles, but direct-current motors and control gear can be provided. Automatic lubrication systems are fitted to the workhead and saddle-feed gearbox. Saddle guide-ways and feed screws are lubricated by a hand-operated pump, and gears in the in-feed bevel box run in an oil bath. Other moving parts are provided with oil nipples. A self-contained motor-driven gear pump supplies the shaving cutter with a continuous flow of cutting lubricant, which subsequently passes through two magnetic filters and a box-type strainer before being allowed to re-circulate.

INQUIRY INTO LOSS OF M.S. "PRINCESS VICTORIA."—The Ministry of Transport states that the formal investigation into the loss of the Stranraer-Larne car ferry Princess Victoria, which is to begin on March 23, will be held at the County Court House, Crumlin-road, Belfast, and not in the Petty Sessions Court Building, as previously announced, and stated on page 287, *ante*.

EXHIBITION OF ELECTRONIC EQUIPMENT.—The north-western branch of the Institution of Electronics are to hold their 8th annual exhibition at the College of Technology, Sackville-street, Manchester, from July 15 to 21, 1953. In addition to the commercial, and research sections, lectures and films will be presented. Tickets for the exhibition and lectures (for which a stamped addressed envelope should be sent) may be obtained, after June 1, from the secretary, Mr. W. Birtwistle, 17, Blackwater-street, Rochdale, Lancs.

LEAD-CYANAMIDE AND RED-LEAD PAINTS.

FIG. 1. LEAD CYANAMIDE PIGMENT. × 1,900

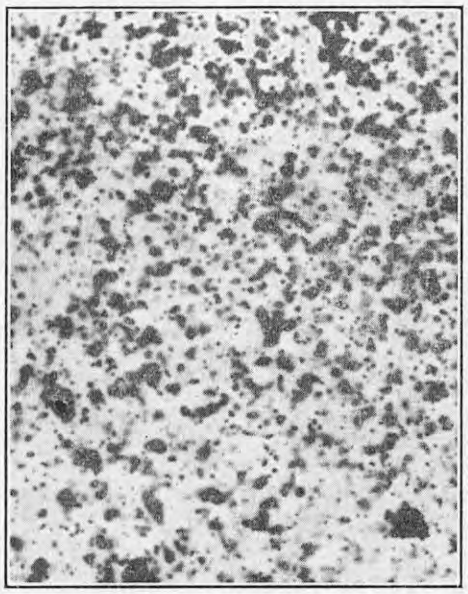


FIG. 3. RED LEAD IN LINSEED OIL. × 520.

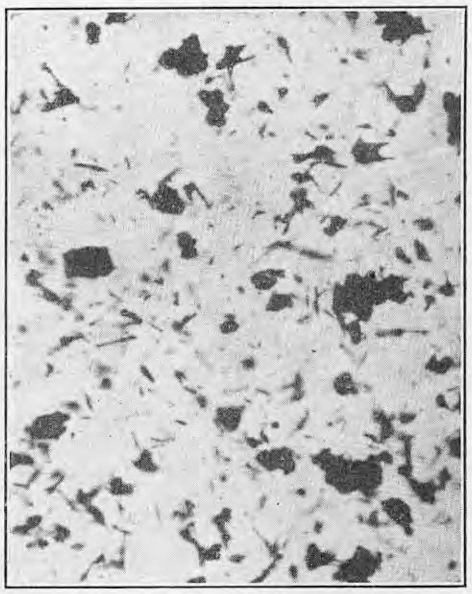


FIG. 4. LEAD CYANAMIDE IN LINSEED OIL. × 520.

FIG. 2. LEAD CYANAMIDE PIGMENT. × 19,000.

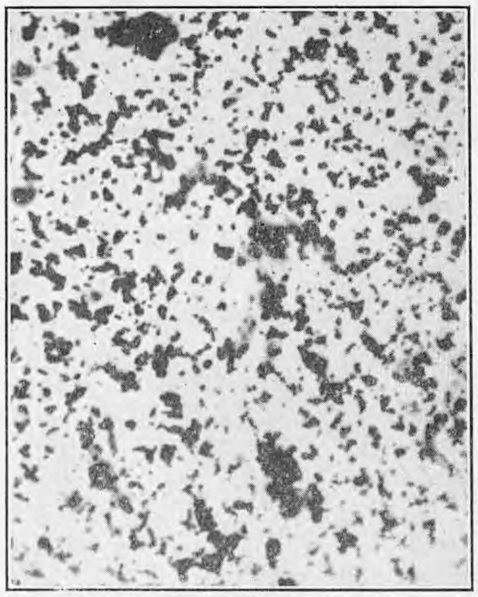


FIG. 5. AS FIG. 3, AFTER 15 MINUTES. × 520.

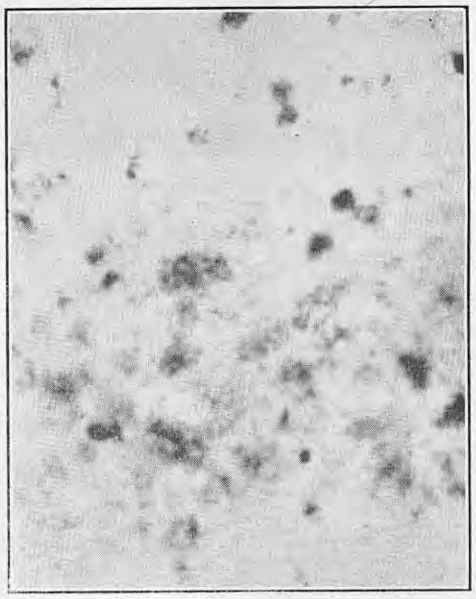


FIG. 6. AS FIG. 4, AFTER 15 MINUTES. × 520.

LEAD-CYANAMIDE PAINTS.

RESEARCH work carried out in Germany in the Hoechst Works of I.G. Farben A.G., some 25 years ago, to develop a satisfactory pigment which would be economical in lead content, led to the demonstration, in 1929, that lead cyanamide, an extremely voluminous material produced by a precipitation process, was a most effective anti-rust pigment for the coating of steel surfaces. The pigment is lemon-yellow in colour and microcrystalline, having a needle-like structure. Its formula is $PbCN_2$ and its specific gravity is of the order of 6·2. The structure of the pigment is shown in the microphotographs reproduced in Figs. 1 and 2, above. The diameter of the needles ranges from 0·5 to 1 micron, and the length from 1 or 2 microns up to a maximum of 5 microns.

It is generally known that lead pigments, and particularly red lead, give excellent protection against corrosive influences because they form soaps with linseed oil, and these not only impart good adhesive properties, hardness and elasticity to the resultant paint films but also render them highly impervious to water and resistant to atmospheric influences. Dr. H. Zirngibl, of the Duisburger Kupferhütte, Duisburg, who has made a special study of lead cyanamide pigments, has stated that owing to the fact that this material is a bivalent lead salt, lead cyanamide forms lead soaps very readily and has also the property of transforming acidic atmospheric products, such as carbon dioxide, sulphur dioxide, hydrogen sulphide and the acid decomposition products of linseed oil, into non-corrosive compounds. The cyanamide split off under the influence of acid, owing to its amphoteric character and its tendency to form ammonia, has an alkaline passivating action with water, which is of great importance. Lead cyanamide made into a paste with water has a pH value of 10 or 11. Its alkaline passivating capacity remains unimpaired over many years.

The process of lead-soap formation has been studied by microscopic methods. The microphotographs reproduced in Figs. 3 to 8, on this and the opposite pages, show the behaviour of lead pigments when mixed with linseed oil. In Fig. 3 is seen red lead and in Fig. 4, lead cyanamide, immediately after mixing. Figs. 5 and 6 show the two pigments 15 minutes after mixing with the oil, from which it will be seen that the reaction of the lead cyanamide, seen in Fig. 6, is more pronounced than that of the red lead (Fig. 5). Figs. 7 and 8 indicate the state of lead-soap formation after 18 hours. As before, Fig. 7 shows the red lead and Fig. 8 the lead cyanamide pigment. The microphotographs, it is concluded, indicate the outstanding reaction capacity of lead cyanamide.

Further interesting features of the new pigment are that its relatively low specific gravity and voluminous nature confer particularly valuable technical properties upon the ready-mixed paints in which it is an ingredient. Practically no settling takes place in the paints and, in spite of its ready soap-formation properties, lead cyanamide, when an ingredient in paint, shows practically no tendency to thickening, the reaction beginning only when oxygen has access to the applied coat. All lead cyanamide paints, including those extended with other pigments, are stated to be easily applied by brush. They are also claimed to possess good hiding power and a high spreading rate, namely, the area covered by a given quantity of paint is high. Ready-mixed lead cyanamide paint has a specific gravity of between 1·8 and 2. Owing to its highly bulky volume, lead cyanamide, when being made up into priming paints, requires what appears to be a relatively high quantity of oil. It is emphasised, however, that as a correspondingly larger spreading rate is obtained with this than with normal paints, the quantity of oil used per unit area of surface, in the end, works out at the same

LEAD-CYANAMIDE PAINT.

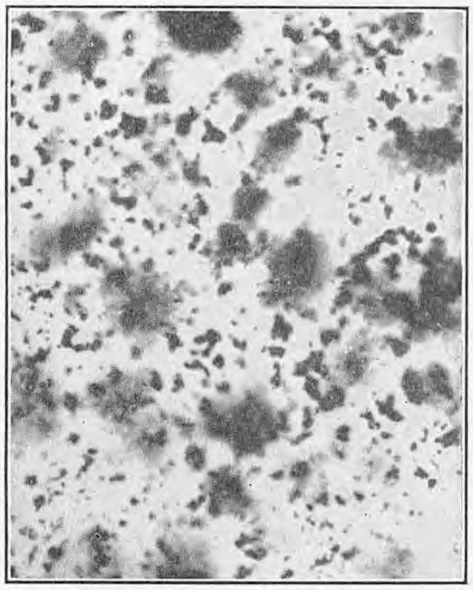


FIG. 7. AS FIG. 3, AFTER 18 HOURS. × 520.

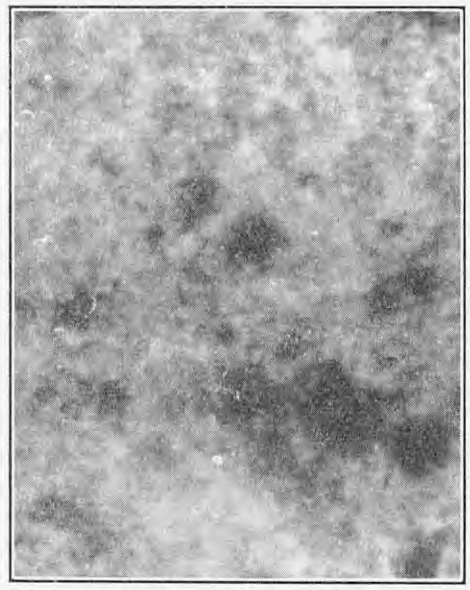


FIG. 8. AS FIG. 4, AFTER 18 HOURS. × 520.

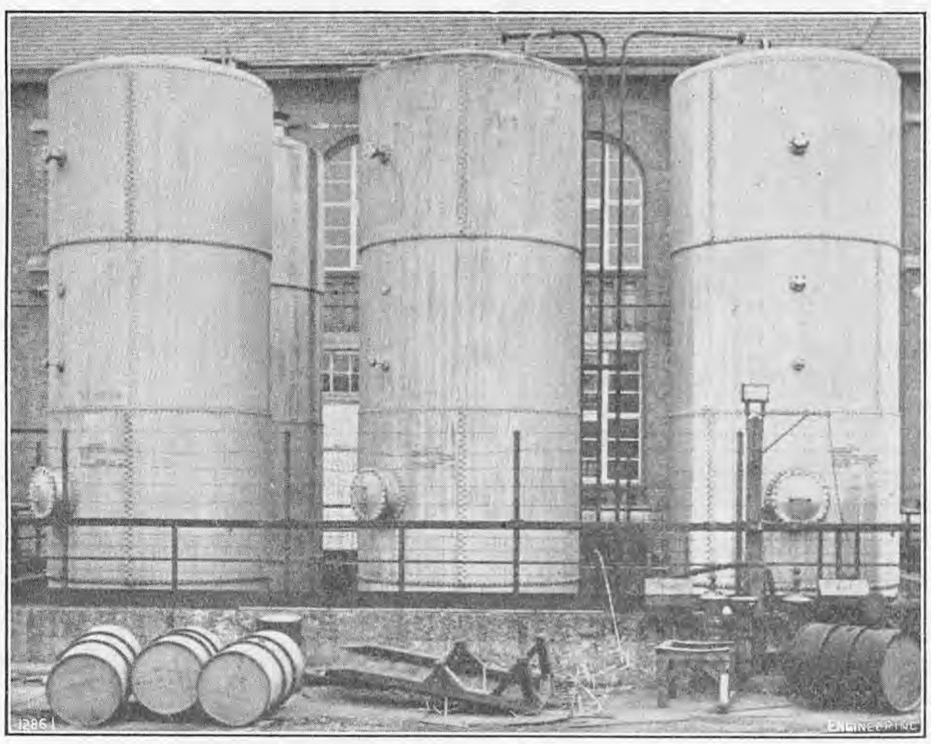


FIG. 9. TANKS TREATED WITH LEAD CYANAMIDE, AFTER 16 YEARS.

figure. As a result of the great reactivity with oil and other media containing oil, paint films containing cyanamide generally dry very rapidly, and, by using suitable driers, the drying time may be further speeded up. Additions of tung oil, up to 5 per cent., hasten the drying time without imparting measureable brittleness to the paint film. Lead cyanamide paints in alkyd resins are characterised by good "brushability" and short drying times. Similarly, all activated grades of linseed oil blend well with lead cyanamide. The new material is miscible with all inert pigments and it has a suspending effect on pigments which tend to settle easily.

Lead cyanamide is now obtainable in this country and is at present used not only for rust-protective priming paints but also for special primers in railway carriage and coach building, and other applications; and for finishing coats of various types. In 1950, the German Federal Railways included lead cyanamide paints in their preliminary technical specifications, and, for the past few years, the Duisburger Kupferhütte have been using lead cyanamide-micaceous iron ore finishing paints. The photograph reproduced in Fig. 9, above, was taken at the Hoechst Works in 1951, and its purpose is to indicate the good protective properties of lead cyanamide paint over a long period. The three tanks shown are stated to have been painted in 1935 and it is evident that they are in remarkably good condition after 16 years. The tanks were treated with a lead cyanamide priming paint and then given two coats of a finishing paint containing 25 per cent. of aluminium.

"FARM MECHANIZATION" SCHOLARSHIP.—A scholarship, known as the "Farm Mechanization" Scholarship, which was given last year to the Institution of British Agricultural Engineers by the publishers of *Farm Mechanization*, will be awarded again this year for the session of study commencing October, 1953. The award will be applied for the benefit of students who experience financial difficulty in completing the year of study leading to the final examination for the National Diploma in Agricultural Engineering and will be tenable at one of the colleges approved by the examination board of the Institution. Preference will be given to candidates having engineering qualifications. Further particulars, together with forms of application, may be obtained from the secretary, Institution of British Agricultural Engineers, 24, Portland-place, London, W.1. The closing date for receiving completed applications is May 15, 1953.

THE SCOPE OF STUD-WELDING.*

By R. W. TAYLOR, A.M.I.E.E.

FOR practical purposes, the present range of stud and fixture diameters which may be stud-welded may be taken as $\frac{1}{8}$ in. to $\frac{3}{4}$ in., though attachments both smaller and larger have been handled. It is not necessary that attachments be limited to cylindrical form; rectangular, elliptical and other sections may equally well be secured, with the proviso that the ratio of length to breadth of the welding section shall not exceed 4 to 1. This limit is imposed by the behaviour and speed with which the arc travels over the surface of the welding end, it being obvious that a full-area weld cannot be obtained unless the whole surface of the welding end is raised to the molten condition. The illustration on page 316 shows a selection of studs and other attachments which can be end-welded.

For the present, $\frac{5}{8}$ in. is the limiting maximum diameter of attachment for which consistent full-area stud welds can be guaranteed on a vertical plane. This is due to the difficulty, even when using special ferrules, of holding a comparatively large volume of molten metal round the base of the stud against the force of gravity and of preventing a partially dry joint or under-cutting of the weld on the upper edge of the attachment. This problem is not encountered in either downhand or overhead stud-welding. If sufficient power were available to enable a $\frac{3}{4}$-in. diameter stud to be welded in about the normal time required to effect a $\frac{3}{8}$-in. diameter stud weld, there would be insufficient time for gravity to act in this way and sound welds could be made.

Stud-welding cycle times are, in general, less than one second, necessitating the use of semi-automatic equipment. Semi-skilled operators, male or female, of average intelligence are capable of becoming reasonably proficient in its use in a few days. Experienced operators are frequently able to detect by the noise of the arc or by "ringing" with a light hammer whether a stud weld is sound or otherwise.

To ensure sound results in any metallic arc-welding process, it is necessary to provide the electrical conditions required for the establishment of a stable arc. With ferrous studs, fluxing assists in scavenging dirt, rust, paint, mill-scale and other impurities from the weld zone, but flux is, of course, ineffective unless electrical contact can first be established between the stud and plate to permit the passage of current and formation of an arc. Cleaning by a scratch brush, shot-blasting or other means are frequently adopted, but where this is impractical a good centre-pop mark is usually effective in providing the initial electrical contact between stud and plate.

Ferrous stud-welding was developed from brass stud-welding. Quite early, experiments proved the necessity for reasonable care in specifying and controlling the quality of naval brass used for stud manufacture. Now that such control is exercised, sound, consistent and good-quality welding of naval brass studs to steel plate is ensured with the modern stud-welder. Brass studs may also be fixed by the same means to copper, provided the latter is de-oxidised. Some satisfactory stud-welding has also been carried out on Monel metal.

For ferrous stud-welding, where maximum penetration into parent metal is desirable, the plate should be positive and the stud negative. In stud-welding certain non-ferrous metals, notably brass, use of the reverse polarity has been found advantageous in melting the stud end while leaving the plate surface only in a plastic condition. In ferrous stud-welding, proprietary mild-steel studs may be satisfactorily welded to the range of low-alloy mild steels with average carbon content. Where the carbon content exceeds 0·25 per cent., i.e., where the range of air-hardening steels is approached,

* Second part of a paper entitled "Practical Stud Welding," presented at a meeting of the Institute of Welding in Nottingham, on February 24, 1953. Abridged. The first part dealt with the history of stud welding and described the equipment, referring particularly to the Nelson and Cyc-Arc methods.

resort to pre-heating may be necessary to avoid excessive hardness resulting from the rapid quench unavoidably associated with arc stud-welding. This is no disadvantage, provided the point is not reached where free carbon exists in the weld zone, an extreme example of this condition being "cast iron." Materials normally suitable for metallic arc welding are, in general, also suitable for stud-welding. The growing use made of aluminium and its alloys in engineering is making a new demand on the versatility of stud-welding. Considerable research work has already been done, and is continuing, mainly using pure aluminium and its non-heat-treatable alloys (the latter being especially in demand for shipbuilding). The high-strength heat-treatable aluminium alloys present serious problems with which little progress has, so far, been made. Due to the small total heat input (which may be measured in terms of a hundred or so coulombs), the distortion of structures, even those comparatively extensively studded, is very small and for most practical purposes can be disregarded.

Where studs are required to be fixed by drilling and tapping, the accepted formula is that the metal thickness into which the stud is screwed shall be at least equal to the diameter of the stud. The accepted ratio of stud diameter to plate thickness for stud-welding may be taken as four to one, say, $\frac{1}{2}$ in. diameter to $\frac{1}{8}$ in. or 10 s.w.g. down to a minimum sheet thickness of 16 s.w.g. Below this the ratio is reduced to two to one, until the surface of the parent metal opposite to the stud weld deforms. To some extent, this marking or deformation of the reverse side may be minimised by conducting the heat, formed by the arc, away from the weld area rapidly by means of steel, or preferably, copper backing plates. To develop the full strength of the stud on this parent metal, the shear strength of the weld at the point of attachment must equal the ultimate tensile strength of the stud.

The strength of a stud weld is, of course, the strength of the weakest link in the chain of zones which exist between parent metal and stud and the weld junctions between them. These zones are: the heat-affected parent metal; the fusion zone (a cast structure comprising a combination of parent and stud material); and the heat-affected stud material. The weld junctions, being approximately hemispherical in form, are appreciably greater in area than the cross-sectional area of the attachment at the point of weld; thus, in tension for a given load the stress in an attachment is greater than that on the weld junctions. In practice, the criterion which determines if stud-welding is of use to industry is its ability to effect a junction stronger than the part attached. The ultimate tensile strength of mild steel used for stud manufacture to-day is about 26 to 30 tons per square inch, with a proof stress of 85 per cent., with 1 per cent. permanent set and a minimum elongation of 25 per cent. Brinell hardness figures range between 130 and 150. After cold-working in thread rolls and after welding, however, it is common to develop 30 to 35 tons per square inch ultimate strength in attachments. The fillet or upset of metal formed round the base of the stud adds little to the strength of the weld and is sometimes removed by a hollow end mill or other means when it is objectionable. This practice is deprecated as it involves an additional and costly operation. It is often permissible to increase the diameter of hole provided for a stud to accept the fillet as well. Failing this, it may be advisable to utilise what is known as "a reduced base stud" having its welding end reduced in diameter to a few thousandths of an inch below thread-root diameter, the recess thus formed being utilised for accommodating the fillet.

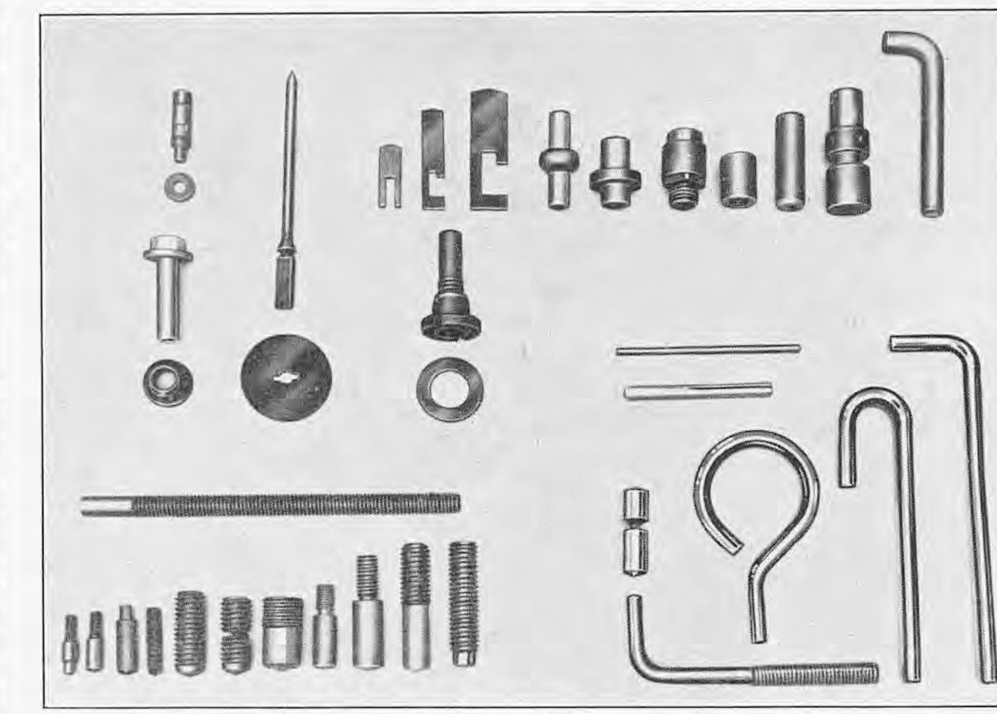
There are few, if any, metallurgical problems peculiar to the stud-welding process which are not met with, possibly in different degrees, in metallic arc-welding. Due to the rapidity of cooling or quenching of the weld metal because of the small total heat input during the stud weld, and the rapid conduction of this heat away from the weld zone through the parent metal, the local hardening effect in medium-carbon and even in low-carbon steels, is more pronounced than with metallic arc welding. Considerable research has already been undertaken and is still proceeding into the problems associated with the stud-welding of air-hardening steels, with a view to eliminating excessively hard zones formed immediately below the weld in the parent metal. Examination of a large number of sectioned and etched stud welds which have satisfactorily withstood the ultimate tensile stress of the stud makes it clear that, while such welds are considerably stronger than the stud, they may still possess noticeable imperfections for various reasons. A need exists for some device better able to evaluate or assess quickly and non-destructively the soundness of a stud weld, and an effort to develop and produce such equipment, suitable for the shop floor, is being made. For the time being, torque spanners or tension wrenches are commonly employed.

Comparative Costs and Advantages.

It is mainly by designing from the outset to use stud-welding that the fullest advantages in material and labour saving are secured, as the saving of material may not immediately be obvious. Perhaps examples may be quoted of flanges and apertures in transformer and switchgear tanks and Diesel-engine crankcase doors, round which it is common practice to fillet-weld pads or frames drilled and tapped to accept studs. The use of stud-welding removes the necessity altogether for the labour and time involved in cutting, fillet-welding and drilling and tapping these pads or frames, as they may be eliminated at the design stage. Moreover, since there is no perforation of the vessel or chamber, the subsequent testing for gas-tightness or liquid-tightness may be dispensed with altogether. To take an actual instance of cost reduction resulting from the increased production speed achieved by stud-welding, consider a current transformer on which 58 studs were required. The cost of studding by drilling and tapping (including labour, materials and overheads) was 2*l.* 7*s.* 9*d.* Fixing the same 58 studs by stud-welding was carried out at a total cost (again including labour, material and overheads) of 1*l.* 0*s.* 6*d.*

The flexibility and portability of stud-welding equipment are valuable factors in a busy fabricating shop, as the studding of structures can often be left to a later stage in the manufacturing programme, thereby saving the replacement cost of studs which may be damaged in the course of movement and manipulation. Considerable savings can accrue from the ability of the equipment to go to the job, thus obviating the necessity for lifting heavy parts about a workshop to take them to radial drills and other machine tools. As it is possible to make attachments to a structure without access to the reverse side, scaffolding and extra labour can frequently be saved, while there are a growing number of cases in which, by slightly modified design, stud-welding may be used considerably to improve and clean-up the appearance of an article. The necessity for perforation or drilling in order to secure an attachment inevitably involves some local weakening of the structure, and, in the case of sheet steel, promotes rusting or oxidising at each hold. By stud-welding, these adverse features are avoided.

In all, some 10,000 stud-welding equipments have been put into use in the United States since 1938, and between 2,000 and 3,000 in Europe since 1942. It is impossible here to do more than mention a few of the industries which have, so far, made the greatest use of this process. On both sides of the Atlantic, men connected with shipbuilding pioneered stud-welding, and it is unquestionably in shipyards that its greatest scope lies. The fixing of ventilation ducting, cables, wiring and pipe runs, all manner of fittings and fixtures, cleats, cargo batters, holding-down studs, insulation fixing and the laying of wood decking are self-evident and obvious uses. In the fabrication of tanks, vessels and furnaces for the chemical, oil and other industries, there are applications involving the fixing of thermal insulation, fire-proofing and refractories for which stud-welding is ideally suited and at which it can show savings over alternative methods. There are many jobs in the construction both of power stations and their equipment for which stud-welding is in use, including the fixing of sheathing to water-tube boiler walls, hand-rail stanchions, metal stair-treads, cable and pipe runs, ventilation ducting and fittings. In the construction industry, big cost savings have already been secured by the use of stud-welding in the fixing of corrugated steel, aluminium or asbestos roofing and side sheeting, sprinkler and overhead 'bus-bar systems, cable and ventilation runs, etc.



A Range of Parts which can be Stud-Welded.

There are few metal-working industries incapable of deriving benefit from this comparatively new tool and process. It is not uncommon to find a new user of stud-welding equipment searching the shop floor for attachments secured by drilling and tapping which may be fixed by stud-welding. This is understandable until he has gained a working knowledge of, and confidence in, the equipment. He may, however, have failed to reap the full benefits stud-welding can offer, including reduced labour and material costs, if attempts are not made to provide for the use of stud-welding at the design stage. One of the most interesting aspects of a close association with stud-welding is the recurring proof of its ability substantially to reduce costs, to help produce a better product, or to do a job not possible by any other means.

POST-WAR PROBLEMS IN ENGINEERING EDUCATION.*

By PROFESSOR L. J. KASTNER, M.A., M.I.Mech.E.

(*Continued from page* 284.)

OF late, the urgent needs of industry, and a growing realisation of the importance of the problem, has resulted in a great deal of hard thinking and earnest discussion as to the best way of encouraging able young men to undertake courses of training in technology. The affirmation in the 1950 report of the National Advisory Council on Education for Industry and Commerce that "a technologist of first-class ability, concerned principally with the productive side of an industry, is as vital to that industry's health and progress as a similarly able technologist whose main interest lies in development, research or design," marked an important profession of faith in a principle which many had long believed to be true, but which had long awaited some official recognition. The National Advisory Council, in the same report, recommended the establishment of a national body with the title of the Royal College of Technologists, whose functions were to be concerned with the educational problems of technology, whose awards (associateships, memberships and fellowships) were to be of high standing, and on whose Council and Academic Board the universities were to be represented. The object of the Royal College was to give technology an enhanced status and its rightful place in public esteem and to make available for students who had not graduated at a university an educational qualification fully comparable to a university degree.

This proposal did not by any means receive universal approbation. A report isssued in 1949 by a study group of the Federation of British Industries pronounced strongly against it, and declared that the existing universities should adapt their courses of study to meet post-war conditions and to take account of the increased importance of technical knowledge. The study group further advised the development of a small number of suitable colleges into colleges of the character of the Imperial College of Science and Technology—being careful to say, however, that this should not be at the expense of technological departments at existing universities or technical colleges. This latter suggestion, or a modification of it, has since found a good deal of support in Government circles, and it has been stated that it is intended to set up at least two so-called "Universities of Technology,"

I do not propose to discuss the fitness or otherwise of these new academic bodies to carry the title of "University." Some people find this particularly objectionable, holding the opinion that a university must be universal, and that any institution which caters wholly or mainly for a restricted range of subjects ought not to be called a university. Whatever the rights and wrongs of this, few will disagree with the decision that such institutions should not be completely new foundations, but should be developments of colleges already in being. It is too early to say much about this new venture, except to suggest that of the various difficulties to be overcome, two will be of paramount importance—first, the difficulty of obtaining academic staff of high quality, capable of giving devoted service as teachers, and enthusiastic and successful performance as research workers; and second, the difficulty which any new institution has to contend with, that of establishing its prestige. In wishing success to these new relations of our existing universities, I hope it will not seem presumptuous to suggest that, in an environment where the Arts cannot be strongly represented, the most strenuous efforts will be made to devise a good general education for engineers and other technologists; an education which will ensure as far as possible that they can handle a pen as confidently as a slide-rule and can express themselves, if not in a literary manner, at least in a literate one.

I wish, incidentally, that it could be claimed that our existing university departments of engineering always produced graduates whose general educational standard was above reproach, but, unfortunately, this is not so. So much depends on the home and on the school where these matters are concerned, and the universities cannot fairly be blamed if it is sometimes impossible to transform a very rough diamond into a smooth and polished stone. In this respect, the older universities have a great advantage over their younger and less well-known counterparts—they tend to attract men whose home and educational background is of the best, and though these same young men do not always compare favourably with their less fortunate brethren where academic attainment and the capacity for hard work are concerned, yet a greater degree of self-confidence, and, often, of *savoir faire*, enable them to put up a good showing when they are interviewed by a prospective employer.

A few words on the relationship between the schools and the applied science departments of the university may be worth while. It is to be regretted that this relationship is not a closer one, and that the careers masters in the schools are often so ill-informed as to the very great opportunities which exist for young men in all branches of engineering to-day. Because the applied sciences are not school subjects, there seems to be a regrettable tendency in many schools to advise boys promising in mathematics and the physical sciences to enter the pure science departments of the universities as a matter of course. A carefully worked-out plan for interviewing candidates for university places can do something to correct the errors of this system; but border-line cases do arise in which an interviewing committee are faced with a candidate who is plainly bewildered when the suggestion is put to him that the branch of science he has chosen is not the one he is best fitted to study. Mistakes of this kind could be avoided if careers masters would make it their business to keep in touch with the heads of the applied science departments or with the secretary of the appointments board of the university nearest to their school. It would also be most helpful if school libraries were to obtain a few popular books, describing in a simple way modern developments in the various branches of engineering, in metallurgy and in the other applied sciences.

AMERICAN AND CONTINENTAL METHODS IN ENGINEERING EDUCATION.

The need for producing more engineers and other technologists has brought with it a close examination of the methods employed in the applied science departments of our universities, and this examination has been accompanied by a critical comparison of the British system with those favoured in American and European institutions. As in other fields, the most vocal critics of British methods have not generally been the most well-informed, and therefore, by reason of its sober judgment and authoritative nature, the report to the Anglo-American Council on Productivity by the British team on the Universities and Industry is immensely valuable. It contains a great deal of information on American higher education and deals at length with American education in engineering and science. It emphasises that most American engineers receive their academic training in degree-granting institutions and that, in the United States, there is no considerable alternative source of supply to be compared with our British technical colleges. It stresses the fact that Americans consider there is no better training for many high executive positions than that of the engineer, a fact which deserves earnest consideration in this country, where the engineer is so often looked upon as a mere expert in technical matters and not qualified to be consulted about matters of administration; though I fear that this misconception may be mostly our own fault and may arise indirectly from a lack of organisation in our profession and an attitude of indifference where professional status is concerned.

The report makes it clear that the number of students taking degrees in America greatly exceeds that in Great Britain, even when America's much larger population is taken into account. The difference in degree standards makes a direct comparison extremely difficult; in science, the Team considered a British bachelor's degree to be roughly equivalent to an American master's degree, and the American bachelor's degree to have a scientific content which is considerably less than that to be found in British first-degree courses. Nevertheless, by sheer weight of numbers of men who take higher (by which I mean post-school) educational courses, America probably has the advantage, and there is every reason over here to strive for some increase in the numbers of students of science and technology. It seems tolerably certain, however, that the standards of those British university departments which offer undergraduate courses in applied science compare favourably with those of their American equivalents.

Where university research in applied science is concerned, the American universities are able to command much greater resources than our own. The report states that, in the United States, approximately 30*l*. million per annum were received by the universities from industry or Government sources for research in science and engineering, not including nuclear physics; whereas the sum so spent in the United Kingdom did not exceed $1\frac{1}{2}$*l*. million, including grants from the Department of Scientific and Industrial Research. Even allowing for the difference in population, the balance is overwhelmingly in favour of America, and the numbers of students who must be receiving some training in research methods, however elementary this may be, is certainly greater in the United States than in this country. It has, of course, been the policy in the United Kingdom to entrust a great volume of research work to Government establishments, but it is possible that, under our present system, the supply of enthusiastic young research workers may be insufficient in the future.

Methods of engineering education on the Continent of Europe were discussed by Professor S. J. Davies in an address, in July, 1952, to the Regional Advisory Council for Higher Technical Education.* He dealt in the main with countries in Western and Northern Europe, and showed that the organisation of those Continental institutions responsible for the higher technical training of engineers differed considerably from country to country, and that there were no very close resemblances with our own. It is noteworthy that he stated categorically that "no single European country can claim such a superiority over others in engineering achievements that its system of education calls for special consideration." In view of the fact that certain of the German, Dutch and Swiss institutions have sometimes been held up as models of perfection which we in this country would do well to copy, the conclusion at which Professor Davies arrived is worthy of particular attention. This is not to say, of course, that certain Continental countries have not developed engineering schools which are admirable in many respects; but these schools have been created to fit in with an industrial organisation which is not the same as the British one. As pointed out by Professor Davies, "in some countries, particularly the smaller, in the absence of other facilities available here, the engineering schools are called upon to provide a much greater part of the contribution of applied research necessary from the national point of view," and "in a small country a professor may be the only independent authority in his field of work . . . and may be required to take part in all Government activities touching his field." The substance of both these quotations might apply equally well to engineering schools in many parts of the Commonwealth and Colonies.

If it is agreed that the organisation of our home schools of engineering is satisfactory in the main and well suited to our industrial system, there is always much that we can learn from the foreigner; for instance, there is one feature of the Swiss schools, of which I have been told and which I presume still exists, which appeals to me strongly. According to my informant, part of a student's final examinations consists of a *viva voce* examination attended by representatives of industry who are free to cross-examine the candidate if they so desire. Though this must be a harrowing experience for the student concerned, he has the assurance that a successful survival of the ordeal is likely to result in attractive offers of employment.

(*To be continued.*)

* Address delivered on January 26, 1953, to the South Wales and Monmouthshire Association of the Institution of Civil Engineers. Abridged.

* ENGINEERING, vol. 174, page 70, *et. seq.* (1952).

MEASURING THE EFFECTIVE DIAMETER OF SCREW GAUGES.

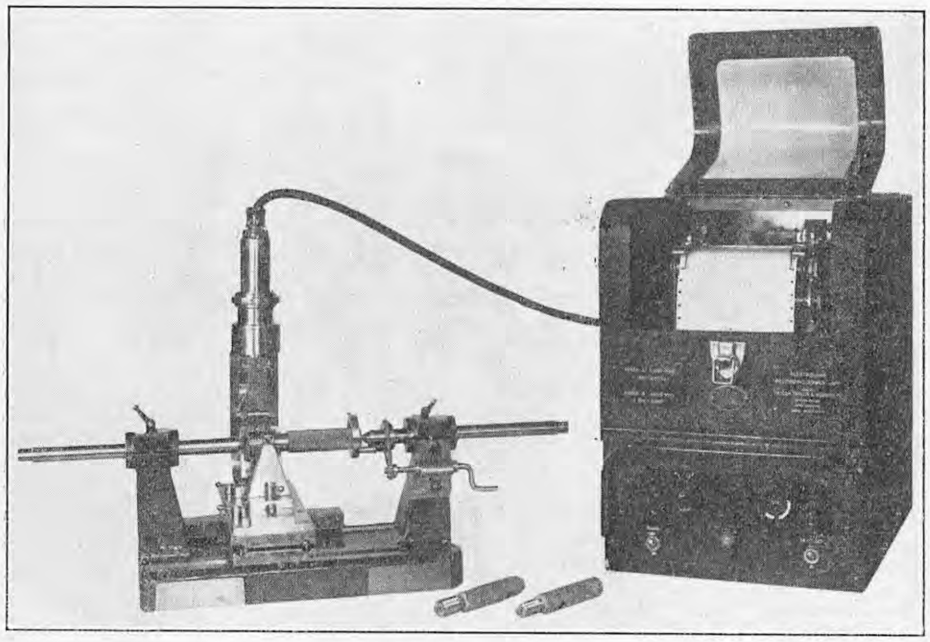
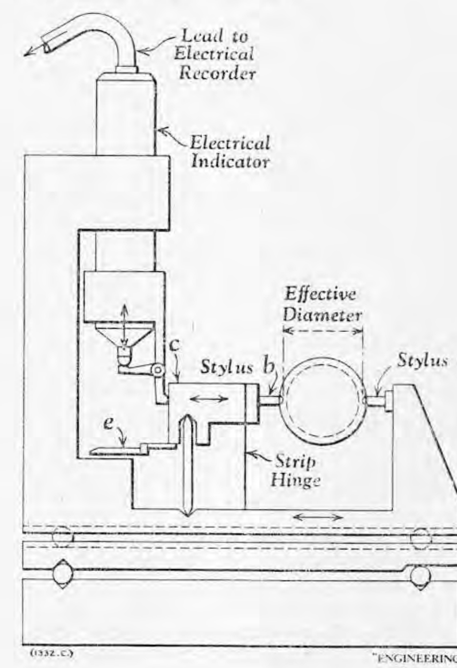


Fig. 1. Measuring Machine and Recorder.

Fig. 2. SCHEMATIC LAYOUT.



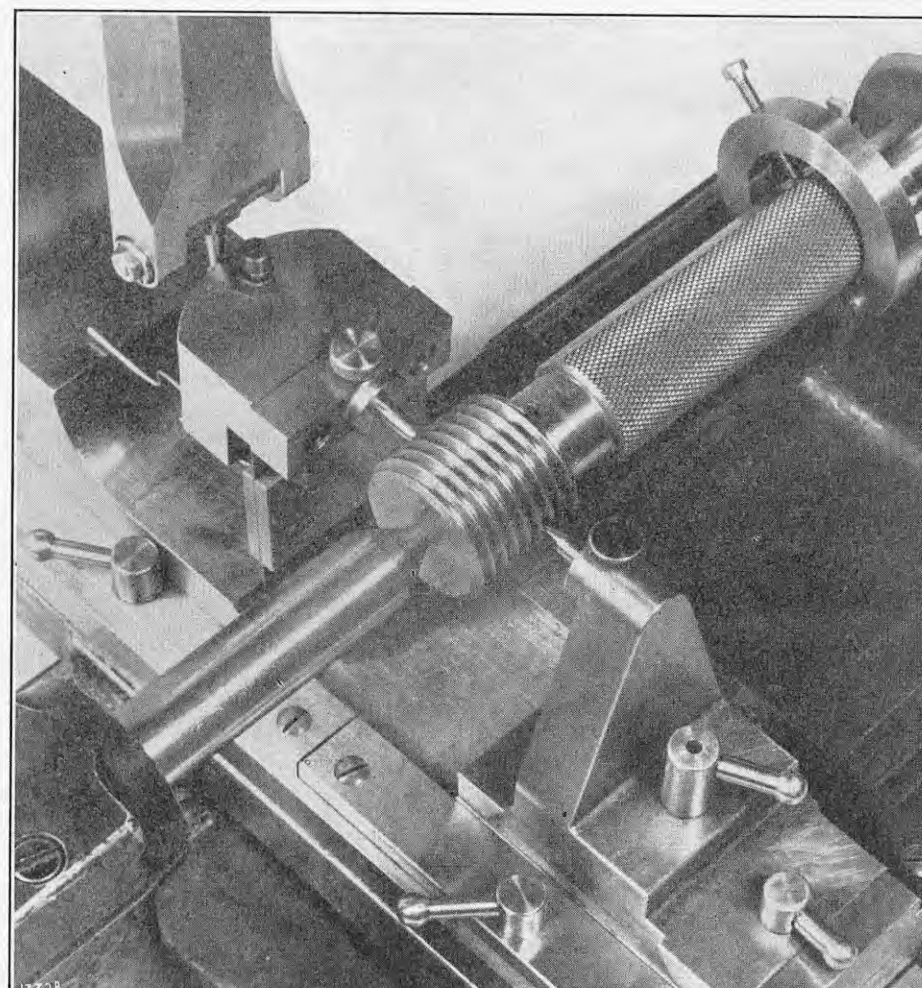


Fig. 3. Plug Gauge in Position for Measurement.

THE EFFECTIVE DIAMETER OF SCREW GAUGES.*

By P. W. Harrison, B.Sc.Eng., A.M.I.MechE., and Mrs. J. G. Wood, B.Sc.(Eng.).

Measurement of the effective diameter of screw plug gauges is necessary, both during manufacture and at intervals during their subsequent use in the inspection of screwed work, to ensure that they conform with the specified size or have not worn below the lower limit. The measuring machine described below produces a continuous record of the simple effective diameter over the full length of helix; this represents an advance over present methods which provide an incomplete picture, due to the limited number of positions at which measurements can conveniently be made. The design is linked in some respects with existing machines and some brief mention of these may be made; a fuller review was given in the first Sir Alfred Herbert paper, by Mr. F. H. Rolt,† O.B.E., at whose suggestion the work here described was carried out.

Prior to the first World War, measurements of simple effective diameter were made by using three needles in conjunction with a hand micrometer, or, for greater accuracy, a Whitworth end measuring machine. During the early part of that war, the floating micrometer diameter-measuring machine‡ was developed at the National Physical Laboratory to meet the greatly-increased demand for rapid and accurate measurements of screw threads, and this, essentially, is the machine in use to-day. The measurement made is basically a comparison between a diameter of the screw plug and the diameter of a plain cylindrical standard, using a micrometer and a fiducial indicator in conjunction with two cylindrical needles. Large numbers of gauges may be more speedily inspected in a modified version of the machine, introduced in 1938,§ in which the micrometer and the fiducial indicator are replaced by an adjustable anvil and a measuring indicator. The effective diameter of a batch of screw plug gauges of the same nominal size may then be quickly compared with the diameter of a similar gauge which itself has been previously measured by the usual method, the errors in effective diameter being read directly on the indicator.

* Communication from National Physical Laboratory. Abridged.

† "The Development of Engineering Metrology," *Proc. Inst. Prod.E.*, vol. 1, page 6 (1952).

‡ *Notes on Applied Science No. 1—Gauging and Measuring Screw Threads*, page 12. H.M. Stationery Office.

§ "A Machine for Measuring Plug Screw Gauges in Quantities," by F. H. Rolt. *Machinery*, vol. 52, page 701 (1938).

The continuous effective-diameter machine is also designed for rapid comparative measurements. The two needles are replaced by spherical-ended stylus points, so that the plug may be freely rotated; a complete graphical record is obtained by substituting an electro-limit measuring head and a recorder unit in place of the indicator. The apparatus is illustrated in Figs. 1 and 3, herewith, which show a plug gauge mounted between the centres of a floating micrometer machine, and in Fig. 2, which shows more clearly the basic movements. The combination of a carriage and saddle, mounted on ways mutually at right angles, provides the carriage with freedom of movement in a horizontal plane. Contact with the thread of the gauge is made through two stylus points a and b, mounted on the carriage at the same height as the axis of the screw; of these, stylus a is rigidly supported, while stylus b and the holder c are flexibly mounted on a steel strip and strut, so that the stylus is free to move to a limited extent in a horizontal plane.

The stylus points have spherical tips of such a radius that contact is made with the flanks of the thread in the region of the effective diameter.

EFFECTIVE DIAMETER OF SCREW GAUGES.

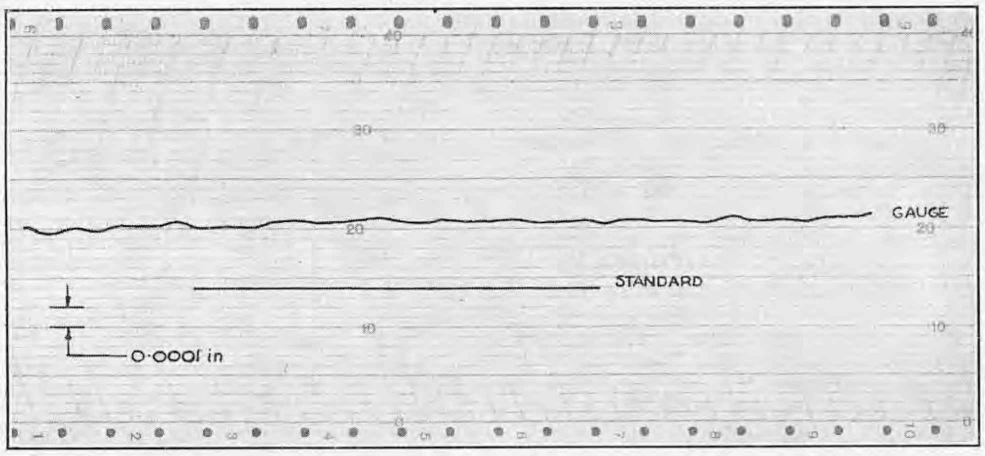


FIG. 4. TYPICAL RECORD.

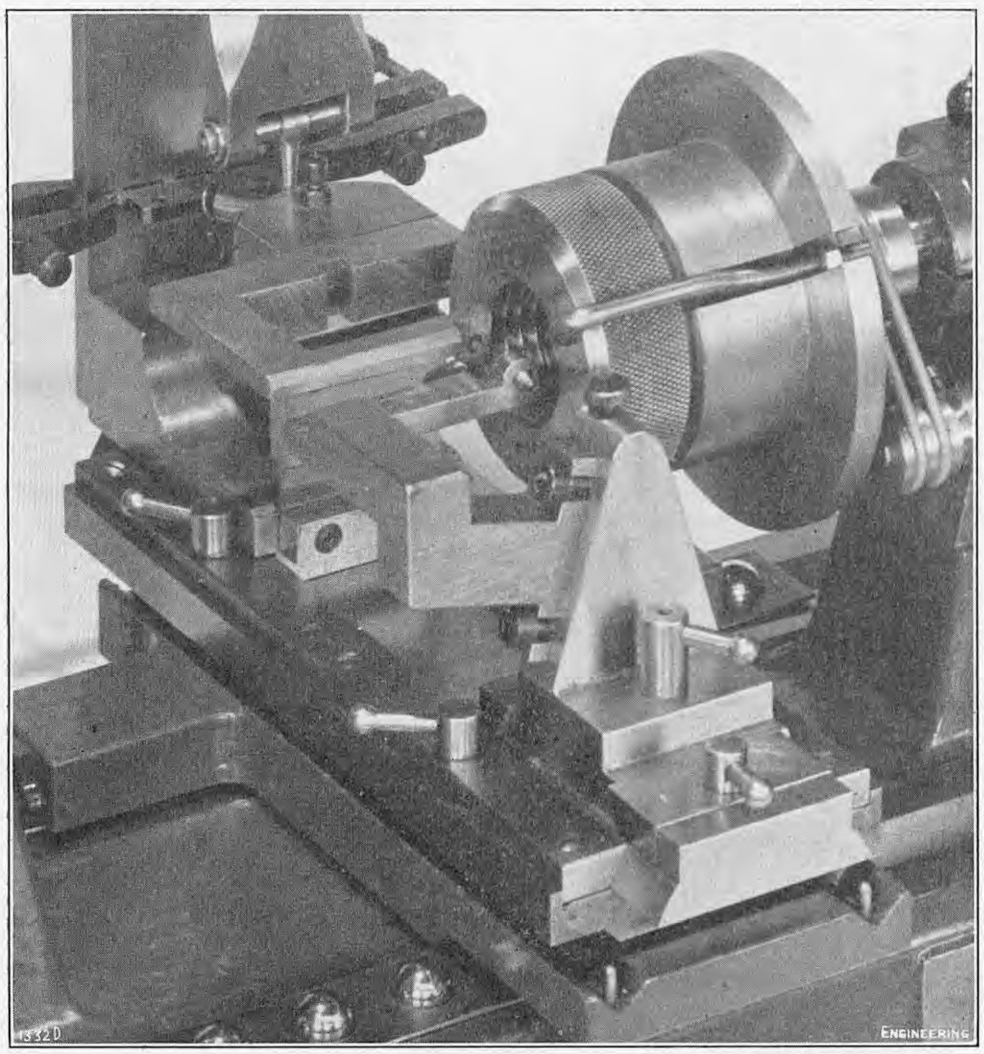


FIG. 5. MACHINE MODIFIED FOR MEASURING SCREW RING GAUGES.

It is necessary that they shall be displaced relatively to each other by half a pitch and this is effected by adjusting the stylus *a*, until the pointer *e* coincides with a line on the carriage. In this way, stylus *b* is set squarely to the axis of the screw. An electro-limit measuring head, associated with an amplifier and recorder, is rigidly clamped to the upper floating carriage and the plunger is effectively held in contact with the holder *c* by means of a bell-crank lever. Variations in effective diameter produce corresponding movements of stylus *b* with respect to the carriage and these appear, at a magnification of 1,000 times, as displacements of the recorder pen on the chart.

It is necessary to eliminate the effect of non-uniform or periodic pitch errors which may be present in the screw and which, by varying the relative displacement of the stylus points in a direction parallel to the axis of the screw, would twist the strip support. In order that this twisting movement shall not influence the electro-limit head, the contact surface is formed, with a radius about the vertical centre-line of the strip-hinge.

A small error will be introduced if damage is present at the centres of the gauge, causing it to rotate eccentrically. This is because the stylus points move away from either end of a diameter of the plug, due to its rising and falling when rotated, and effectively measure a chord displaced from the diameter by an amount which is varying. The error is more marked, of course, if the defective centre is adjacent to the threaded part of the gauge, and the gauge diameter is quite small. However, the following figures suggest that this error is not of serious consequence for values of eccentricity likely to arise in practice. For a plug gauge of $\frac{1}{8}$ in. (3·2 mm.) diameter, in which the thread is rotating with an eccentricity of 0·001 in. (0·025 mm.), the error is rather less than 0·00002 in. (0·0005 mm.). An error of similar magnitude would arise in measuring gauges of $\frac{1}{2}$ in. (12·7 mm.) and 1 in. (25·4 mm.) diameter if the thread rotated with eccentricities of 0·002 in. (0·050 mm.) and 0·003 in. (0·075 mm.), respectively.

Unlike the normal diameter-measuring machine, the saddle as well as the upper carriage of the new machine is free to float, so that, as the plug is rotated by the handle and pulley system seen in Fig. 1, the two stylus points automatically traverse the length of the helix and the corresponding variations in effective diameter are recorded. With the plug gauge dry, there is a slight tendency for chatter to be set up at the stylus points. This may be overcome by coating the plug gauge with a thin film of micrometer oil, a procedure which does not introduce noticeable errors into the recorded size.

The trace so obtained shows the variation of simple effective diameter along the helix of the screw. A typical record is reproduced in Fig. 4. To obtain the absolute size at any point, it is only necessary to measure a selected diameter of the screw in the normal diameter-measuring machine and to provide on the trace a datum line corresponding to this diameter. This is simply done when making the trace by temporarily arresting the motion of the screw when the stylus points are registered on the selected diameter, so drawing a straight line on the moving chart.

When it is required to measure a batch of screws of the same nominal size, each screw is placed, in turn, in the machine and its trace recorded. The errors are then determined from the relationship of these traces to the datum line recorded on any one of the screws, in the way described above. It is essential, of course, that the setting of the solid stylus *a* should remain unaltered during these measurements. It is possible to reproduce a chart to an accuracy within ± 0·00003 in. (0·0008 mm.), and it is estimated that the accuracy to which the absolute magnitude of the effective diameter of screw plug gauges can be obtained by the methods described is within ± 0·00015 in. (0·004 mm.).

The apparatus may be modified to measure screw ring gauges, as shown in Fig. 5, herewith. Variations in effective diameter are recorded as for screw plugs, though the accuracy of determination of the absolute size is lower, due to the greater uncertainty in the absolute measurement of the datum diameter. Contact with the thread is effected by cranked stylus-holders, which require that the load on them shall be reversed; to achieve this, the holder *c* is biased by a coil spring in tension. The ring is held in a rotating head, mounted on a hollow spindle, and it is centred by means of a hollow conical attachment, mounted on a shaft. The shaft enters the hollow spindle until the conical surface makes contact with the bevelled face of the ring, so bringing the ring concentric with the axis of rotation. The ring is clamped in this position and the attachment is removed. If the bevelled face is not formed concentrically with the thread, it becomes necessary to use a more complex attachment, such, for example, as an expanding mandrel locating on the crests of the thread. To allow room for manipulating the conical centring attachment, the traverse of the saddle was increased by replacing the three-ball support by a row of equal-sized balls placed in each V groove and held in position by a spacer.

It may be noted that the machine could be used for recording "drunkenness" of screw plug gauges, by arranging for a bell-crank lever to register on the side of block *c* and thus employing the principle used in the "drunkenness" measuring machine of N.P.L. design.*

THE ROYAL AGRICULTURAL SHOW IN 1955.—The Council of the Royal Agricultral Society have accepted an invitation from the City of Nottingham for the Royal Agricultural Show to be held at Wollaton Park, Nottingham, in 1955. The Agricultural Show was held at Nottingham in 1888, 1915 and 1928.

* *Notes on Applied Science No. 1—Gauging and Measuring Screw Threads*, page 20. H.M. Stationery Office, Kingsway, London, W.C.2.

NOTES ON NEW BOOKS.

Visual Lines for Spectroscopic Analysis.

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

THIS reference handbook presents the wavelengths, intensity values and relative sensitivities of all the principal lines in the visible spectrum due to 72 elements. The data are assembled in two sets of tables: first, under the names of the elements, in alphabetical order, and secondly, in numerical order of wavelength. The general arrangement of the reference matter is much the same as that followed in the first edition, published 25 years ago, but all the values have been revised to conform with the best experimental results now available. All wavelengths, for example, are in international Ångstrom units, rounded off to the first decimal place, from the Tables of the Massachusetts Institute of Technology. Some little-used material in the first edition has been omitted and replaced by a valuable account of arc excitation sources, together with brief notes on a modern design of constant-deviation wavelength spectrometer, and new data for the spectroscopic detection of the halogens, selenium and sulphur.

The Structure and Properties of Mild Steel.

By DR. C. A. EDWARDS, F.R.S. Published by J. Garnet Miller, Limited, and distributed by Quality Press, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 20*s.* net.]

THE author of this book was formerly Principal and Professor of Metallurgy of University College, Swansea, and is well known for his researches on mild steel. His aim is to draw attention to the experimental evidence published in recent years in the particular field covered and to discuss the views expressed by various investigators. The work is intended for students of metallurgy and engineering, and also for producers and users of mild steel. The book opens with a chapter on steelmaking, followed by others on microstructures and constitution, and the influence of various elements on the properties of mild steel. The remainder of the book is devoted to physical metallurgy of a more advanced character, including crystal growth by straining followed by annealing, the influence of crystal size upon tensile properties, and the effects of age-hardening, strain-age-hardening, and quench-age-hardening. The last two chapters deal, respectively, with the changes of structure and properties produced by cold-rolling and annealing, and with the pickling of mild steel.

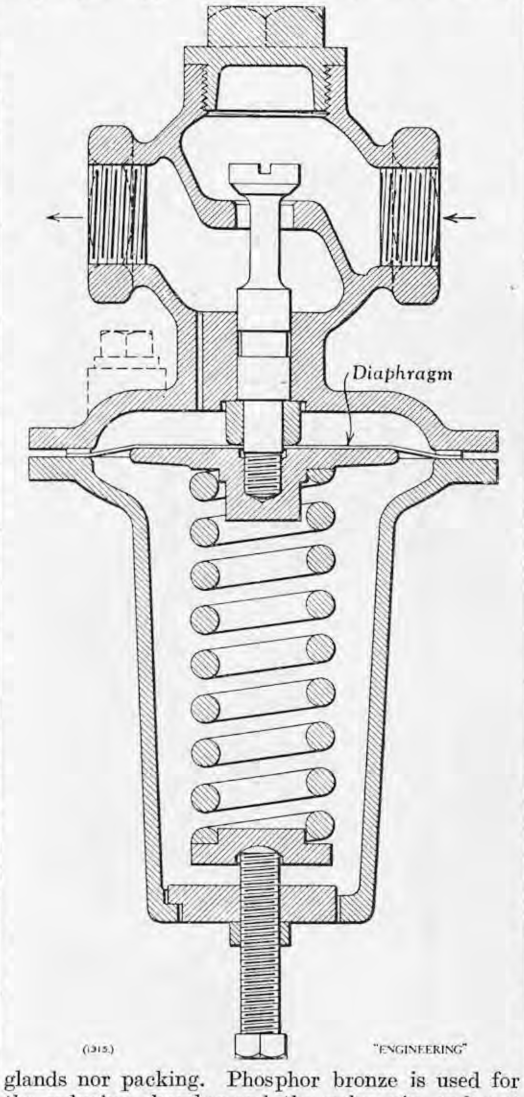
Direct Current Machines for Control Systems.

By PROFESSOR A. TUSTIN, M.Sc., M.I.E.E. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 50*s.* net.]

AUTOMATIC-CONTROL systems and servo-motor arrangements now form important adjuncts in many industries. Many automatic controls belong to the sphere of electronics, but, where considerable power amplification with great quickness of response is required, a series of types of direct-current generators, which might be described as "rotary amplifiers," has been developed. Some of these, such as the Metadyne and Amplidyne, will be familiar to most electrical engineers. Professor Tustin points out that, at first sight, the various types appear very diverse and, though much information is available about them in institution papers and technical journals, there have been few attempts to relate their various forms of construction to common principles or to show the relationship of one form to another. The purpose of this book is to fill the gap. Controls of the type dealt with are used, and are of importance, in steel and chemical manufacture and in some classes of machine tools; they have also naval and military applications. The book begins with a general analysis of control systems followed by a consideration of the characteristics of direct-current machines. This leads up to chapters on the special types with which the book is concerned. The last chapter, on torque motors and linear-stroke motors, covers a subject on which not much has been published.

PRESSURE-REDUCING VALVE.

A NEW range of pressure-reducing valves, suitable for either liquids or gases and capable of reducing pressures up to 250 lb. per square inch down to between 5 and 125 lb. per square inch, is now being made by Sir W. H. Bailey and Company, Limited, Patricroft, Lancashire. The maximum steam capacity of the largest valve in the series is 3,900 lb. per hour for an initial pressure of 250 lb. per square inch, when reducing to 125 lb. per hour. Applications for which these valves are suitable include various types of medium-pressure and low-pressure installations in laundries and hospitals, the operation of kitchen equipment, canning and the processing of rubber, paint or plastics, and impregnation work generally. The valves, shown in the sectioned drawing herewith, are of the diaphragm type and, therefore, have neither



glands nor packing. Phosphor bronze is used for the reducing chamber and the valve pin, and cast aluminium for the housing containing the regulating spring; the diaphragm, which is dished and fully annealed to develop the necessary pliability, is of phosphor bronze. A feature of these valves is the arrangement adopted to prevent a build-up of pressure in the delivery line; in such an event, the rising pressure is transmitted to the top side of the diaphragm, so depressing it and closing the valve against the calibrated regulating spring so long as the excessive delivery pressure persists. For each size of valve, three regulating springs are available for controlling delivery pressures of 5 lb. to 60 lb., 20 lb. to 80 lb., and 40 lb. to 125 lb. per square inch; a quick-release cap to the spring housing facilitates the changing of the spring. A simple adaptation makes the valves operable by remote control and they are readily mounted in any position. The valves are made in six sizes for fitting in pressure lines $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and 2 in. in diameter. The overall height of the smallest valve in the series is $10\frac{1}{2}$ in., and that of the largest, $20\frac{1}{2}$ in.

BOOKS RECEIVED.

Productivity Report. Inspection in Industry. Report of a Visit to the United States of America in 1951 of a Specialised Team on Inspection Methods in Industry. British Productivity Council, 21, Tothill-street, London, S.W.1. [Price 3*s.*, post free.]

Department of Scientific and Industrial Research: National Building Studies. Special Report No. 20. *Survey of Building in Sandstone in Scotland.* By H. F. BROUGHTON, J. R. ILLINGWORTH and G. G. RICE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

Electricity Tariff Handbook. Compiled for *The Electrical Review*, with the assistance of V. A. H. CLEMENTS. Electrical Review Publications, Ltd., Dorset House, Stamford-street, London, S.E.1. [Price 7*s.* 6*d.* net.]

Institute of Metals. Monograph and Report Series No. 14. *Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys. A Symposium on Metallurgical Aspects of the Subject Held in London on the Occasion of the Annual General Meeting of the Institute, 26 March, 1952.* Offices of the Institute, 4, Grosvenor-gardens, London, S.W.1. [Price 15*s.*]

Industrial Diamond Trade Names Index and Year Book for 1953. For Users of Diamond Tools, Hard Abrasives, Sintered Carbides, and Materials for the Precision Engineer. Compiled by the Industrial Diamond Information Bureau and *The Industrial Diamond Review*, N.A.G. Press, Limited, 226, Latymer-court, Hammersmith, London, W.6. [Price 3*s.* 6*d.*]

Ohio State University. Engineering Experiment Station. Bulletin No. 150. *Proceedings of the Ohio Highway Engineering Conference,* 1952. The Director, Engineering Experiment Station, Ohio State University, Columbus, Ohio, U.S.A. [Price 1 dol.]

The College of Aeronautics, Cranfield. Report No. 62. *The Laminar Boundary Layer in Slip Flow.* By T. NONWEILER. The Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5*s.*]

United States National Bureau of Standards. Handbook No. 46. *Code for Protection Against Lightning.* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 40 cents.]

Administration Report of Aden Port Trust for 1950-51. The Port Trust Office, Aden.

Building Construction. Vol. I. By W. B. MCKAY. Third edition. Longmans, Green and Co., Ltd., 6 and 7, Clifford-street, London, W.1. [Price 12*s.* 6*d.*]

Statically Indeterminate Structures. By PROFESSOR CHU-KIA WANG. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 7.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 64*s.*]

TRADE PUBLICATIONS.

Low-Resistance Testing Set.—The "Ducter" low-resistance testing set is the subject of a pocket-size pamphlet published by Evershed and Vignoles Ltd., Chiswick, London, W.4. Details of the operation of this apparatus and examples of its uses are given.

Mine Telephones and Signalling Equipment.—A catalogue dealing with their mine telephone and signalling equipment has been received from Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7.

Telecommunication Cables.—Full details of their Telecothene-insulated coaxial carrier-frequency multiquad, subscribers' distribution and mole drainer cables for telecommunication purposes are contained in a pamphlet received from the Telegraph Construction and Maintenance Co., Ltd., Greenwich, London, S.E.10. Jointing, laying and testing methods are also described.

Lighting Problems and Their Solutions.—"Lighting Problems and Their Solutions" is the title of a pamphlet prepared by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

Copper Tubes.—The Aryan Drawing Mills, Ltd., 2-20, Pancras-street, London, W.C.1, have sent us a leaflet giving the weights of their solid-drawn copper tube for bores from $\frac{1}{16}$ in. to 12 in. diameter and thicknesses from 24 to 4/0 s.w.g.

V-Belts.—A booklet has been received from Henry A. Cole, Ltd., Coronet House, 287-289, Old-street, London, E.C.1, which lists their range of corded-rubber V-belts, pulleys and pulley accessories, together with recommended uses.

O-Rings.—Details of rubber O-rings for use as oil seals on static and moving parts are given in a pamphlet received from Howard Clayton-Wright, Ltd., Wellesbourne, Warwickshire.

Aluminium Paste Pigments.—An illustrated brochure has been issued by the British Aluminium Co., Ltd., Norfolk House, St. James's-square, London, S.W.1, describing briefly the general characteristics and types of aluminium paint, painting techniques, and the properties, storage and testing of their aluminium paste, which is available in standard, fine, and extra fine grades and one "non-leafing" grade.